Institute for Land Water and Society
Report No. 58

Irrigation day-to-day scheduling decisions: A summary

May 2010

Kerri Whittenbury & Penny Davidson

Institute for Land, Water and Society, Charles Sturt University, NSW

Acknowledgements

The success of this project was dependent upon the involvement, support and contribution of numerous members of the CRCIF community, and irrigation community. We would particularly like to acknowledge the time and information about their decision making processes provided by the irrigators. We would also like to thank the CRCIF's Tools for Irrigation Profitability and Longevity project leader Evan Christen, and the Irrigation Toolkits project leader, Bill Williamson for their guidance and critical thinking. In addition we would like to thank the time and thoughts provided by the Griffith team, and other CRCIF members who reviewed, commented and attended workshops and interviews. In addition we would like to thank the support of the Institute for Land Water and Society and its members who gave administration support or provided valuable comments on the work.

Financial support for this research was provided by the CRC Irrigation Futures and the Institute for Land Water and Society.

Disclaimer

The views expressed in this report are solely the authors', and do not necessarily reflect the views of Charles Sturt University, CRC Irrigation Futures or people consulted during the research project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This report contains the findings from a study which examined the decision making processes associated with irrigation scheduling for growers in the Murrumbidgee irrigation district. The project contributes to a broader development of tools and technology designed to achieve efficiencies in irrigation water, sponsored by the CRC for Irrigation Futures, Tools for Irrigation Profitability and Longevity. Water management remains a critical issue in Australia ever more so for agricultural producers who depend upon irrigation water for successful crops. The approach to water management is multi-pronged ranging from greater use of market instruments, policy, and technological improvements in irrigation systems. Whilst agricultural water use has decreased dramatically (ABS 2009) there are still irrigators choosing to use irrigation systems and schedules that could be made more efficient. In the face of the challenge of developing more relevant technologies for irrigators and better supporting their needs this project adopted an ethnographic case study approach interviewing thirty irrigators and ten key informants in the field about the process of day to day irrigation scheduling. Whilst the findings predominantly reinforce existing knowledge about farmer decision making and adoption they particular reinforce the priority given to experience, the need to validate any new set of data, and that farming goals tend to be a balance between economic survival and lifestyle. In addition, it became obvious that we were researching with a purpose of informing the goal of saving water and yet saving water was not one of the decision factors of concern to the irrigators in the study.

1. INTRODUCTION

BACKGROUND

> The agriculture industry remained a major consumer of water in the Australian economy in 2007-08. The volume of water used for irrigation and application rates declined further in 2007-08 due to the continuing unavailability of water following the drought.
>
> Australia's agricultural water use in 2007-08 decreased 18% to 6,989 gigalitres on the back of a 27% drop in 2006-07.
>
> In both years, the decrease was substantially driven by decreases in New South Wales where water use decreased by 41% in 2006-07 and by 35% in 2007-08. Since 2005-06, New South Wales' agricultural water use has declined 2,939 gigalitres.
>
> ABS (2009) 4618.0 - Water Use on Australian Farms, 2007-08

This project is part of the broader CRC for Irrigation Futures Tools for Irrigation Profitability and Longevity project, which has a focus on developing tools and technology designed to achieve efficiencies in irrigation water use. Our quest is to gain greater insight into irrigators' day to day decision making so that we will have a greater understanding of irrigators' needs for the ongoing research into irrigation improvements. We have explored this question from a number of social science perspectives and attempt to outline these in this background and use them in our interpretation and discussion. Our results offer a particular 'understanding' of irrigators decision making which highlights yet more gaps and opportunities but hopefully also adds to our understanding of the irrigator experience and approach on a day to day level.

The farming industry, which has a high proportion of family farmers (80 % - ABS 2008), has relatively little capital to fund their own research and develop improved species, tools and strategies (although research cooperatives attempt to address this need on behalf of the farmers). Because the failure of the farmer to 'get it right' not only impacts on their own viability but also on the community's access to primary produce and associated resources (ie ongoing soil health, healthy rivers etc) the government and community is interested in understanding and influencing what the farmer does. There is extensive literature around the process of finding ways to help farmers improve their productivity and efficiency. The seminal work of Rogers & Shoemaker (1971) provides a theoretical framework for innovation diffusion and social change based on communication theory. There has also been a transition from a regulatory approach (or authority innovation-decision), shifting to demonstration, then top down extension or transfer of technology, through to more participative 'bottom up' approaches (Dunn 1997), including the participative research programs such as Rapid Rural Appraisal (Dunn et al. 1996).

There are a number of ways of facilitating farmers / landholders to engage in 'better' practice. These range from the use of policy and legislation to the application of governing / guiding set of regulations, and incentives; to behaviour change programs through education and awareness programs; to self-directed or community based change. In terms of number of instruments, level of awareness and quantity of resources involved the policy and behaviour change programs dominate. Three broad categories exist in the latter: transfer and uptake of new knowledge or technology (adoption) (Douthwaite et al.'s 2001); the gathering of detailed information about user

groups and their needs and providing for these needs (marketing) (Vanclay, Mesiti & Howden's (1998) styles verges on this); and the joint definition of issues and development of solutions in an iterative approach (participatory action research) (Douthwaite et al. 2001; Dunn et al 1996).

One of the main approaches to encouraging water use efficiency among irrigators has been to promote irrigator adoption of technological innovations designed to improve water use efficiency, that is, to achieve water savings. It is well known and documented that the uptake of such innovations is low (Montagu et al 2006; Everingham, Jakku, Inman-Bamber, Thorburn, Webster, Attard and Antony 2006). Indeed, the traditional transfer of technology and diffusion approach to encouraging adoption has been criticised as being 'top down' and for failing to consider and value local farmer knowledge (Kloppenburg 1991). In this approach farmers are not viewed as active, contributing participants in knowledge development. Instead, Kloppenburg points out, farmers are presumed to be passive recipients of new knowledge. Despite this criticism and a concerted effort in some projects, traditional models of adoption such as transfer of technology approaches remain popular among organisations research projects, in order to meet funding organisations' requirements of behavioural outcomes in terms of adoption of technology (Dunn et al. 1996).

The alternative to the top down approach is logically the bottom up approach, or participatory approach which has been advocated since the 1980s (Dunn et al. 1996). Going under the name of 'farmer-back-to-farmer, or 'farmer-first' or 'farmer participatory research these approaches locate the farmer as a co-researcher or problem solver rather than recipient of the solution independently resolved by scientists and non-practitioner 'experts'. Past examples of a participatory approach include the use of Rapid Rural Appraisal by Dunn, Humphries, Muirhead, Plunkett, Croker and Nickl (Dunn et al. 1996), participatory approaches by Inman-Bamber, Webb and Verrall (Inman-Barber et al. 2006) and Jakku and Thornburn (Jakuu & Thornburn 2008), participatory rural appraisal applied by Allan and Curtis (Allan & Curtis 2004), and adaptive management as tested by Allan (Allan 2004). As noted by Matthews et al. (2008) participatory approaches address the key issues of credibility and maintenance of control over decision making, as well as a more informed research community, incorporation of required on-ground knowledge, empowerment of farmers, improved relationships and partnerships between the research community and growers (Dunn et al. 1996). In the words of Jakku et al. (2007) the participatory process creates a space for improved communication and co-learning between industry stakeholders and scientists.

At the same time that participatory approaches were developing strength Jan Douwe van der Ploeg developed a theoretical construct of 'farming styles' or typologies in order to better understand farmer's decision making, socio-economic and behavioural characteristics (Vanclay et al 2006). For example Mesiti and Vanclay (2006) identify 14 researcher defined typologies of grape growers. Initially it was thought that identifying 'types' of farmers would allow the development and delivery of a targeted behaviour change campaign (or adoption / extension). However, Mesiti and Vanclay (2006) question the efficacy of using the typologies as the 'types' aren't consistent with the farmer's self perceptions (although farmers agree with the concept of 'types'); they argue that they are still useful as a researcher heuristic to better understand the variability across landholders. They emphasise that the famer styles can assist adoption and extension programs but also point out the benefit of this knowledge in the active process of research (Vanclay et al 2006). That is, the typologies can be of use in tool design or problem solving. Fairweather and Klonsky (2009) argue that the identification of farming styles incorporating the farmer's perspective, such as through Q methodology, provides a set of farming styles that is useful for extension.

MARKETING

Early work in developing farming 'styles' or target groups emanates from marketing research which provides an approach (arguably very successful) to understanding and influencing people's decision making behaviours. Understanding the habits, values and attitudes and the links to decision making and behaviour of particular segments allows us to target those groups most open to change. Marketing requires an understanding of the influence of thoughts and feelings on behaviour (cognitivism), and how behaviour influences thoughts and feelings (behaviourism) (East, Wright & Vanhuele 2008 p 23). We know that there is a consistent correlation between attitude and behaviour where the behaviour is a single specific behaviour rather than a set of behaviours (eg putting up nest boxes vs looking after habitat) (East, Wright & Vanhuele 2008 p 125). Generally from a marketing perspective the decision to purchase a product correlates to the expected costs and rewards; social marketers base their approach on the 'purchase of a behaviour' (eg putting litter in the bin, installing drip irrigation instead of using sprinklers). However decision making, and consequent behaviour is not usually a simple 'rational' process and is explored more recently in terms of 'planned behaviour', as per 'the theory of planned behavior' developed by Fishbein and Ajzen in 1975 (East, Wright & Vanhuele 2008). According to the theory of planned behaviour the three key variables are: attitude to behaviour, subjective norm and perceived control. That is, engaging in a particular behaviour is significantly influenced by 'beliefs about the outcomes of behaviour (attitude), the referents who think that a person should engage or not in the behaviour (subjective norm), and the ability and opportunity to engage in the behaviour (perceived control).' (East, Wright & Vanhuele 2008: 142).

That is, the decision to engage in a particular behaviour be it to purchase a product / technology or to try a new behaviour correlates to the weighing of the costs and benefits, but those costs and benefits are quite complex and include a broad range of factors. The marketing approach does not attempt to identify this list of factors; rather it seeks to understand the person's intention to engage in the behaviour, and what the perceived limits of control might be. As such, a marketing approach such as social marketing will explore barriers and drivers to specified 'behaviours'.

DECISION MAKING RESEARCH

Other sociological work has explored the range of factors that influence people's decisions and behaviours. Rogers and Shoemaker (1971 p128) point out there are numerous 'decision' involved prior to adoption including the decision to attend to innovation messages, the decision to seek further information, and the decision to trial an innovation. He notes that interpersonal communication is crucial in the adoption process to provide the adopter the know-how of employing, interpreting and valuing the new approach. The importance of the social and communication context continues to be highlighted in recent work such as Burton's (2004) ethnographic study of farmers in the UK where he was able to uncover the strong influence of social identity and status in farming practice. Whilst the farmers work within a productivist model and position economic goals as important to their decision making, they do so using an approach that demonstrates good farming practice to others; consequently farmers will make some decisions which often do not result in the most economic outcome. This work reinforces and provides a clear example that whilst it is possible to predict the decision someone might make based upon a rational and logical process the outcome rarely matches with what people actually do (East, Wright & Vanhuele 2008). The UK case study showed very clearly that economic outcomes were not the only or main driver for some of the farming decisions. In the UK farmers would put more effort into the fields

adjacent to the roads and public ways in order to demonstrate that they were ‘good farmers’.

More specific decision research or decision theory explores the range of factors that are considered in decision making and the way that people will assess these factors to reach their decision and behaviour. As noted above, people do not act in highly rational ways, rather people’s decision making is influenced by anchor points, the social context, the complexity of the decision and so on. For example, we are strongly influenced by reference points or ‘anchors’, a behaviour frequently used in real estate auctions and other marketing strategies. An explanation of anchor points is best demonstrated by Tversky and Kahneman’s study (1974) where they asked people to guess the percentage of African nations which are members of the United Nations. People who were first asked "Was it more or less than 45%?" guessed lower values than those who had been asked if it was more or less than 65%. The behaviours or ideas from previous generation farmers are therefore possible anchor points for contemporary farmers.

There has also been more specific research on the decision making itself process in the farming community. Farmar-Bowers & Lane (2009) for example aimed to understand decision making in terms of how farmers think, how they sort the information and make sense of it. Similar to previous decision making models their model includes motivation, strategic opportunity and action (Figure 1).

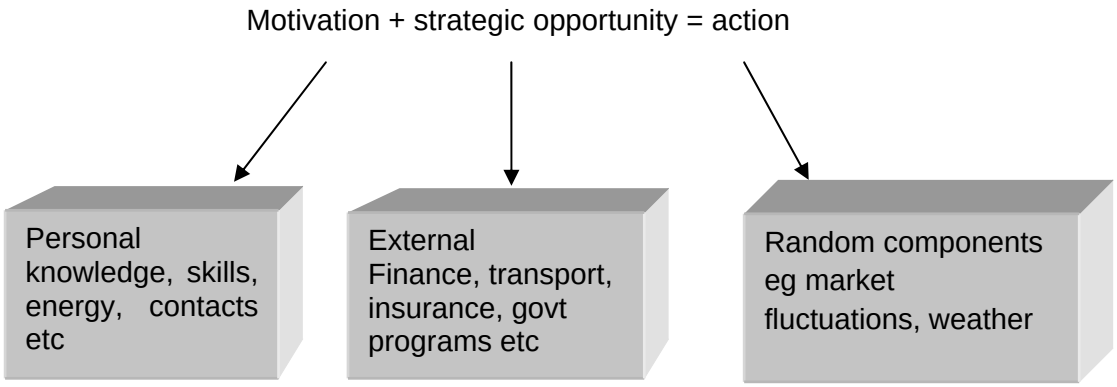

Figure 1: Mental model of decision making
Source: After Farmar-Bowers & Lane (2009)

Farmar-Bowers & Lane (2009) for example derived a decision making model which suggests that farmers use three different decision-systems:

Family decision system – based on ethic of care

Farm business trading decision system – based on ethic of business

Land ownership decision system – based on goals and values related to who owns the land

Each decision system uses the model of decision making given above, but they found that of the different decision systems there was a hierarchy in which the decisions were made. And so the decision to farm would be made in the family decision system but the operational decisions and whether to buy land or not would be made in the farm

business trading decision system and land ownership decision system (Farmar-Bowers & Lane 2009).

There is an increasing literature on decision making in the context of climate change and risk management, and Milne, Stenekes & Russell (2008) explore the range of factors that influence decision making around adapting to climate change. Their work uses behavioural theory as a framework and they found that the factors influencing adaption (so a particular kind of behaviour) were:

- Values and attitudes related to rural life
- Knowledge and awareness
- Business skills and professionalism
- Networks and relationships (social capital)
- Regulatory policy and context
- Economic and financial factors

Milne et al (2008) highlight the high value of farming lifestyle in the decisions that the farmers were making. Based on the theory of planned action people are first motivated to act, develop an intention to act and then will act, all of which will be influenced by the capacity to act. Capacity to act is determined by:

- Condition of the natural assets
- Social capital
- Human capital
- Financial capital
- Physical capital (Milne et al. 2008: 11)

AFFECT AND INTUITION

Other literature explores in more detail the non-rational influences in decision making such as affect, emotion or the use of heuristics. In general terms Loewenstein and Lerner (2003) has found that people make decisions based on their anticipated feelings not on the expected utility of that decision. That is, people tend not to look at the big picture but at the consequences of the immediate action and how that will make them feel, a gambling example is that people will anticipate the satisfaction of winning or losing $100 and will make their decision based on that feeling but won't calculate or consider their feelings of this win/loss on their overall assets (eg they will now have $99900 as total assets). Or taken to a farming example a decision to revegetate a water course or section of a paddock will be made partly considering their anticipated feelings once they have done that action, not just upon a rational input-output calculation, or the overall impact of the strategy on local vegetation.

The influence of feelings is also called the affect heuristic – where people's affect will influence their decision making. Finucane et al. (2000: 1) showed that 'people rely on affect when judging the risk and benefit of specific hazards', and that perceptions of risk and benefit are linked. That is, objects and events are 'tagged' with positive and negative feelings in people's minds and these are consulted when a judgment or evaluation is required. And changing either the perception of risk or benefit will impact on the alternative: for example increasing the perception of risk will decrease the perception of benefit. The affect heuristic explains why someone will buy a house based on first perception, and why we're influenced by the charming sales person.

Intuition is a contested concept (Easen & Wilcockson 1996) variously defined as representing irrational decision making, gut feeling, tacit knowledge, and discussed as a conscious, unconscious, pre-conscious and subconscious process. Whilst intuition is considered an unprofessional form of judgement it is frequently reported as the basis for a particular action or decision within professions such as nursing, policing, emergency service people and high level managers. In this report we use Easen & Wilcockson (1996) position that 'intuition' represents a non-conscious process of making sense of a situation. It is based on a sound and relevant knowledge base which allows the actor to recognise patterns in the situation or diagnose the current state (Pomerol & Adam 2006). Associated with these patterns are past decision making, experience and 'know-how' which forms the basis for a speedy and effortless 'intuitive' decision, triggered after the recognition state (Pomerol & Adam 2006).

HEURISTICS

One of the reasons attributed to inconsistent and non-optimal decisions is a reliance on heuristic rules or intuitive judgements (Trailer & Morgan 2004). There is certainly no lack of 'heuristics1' associated with farming and this report will outline those that are used by the participants. However, Leith's study shows a reluctance to use heuristic rules. Five interesting points emerged from Leith's (2006) study of Queensland graziers. First, he found that graziers would tend not to base their decisions on formal records or processes but on their experience and knowledge of the country; this study reflects the psychological and marketing studies which point out that decisions are not purely rational processes. He also found that great value was placed on having long experience and knowledge of the seasons and country, and so listening to the 'old hands' was a significant part of management practice. Second, graziers would pay attention to available information such as long range weather forecasts but tend to want to 'test' the accuracy of the forecasts rather than simply trust them and factor them immediately into their decision making. Leith suggested this was a desire to 'be independently responsible' rather than follow a simple logical formula where you enter, for example, x (weather) + y (soil moisture) = z (do …). Third, Leith also found that whilst there were a number of 'natural indicators' which might be used as heuristics known to the graziers (eg strong monsoons in India) they tended not to trust these. And fourth, they had a belief in the law of averages that that things will eventually even out, after a few years of drought there will be rain or a flood. Mazur et al (2008) interpreted this as a possible 'Optimism Bias' (from Bazeman 2006) which can lead people to interpret the situation as not requiring a different course of action. Fifth, whilst Leith developed a list of 50 factors that influenced management practice most graziers only considered 2 or 3 of these factors. He concluded that whilst some graziers would apply scientific training and calculation, experiential learning and gut instinct still played a significant part in management practices.

There is, however, little information that specifically addresses irrigators' decision-making from the perspective of irrigators themselves (Whittenbury and Davidson 2009). The approach taken in this project recognises that knowledge is socially constructed

[1] "A heuristic is a mental shortcut that allows people to solve problems and make judgments quickly and efficiently. The rule-of-thumb strategies shorten decision-making time and allow people to function without constantly stopping to think about the next course of action. While heuristics are helpful in many situations, they can also lead to biases." (van Wagner nd)

and made sense of using our existing mental maps and world view (Douthwaite et al. 2001). Hence the knowledge and approach of the irrigator is likely to differ to that of the scientist who has specialist knowledge about some aspects of the irrigator's world.

The primary aim of this project was to explore irrigators' decision-making, with a particular focus on short-term day-to-day irrigation scheduling decisions, from the perspectives of the irrigators themselves. Findings from the project will contribute to the development and modification of technological innovations to better reflect irrigator needs and to the implementation of support mechanisms designed to yield improvements in water-use efficiency.

A secondary aim of the project was to provide a mechanism and approach that will foster social science input into tool development, not only through the contribution of this project's findings but also through a strategy of inputting social data in traditionally technical research projects; yielding a more interdisciplinary approach. It is important for researchers and tool developers to understand the broad social context in which irrigators operate and the varied factors that influence their irrigation-related decisions. This project differs from previous research into irrigators' decision-making, which has focused on adoption decisions, in that its focus is on understanding irrigators' decision-making at a day-to-day level.

DECISION-MAKING SUPPORT SYSTEMS

The development of decision-making support systems (DSS) began in the context of organisational decision making but applications have since been developed in defense, engineering, medicine, forestry management and agriculture. Recent agriculture DSS include by way of example: SWAGMAN, MaizeMan, FARMSCAPE, Wheatman, GrassGro, and WaterSense.

The purpose of using a DSS is to improve the process and outcome of decision making. The decision making process can be enhanced through support of real-time decision making, greater understanding of the problem, facilitation of generalising, and facilitates faster decision making, more efficient decision making and more systematic approach. The decision making outcome should be greater user satisfaction, better performance and ability to predict outcomes (Phillips-Wren et al. 2006). A key thinker with respect to artificial intelligence and understanding decision making was Herbert Simon (Pomerol and Adam 2006) who simplified the decision making process into three stages:

1. Identifying all the possible alternatives;
2. Determining all the possible consequences of these alternatives;
3. Evaluating all the possible consequences.

Pomerol and Adam 2006, p. 27

Pomerol and Adam (2006) add that the common 'weaknesses' of decision making are not exploring the alternatives fully (alternatives not investigated are much more likely not to go ahead) and the underlying assumptions are not understood.

In agriculture DSS are designed to make the process of awareness and consideration of a large number of complex factors (soil type, humidity, soil moisture, plant type and needs etc) more easily and accurately incorporated into the decision making system; to more fully explore all the alternatives and avoid erroneous assumptions.

Whilst a large number of agricultural DSS have been developed they are not being used as fully by farmers as the designers / developers would have liked. Matthews et al. (2008) has reviewed and explored the reasons for the limited use of DSS undertaking a market survey of potential DSS users. They found that while only 5% of

respondents used DSS 44% used spreadsheets, and 34% used Geographical Information Systems supporting McCown (2002) that software which supports but does not cede control of the decision making process is preferred. They also found that DSS tools are not immediately credible (also reinforcing McCown's findings) as there was a high degree of skepticism that the tool could deliver on its promises and desire to 'see relevant success stories' before it would be tried. They conclude that land management decisions now need to consider multiple goals such as environmental protection, sustainable rural development and no longer just production efficiency; as such a process is required where the trade-offs between the multiple objectives can be explored. Matthews et al. (2008) advocate what they call a deliberative inclusive process (DIP) and conclude that the socio-political environment around DSS which determines the overall availability of resources is likely to be more influential than the technical or theoretical aspects of the DSS tool.

Jakku and Thorburn (2007) add to the DSS evaluation discussion with the development of their theoretical model and emphasis on participatory processes, concluding that 'successful DSS development should be defined in terms of practice change, rather than solely being based on the ongoing use of a DSS.' They emphasise that the participatory process was key in order to achieve, as one respondent noted: 'at the end of the day something (that) was useful to the grower at his level rather than the scientist … level'.

2. METHODOLOGY

DURATION OF PROJECT

This was a two year project, which commenced early in 2007 and concluded in 2009.

Research design

This exploratory research utilised a qualitative social research methodology, specifically a case study approach. A qualitative approach is well suited to exploratory research as researchers begin with minimal expectations, or assumptions (Alston and Bowles 2003). This form of research reflects an interpretive philosophical paradigm (Neuman 2003 p76), which differs from the positivist philosophical paradigm that underpins traditional, scientific research in that it assumes that our knowledge of reality is a social construction and that understanding involves getting inside the world of those generating that knowledge (Orlikowski and Baroudi 1991). Qualitative research is inductive in that findings emerge during the process of undertaking the research. There are no initial hypotheses to be tested as in more deductive-style research projects[2]. Researchers may begin with 'sensitising concepts' reflective of particular themes that provide a starting point for exploration.

A qualitative and ethnographic approach provides the opportunity to explore the broad context while enabling researchers to delve more deeply into factors discussed by irrigators as impacting on their irrigation decision-making. Ethnography, is a methodology associated with anthropology, which primarily aims to describe the 'way of life' or culture of a society or community and might use a number of social science methods (Patton 2002). This approach allows for individual, or personal, characteristics of the irrigator to be considered. It also enables exploration of social, cultural and structural factors that influence irrigators' in their decision making. Examples of social and cultural factors include farming or community norms, social networks and family characteristics. Structural, or macro, influences include broader factors that tend to be beyond the influence of individual irrigators, such as financial and regulatory systems, marketing and distribution relationships and costs of inputs such as electricity for pumping and fuel for operating machinery.

Fieldwork, comprising interviews and participant observation, was the main data-collection method for the project. The fieldwork for the project was conducted mostly among wine-grape growers in Griffith, NSW[3], a grower population targeted by other projects in the broader Tools for Irrigation Profitability and Longevity project.

[2] In practice inductive and deductive approaches are often combined in a form of methodological triangulation. The inductive/deductive dichotomy is somewhat artificial. However, more inductive approaches are useful in exploratory research as researchers seek to identify key themes.

[3] Four rice growers were interviewed during the project. Some of the grape growers interviewed grow other crops, most commonly citrus, in addition to grapes.

DATA COLLECTION METHODS

The research interviews were in-depth and semi-structured and were supplemented by participant observation. Participant observation and semi-structured interviews are well suited to exploratory research as they do not set limits on the topics being studied (Berg 2004). Participant observation enables researchers to observe respondents in their day to day activities and interactions. Semi-structured interviews allow for some uniformity in the topics discussed while allowing for individual variation to be explored. They enable researchers to follow leads and probe respondents in greater depth to explore emerging themes and concepts. Such themes and concepts are then further refined as data collection continues (Alston and Bowles 2003). The interview questions are based on information from the literature, interviews with key informants (see below), and pilot interviews with irrigators.

INTERVIEWEE RESPONDENTS

As the project is part of the broader Tools for Irrigation Profitability and Longevity (TIPL) project and was incepted, in part, to provide decision-making input to the larger project, our research population was comprised of enterprises that would be potential consumers of TIPL developments. In particular, horticultural producers, predominantly wine grape growers, were targeted for this research.

Interview respondents were comprised of key informants and grower-irrigators. Some respondents were representative of both categories. The responses of such interviewees were analysed from the perspectives of both key informants and irrigators.

Table 1: Number of interviewees: N=36

	Primary respondents	Secondary respondents	Total
Male	25	3	28
Female	8	-	8
Total	33	3	36

IRRIGATORS

Irrigator respondents were recruited from the Griffith area in New South Wales. Initially key informants nominated potential irrigator respondents. Further respondents were then recruited using a combination of ‘snowball’ and targeted theoretical sampling. For targeted theoretical sampling respondents were sought who fit specific (theoretical) criteria. Snowball and targeted sampling are particularly useful when seeking to locate respondents in rural communities as the researcher can draw on a familiar source to the potential respondent, or ‘name-drop’, which can make them feel more comfortable about participating in an interview. Some respondents were directly recruited by the researcher at irrigator meetings.

A broad spectrum of wine-grape grower-irrigators was targeted aiming for a sample that reflected the varied characteristics of wine-grape growers in the locality. Our sample included:

- Irrigators with different irrigation systems such as flood, furrow and drip
- Irrigators at different lifecycle stages
- Different ownership and management structures such as family and corporate
- Different irrigator 'styles' such 'innovative' and 'traditional' (according to key informants and other irrigators)
- Irrigators who may not usually come into contact with extension officers and other liaison workers.

Developers of irrigation scheduling tools are keen to reach this latter group of 'uninvolved' irrigators. Such irrigators were identified simply by asking irrigator respondents to nominate other grower-irrigators who fit this criterion.

Thirty irrigators were interviewed – twenty-two males and eight females. This included three 'secondary respondents' – irrigators who participated in part of an interview with another family member who was the primary respondent (Table 1). Twenty-seven respondents were involved in family farming enterprises (Table 2). These varied from husband and wife partnerships, parents and adult children, to family companies. Three respondents were employed by 'corporate' vineyards – two were vineyard managers and one was irrigation manager.

Table 2: Grower-irrigators: N=30 (4 irrigators are also key informants)

	Family farming enterprise	'Corporate vineyard'	Total
Male	19	3	22
Female	8	-	8
Total	27	3	30

The thirty irrigator respondents were drawn from 21 irrigation farming enterprises. In nine instances more than one irrigator per enterprise/business was interviewed. In most cases, an enterprise consisted of more than one property title.

Twenty-four respondents grow wine grapes, most of these grow wine-grapes only but more than a third grow other crops as well, predominantly citrus and prunes (Table 3). Three of these irrigators also had broad acre properties. Two respondents grow citrus only – one of these was allowing his trees to die and selling his water on a temporary (seasonal) basis. Four irrigator respondents were predominantly broad acre growers,

formerly rice, although one grower also grows 'high value' seed crops (see Tables 3 and 4 below).

Table 3: Grower-irrigators who grow wine-grapes: N=24

Type of crops	Number of irrigators
Wine-grapes only	14
Grapes and citrus 50/50	2
Predominantly grapes – with some other horticulture: citrus and prunes	5
Predominantly grapes – with some horticulture: prunes and also have broad acre properties	3
Total	24

Table 4: Main crop type (per Grower-irrigators): N=30

Wine grape	Citrus only	Broad acre	Total
24	2	4	30

Most of the interviewees have high security water entitlement, which has resulted in these growers having received almost full water allocation during 2007-2008. A small number of respondents were general security growers, who would usually grow annual crops (previously rice), and some high security growers also had general security water for broad acre properties. Three of the respondents with predominantly broad acre enterprises had recently bought high security water on a permanent basis, one in the form of water delivered via the channel system. The other two bought permanent water rights in conjunction with investing in an on-farm bore.

KEY INFORMANTS

Key informants are people who have knowledge of the issues and situations in which the researcher is interested (Sarantakos 2005). Key informants provided the initial point of contact for the researchers commencing data collection in the field. Key informants interviewed for the project included researchers working in related Tools projects and other service providers such as extension officers, industry representatives and irrigation providers. Key informants provided valuable insight into the topic and acted as facilitators (Berg 2004) in linking us with irrigators to interview. Information from key

informants provided initial structure to the emerging issues and assisted in developing interview questions for the irrigator respondents. Key informants also facilitated participant observation by inviting the researchers to participate in meetings and other group functions conducted with irrigators. One of the researchers attended a 'Farm-wise' course conducted by government extension/irrigation officers. Attendance at this course enabled the researcher to recruit several irrigator respondents in addition to being invited to attend another group meeting of irrigators.

A total of ten key informants, eight males and two females, were interviewed. Five were researchers working on TIPL and related projects and the remaining five were service providers such as extension officers, industry representatives and irrigation providers. Four of the key informants were also involved (personally and in their families) in irrigation enterprises (see Table 5 below).

Table 5: Key Informants: N=10 (4 key informants are also irrigators/members of irrigator families)

	Researchers	Service providers	Total
Male	5	3	8
Female	-	2	2
Total	5	5	10

METHODS OF DATA COLLECTION

Participant observation occurred on farms, in respondents' homes and at grower and/or irrigator group meetings. In some instances, farming and irrigation activities were observed and one of the researchers spent a day accompanying a grower respondent harvesting grapes. The researcher also accompanied the truck driver delivering grapes to the winery and was guided through the winery by the winemaker in order to observe the processing of the grapes into wine[4].

The semi-structured interviews were conducted in homes, on farms, in offices, in cafes, in wineries and in vineyard paddocks. In most instances the interviews were audio-recorded and transcribed. A small number of grower-irrigators chose not to have their interviews audio-recorded. In these instances the interviewer took extensive interview notes, which were written-up in detail.

Most respondents participated in a single interview; the interviews were usually between one and two hours in duration. In one instance, a second interview was undertaken to seek further information required from a particular (key informant) respondent.

Topics explored in irrigator interviews included:

[4] The researcher subsequently visited the winery to observe further development of the wine.

- Information about farm enterprise including:
    - Type of farm, size, land use etc
    - Management/ownership eg family, corporate
    - Who makes investment decisions
    - Irrigation systems current, past, planned
    - Water allocation, entitlements etc
- Irrigation related decision-making
    - What sorts of irrigation-related decisions need to be made
    - Who makes irrigation decisions
    - Perceived impacts/influences on irrigation decision-making
    - Where do irrigation requirements 'fit' relative to other responsibilities and activities
    - Use of irrigation scheduling products
    - Views about irrigation scheduling systems
    - Likelihood of utilising such systems
    - What would interviewee want in such systems
- Demographic information
    - Age
    - Gender
    - Family/household composition
    - Farming future, succession considerations

The interview guide for grower-irrigator interviews is appended (see Appendix i).[5]

In addition to participant observation and semi-structured interviews as outlined above, a 'mini' case-study was undertaken. One respondent (and enterprise) was followed over time using a combination of follow-up interviews, observation, discussion and email correspondence. This allowed for data to be collected over time and enabled a more in-depth exploration of the farm enterprise and the influences affecting the respondent. It was this mini-case study that provided the opportunity for one of the researchers to participate in harvesting and to visit the winery.

The case study did not yield qualitatively different information from the main irrigator interviews but was useful in that it provided a helpful resource in terms of seeking clarification and fleshing out concepts and terms that arose during the research process.

DATA ANALYSIS

Data analysis occurred as the project progressed. Data analysis was not a separate phase of the project but was ongoing and became part of the research process in which themes and concepts were identified, further explored in subsequent interviews then further refined and analysed (see Figure 2).

[5] The interview guide for key informants was very similar to the grower-irrigator interview guide. Key informants were asked for their views and perceptions about irrigators and irrigators' decision-making.

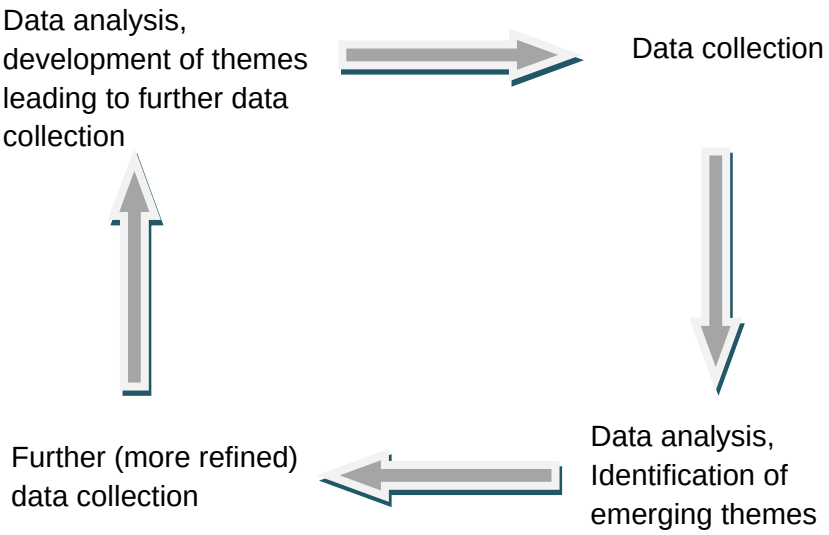

Figure 2: The circular nature of the qualitative research process

Interview recordings were transcribed. Transcriptions, field notes[6] and detailed notes of unrecorded interviews were coded according to emergent themes. NVivo 7 (©QSR International 2007) qualitative data analysis software was used to assist with coding and data management. Data were grouped into themes, which were refined and developed as the project continued. Themes were further classified into groupings reflective of the data. The main themes are presented as findings (see below).

FINDINGS FORUMS

One of the key aims of this project is to inform researchers working in technical (tool) development and to map out the implications of irrigators decision making to other researchers. After our initial analysis we conducted three forums with CRC IF Tools researchers and interested practitioners, presenting our initial findings in order to obtain feedback on the implications of this work to their research projects. One forum was conducted at Griffith with researchers who work with irrigators reflective of our respondents. Another forum was held at Tatura with researchers working with a different group of irrigators and the third forum was conducted at Toowoomba and included researchers and practitioners working with diverse groups of irrigators. Feedback from the participants in these forums assisted us in interpreting our findings.

[6] Field notes are the researchers' notes taken during observation and interviews.

3. FINDINGS AND DISCUSSION

Our findings both reinforce existing knowledge in the literature, for both researchers and practitioners, as well as offer new insights into the topic of irrigators' decision-making.

Irrigators discussed a range of topics and the interviews yielded a large amount of data.[7] Irrigators' decisions can be loosely classified into longer term, medium and shorter term decisions.

A long term decision occurs infrequently and has long-term implications. Such decisions often incur significant investment. Examples of longer term decisions include:

- farm expansion plans;
- major investment such as buying more water entitlements (permanent water trading);
- what type of plants/crops to grow such as grape varieties;
- layout and types of irrigation system for instance converting from flood to drip;
- succession considerations such as – Will the farm continue in the family? Will it be sold?

Medium term decisions are taken more frequently than longer term decisions. They include:

- yearly water plans/water budgets:
- buying and selling (trading) water on a temporary basis;
- contracts and arrangements for selling produce.

Shorter term decisions occur on a day-to-day or week-by-week basis. Examples include:

- irrigation scheduling decisions;
- determining application rates.

The focus of this report is primarily on shorter term scheduling decisions, bearing in mind that such decisions occur in a context that is influenced by medium and longer term decisions.

[7] Not all of the data collected has been used for this report. For instance many interviewees discussed their views on water trading policy. Analysis of water trading policy is beyond the scope of this project and report but the data could be used to explore such topics.

DECISION MAKERS

Day-to-day decisions are made by the farmer-irrigator in owner operated farms or the irrigation manager in corporate vineyards. If there are several properties in family partnership – usually the family member who lives on that property makes the scheduling decisions. This differs from medium and longer-term decisions that are made jointly or unilaterally by the 'head' of the family farming enterprise (this may be in exercising a right of veto).

> *And who makes the irrigation decisions that you make, those day to day and the season to season, who makes those? (Interviewer)*
>
> *That's what I was saying before, the bigger ones, we all sit around and have a talk, take in all ideas and then of course take in Dad's experience over his 70 years. (Male grape grower)*
>
> *Is your mother involved in those decisions? (Interviewer)*
>
> *Probably not to a point where she will sit around the table and talk about it but because she is always there in the background she remembers a lot of things and say 'remember when that happened and that year when this happened'. Mum is like the computer memory in the background. She loves that side of it. (Male grape grower)*
>
> *So you will discuss those then formulate what you are going to do – effectively some plan or goal? (Interviewer)*
>
> *Yes. (Male grape grower)*

Day-to-day decisions are made in a context that has been established by longer and medium term decisions. For example, scheduling decisions are influenced by the type of irrigation system on farm: in particular drip or flood. Decisions to invest in scheduling technology may be made by people other than those who make the day-to-day scheduling decisions. Investment decisions are likely to be jointly made in family farm partnerships, although 'Dad' may have overriding authority, and by senior managers in corporate farms. It is important to note that it may be a different person who is making short term scheduling decisions from the person/s making decisions to invest in scheduling or other decision support technology. Just over one third[8] of grower-irrigators reported that there was some type of joint decision-making for investment decisions although, as mentioned above, one of the parties to the joint decision may have had more power in the decision-making arena.

Having said this, the process of decision-making is not often consciously observed by those involved in the decision making, and so whilst the responses to the interviews indicate that specific processes and factors can be identified with respect to a specific irrigation decision (eg what is considered in determining the scheduling) they also indicate that the shared decision making process is an event less reflected on:

[8] Eleven of a sample of thirty.

> *We just talk it out between us. No one makes the decisions. Someone has an idea it is put out there, listen to it then we go from there. No one makes one decision* (male grape grower)

This grower is describing a scene where ideas are gathered and developed with no clear decision point, implying that the decision making process is most akin to a consensus. This may well be the case, but on the other hand it is also possible that the nuances of power and influence are being missed during the group decision making; or are not events that are deemed reportable or relevant to the researcher. Indeed most of us would be unaware of exactly how the decision making occurred in our own groups or teams, apart from when we layout an explicit process such required for formal meetings.

INFLUENCES ON DAY-TO-DAY DECISIONS

Not unsurprisingly irrigators drew on multiple sets of data in making their decisions. Influences on day-to-day decision-making can be classified as being (mostly) objective, (mostly) subjective or having both objective and subjective characteristics. The more objective influences are those that are largely independent of the grower's immediate influence. These influences include:

- The type of irrigation system - (Irrigation systems are influenced by longer-term decisions and are not changeable on a day-to-day basis);
- Water availability;
- Water price/cost;
- Cost of electricity;
- The weather, including rainfall;
- Soil characteristics;
- Plant growth stage;
- Information from tools eg soil moisture monitoring;

Socio-cultural influences have both objective and subjective elements. They include:

- Local and industry norms and expectations;
- Irrigator cultural heritage;
- Gender;
- Neighbours;
- Family and rural values.

More subjective influences are those factors that tend to vary with the individual growers. They act as a filter through which grower-irrigators interpret information when making decisions. Subjective influences include:

- Rules of thumb;
- Knowledge;
- Experience;
- Intuitive factors such as gut-feeling;
- Affinity/relationship with plants/vines.

OBJECTIVE INFLUENCES

STRUCTURAL INFLUENCES

Structural factors (Giddens 1984; Ortner 1994) frame the context in which growers and enterprises operate. Examples of structural factors include financial and regulatory systems, product marketing and selling relationships and water markets. The political context and changes in government priorities also influence growers as individuals and the industry more broadly (Whittenbury and Davidson 2009). Influences that we have classified as structural include:

- Type of irrigation system – such as drip or furrow/flood
- Availability /delivery of water
  - neighbours may use available water on a small sub channel
  - flow levels in the channel
  - problems/breakdowns with pressurised pipe system – many growers connected to the pressurised water supply report problems with water quality
  - water allocation – how much water the grower has available
- Economic factors such as the price/cost of water
  - The price of water influences decisions to buy and/or sell water
  - Some growers with high security entitlements preferred to sell water than to grow produce in times of high water prices. One grower-irrigator let his citrus trees die because he earned a higher return selling water on a temporary trade capacity than in using the water to irrigate his trees.
- Off-peak electricity for running pumps
  - Off-peak electricity costs around one third of the price of regular, or peak, electricity. Off peak is during the night on weekdays (eg 10pm to 6am) and all weekend from (approx 10pm Friday night to 6am Monday morning).
  - Nearly all growers who run electric pumps – pumps required for drip systems, (some run on diesel but vast majority are electric) – run pumps to take advantage of off-peak electricity pricing. They water during evenings and during the day on weekends. Not all growers water during the day on weekends but many do.
  - Watering in the evenings has the added rationale of less loss of water to evaporation than in the day
  - Several growers reported that they know they may be over watering by watering all weekend, or that this timing is not ideal, but cost considerations, in the form of cheaper electricity, strongly influence scheduling.
  - Electricity costs for pumping remain even with MI's[9] pressurised system as pumping costs are passed on to growers. At the time of data collection, MI has not been able to negotiate a pumping tariff with Country Energy, the electricity provider.

[9] MI – Murrumbidgee Irrigation is the irrigation company that supplies water to irrigators.

I heard at the rice growers' conference somebody told me a number of farmers converted to drip their electricity bill is costing them more than the value of the water saved. So you know I mean as an economic proposition. (Male researcher/grape grower)

- Wineries may demand growers comply with particular requirements as a condition of contract and/or sale. Several respondents reported that they had installed drip irrigation and/or soil moisture monitoring at wineries' insistence[10].

WEATHER

All respondents said that the weather influences their irrigation scheduling decisions. They discussed different aspect of weather including rainfall, forecasts, observations and evapotranspiration.

- Rainfall – Many growers reduced/cancelled irrigation if it rained but a small number of growers said that they irrigate as usual when it rains, particularly as it has been so dry and rain is not necessarily penetrating the soil.

- If winter has been dry, some growers stressed the need to irrigate before vines start to shoot.

- Irrigation is increased if hot weather is expected.

- Data sources include observations, reports and forecasts – some farms have installed weather stations that record weather, some of these feed data back to grower's computer. Others use internet weather sites, radio and television.

- Evapotranspiraton (ET) data – Growers varied in whether they used evapotranspiration data. All growers had heard of the term and most had some understanding of what it meant. The growers who used it said it was a guide that they incorporated with other factors in deciding when to irrigate. Some growers participated in a trial and received ET figures via a text message every morning. These growers reported it was a convenient way to get the ET figures and that even though the ET figures may be available on the internet or television, they did not otherwise seek them out.

SOIL MOISTURE LEVELS

Irrigators reported using a variety of tools and systems for soil moisture monitoring. These tools vary in sophistication from simple portable probes to complex systems that transmit readings to the grower's computer.

---

[10] Some growers also discussed their views that wineries try to create an environment where there is an oversupply of grapes each season, which reduces the price paid by the wineries. This leaves some growers with some uncertainty over whether some or all of their grapes will 'have a home', that is, be bought by the wineries.

- All growers report using a shovel to inspect soil moisture – even those growers who have sophisticated integrated systems.

- Most growers who use a soil moisture monitoring tool say they use it as only as a guide to be considered with other factors such as weather and stage of plant growth.

- Growers say that soil moisture monitoring is not always reliable – 'probes sometimes lie'

- One grower said that although he doesn't have an integrated system for soil moisture monitoring, a 'mate' does and the grower is able to use his mate's readings as a guide.

  Do you think the scheduling system you use, from my understanding the system where you are using your soil moisture sensing and deciding when you need to fill those profiles, is that optimum for you or do you think you could improve on it, or are you happy with it? (Interviewer)

  I think I am happy with it. It's what I want but don't forget I don't follow the C probe to the letter, I also work with my understanding of a plant, how the plant works. For arguments sake until pit hardening, we have been taught, that the plant requires as much water and nutrients as is humanly possible because the bigger that pit the more cells we can get dividing into that fruit, the bigger the fruit we are going to get at the end, so basically up to pit hardening it's very critical we follow that. Finish that season we have about six weeks and we don't then take little notice of that, we consolidate the plant, stretch the plant to a degree until we start getting the first warmer type days and then we have to start applying a bit of water and then veraison comes then your probes come in again and then it's very important to watch your probes again. (Male grape grower)

Some growers discussed soil type such as sandy or clay and a few discussed soil water holding capacity. Growers on originally designated horticulture properties probably have fairly consistent soil types. Differences in soil types may be more apparent in areas not originally designated as horticulture[11].

PLANT/CROP CHARACTERISTICS

All growers said that plant requirements influence scheduling and application decisions. They also said that observable plant changes may indicate stress due to inadequate watering.

Plant requirements may differ due to a number of factors such as:

- Stage of plant growth;

[11] When the Murrumbidgee Irrigation Area was developed early in the 20th Century, government surveyors determined land use according to soil types – horticultural crops could only be grown on land designated as horticulture. Horticultural land was granted high security water entitlements.

- Grape variety – less water for reds than whites;
- May deliberately stress (under water) reds to achieve particular quality;
- Aim for specific baume (sugar) levels.

Specifically growers watch out for plant and/or vegetation changes such as leaves beginning to wilt and vine tendrils becoming dry and brittle.

Some growers reported that observable changes to plants and nearby vegetation may indicate that soil water is being depleted and there is a need to irrigate. Such changes include:

- Grass under vines beginning to wilt;
- Crops near trees may start to dry out as trees take more moisture out of ground.

SUBJECTIVE INFLUENCES

RULES OF THUMB

Irrigators interviewed for the project were asked if they use any rules of thumb in deciding when to irrigate. Most respondents said that they did use rules of thumb. We grouped the rules of thumb data reported by growers into themes and categories. We have outlined findings below that depict responses that were reported by a number of growers.

Weather

Rules of thumb relating to weather were of two types:

- Hot weather

Growers reported that they increase irrigation, both output and frequency, if hot weather was forecast/expected (many mentioned 40º in this context).

- Frost prevention

A number of growers indicate that they irrigate in late September/early October for frost prevention. Some irrigators said that this applied to both drip and flood irrigation systems but the majority of growers said that irrigating for frost prevention was only useful if it was flood irrigation.

Management of vines and trees relating to stress caused by under-watering

Many growers said it was imperative not to let plants become stressed due to under-watering. They said it is very hard even impossible to catch up if the soil dries out – very hard to wet it again.

- Vines, in particular reds, are more tolerant of stress than citrus. As soon as citrus stresses it drops its fruit;

- Growers indicated that over-watering was preferable to under-watering.

Their watering is determined by other factors than simply the immediate level of soil moisture.

Plant requirements/plant indicators

Growers indicated that that there are important times in the plant stage of growth for watering. They mentioned:

- start of season – bud burst – (Sept/Oct);
- End of flowering – berries set (balling) – (Nov);
- Veraison – berries start to colour – (Christmas/New Year) – not so much lots of water needed at veraison but critical to monitor water at this time;
- After harvest – the vine is exhausted and depleted of nutrients – so need to irrigate. The importance of irrigating after harvest was stressed by many growers. They said harvest is a significant stress on the plants so a substantial watering after harvest is necessary. A number of growers also said that it is important to fertilise at this time.

Many growers said they followed a procedure for watering based on the stage of the plant although not all growers adhered to the identified procedure in practice.

- Sometimes because of a shortage of water – growers may have used their entitlement or may have sold water earlier in the season;
- One grower intentionally missed the end of season fertilising (that he said is necessary). We speculate that this is because the property is on the market and may sell before the next season.

Seasonal factors

Growers reported a variety of seasonal factors that influenced their irrigation decisions in addition to those mentioned above relating to weather and plant requirements and stages. These include:

- A substantial irrigation at the beginning of the season as soon as water comes on to fill the soil profile (late August/early September);
- By the end of November all sub-soil moisture is depleted, canopies have grown and berries are forming so need to step up irrigation;
- A ‘big’ water at the end of the season to ‘put vines to sleep with a full belly’.

Emerging rule of thumb

Water every night

A small number of growers said that irrigating every night is better (than for instance twice a week). Nightly irrigations may be of shorter duration but watering is more frequent. The growers who had used this method reported favourable results, particularly in more consistent baume levels.

Appendix ii of this report includes quotes from the data that illustrate the rules of thumb summarised above.

KNOWLEDGE AND EXPERIENCE

Knowledge and experience are extremely important for growers in deciding when to irrigate. Growers talked about 'knowing their vines'. One even said 'my vines are my babies'. Growers also talked about intuitive knowledge and used terms such as 'gut-feeling' and 'taken-for-granted' when describing how they decided when to irrigate (see Bourdieu 1990; Whittenbury 2003).

> How do you know when to irrigate? (interviewer)
>
> *Experience. That's a short, sharp, sweet answer, experience. When the irrigation season comes on – beginning of the irrigation season which is the first week in August give them a good drink, feed them up because all your feeder roots are starting to work so give them a good drink, get them out of hibernation, give them breakfast basically and then just wait and see. The vines starts bud bursts which is a month later – that's brunch – give them brunch and then it's getting a bit cold they are getting a little bit long we need to put a jumper on them so give them a big drink so that the soil has moisture in it to help frost protection. (Male grape grower)*

Growers who use tools such as soil probes say that they use them as a guide, the soil moisture readings being subordinated to experiential knowledge. Several experienced[12] growers suggested scheduling tools may be more useful for inexperienced growers, that is, new growers or growers new to the industry.

> *If it's dry soil for a month and no rain forecast then we know we have to put a certain amount of megs on in a two week period … it's very simple like you can get technical and have all these watering devices measuring this and that, computerising and spending time on the computer you don't need to unless you have a 1,000 acres and you can't literally get over the whole area, it's very simple. (Male grape grower)*
>
> *So you think people can make it more technical than it is? (Interviewer)*
>
> *Definitely I think it's the case for a lot of things. I think it makes it look more professional to use all the measuring on the computer and look at this bla bla*

[12] In this context, experienced growers have had ten or more years experience growing grapes under irrigation.

bla but small acres under 300, I don't think you need unless you are inexperienced and only growing vines in the last 5 years.(Male grape grower)

Some growers reported having used tools in the past – to assist them with developing experience – then, when learning has taken place, they discontinued using the tool.

When asked about irrigation-scheduling tools, one grower commented "I have tried them all but they are in the cupboard". He says he relies on his experience and knowledge of his vines.

INFLUENCES ON ADOPTION

Decisions to adopt irrigation scheduling technology tend to fall into the category of longer-term decisions as they are made infrequently due to the investment of time and financial resources required. Our project focuses on shorter-term, or more day-to-day, decisions and as such we are not reporting on longer-term decisions. Notwithstanding, given our project's association with the broader Tools project, we include this brief section concerning influences on adoption.

Our findings regarding influences on adoption reinforce what is known in the field and in the literature. Growers indicated that they want tools and technology to be simple to use. They do not want to invest the time and mental resources in learning to use technology that is complex to operate. Important considerations in tool adoption are:

- Labour and time (saved or required by use of tool)
- Cost (of the tool/technology and of adoption)
- Ease of operation

For instance, with soil moisture monitoring growers prefer an integrated system rather than having to manually check probes with a logger as this is time consuming. However cost was an important disincentive for growers adopting the more sophisticated integrated systems.

Another example is use of Evapotranspiration data. A number of growers indicated that they use this data as it is sent to them via SMS. Even though they know how to obtain this data, most said they probably would not bother to seek it out as this can be time consuming. With the information being automatically sent to their mobile phones, they can incorporate the data easily in their scheduling and application decisions.

COMBINATION OF BOTH OBJECTIVE AND SUBJECTIVE ELEMENTS

SOCIO-CULTURAL INFLUENCES

Social and cultural factors affect irrigators and influence decisions. These include localised norms and expectations and industry norms and expectations. Industry 'culture' such as wine grape growers' culture may vary between locations. One would expect different cultural features of Griffith wine grape growers from wine grape growers in other localities such as the Hunter Valley. The overwhelming majority of wine grape growers in Griffith are of Italian heritage, which was reflected in the backgrounds of our respondents. This influenced respondents in their values and world views, which, in turn, influenced their farming and irrigation decisions and practices. This was especially evident for family farming enterprises. Many such enterprises had

a patriarchal management style often the oldest male, frequently the father of adult sons who work with him, has overriding authority. In these types of enterprises, women often played a subordinated and background role. Women of the older generation, who were frequently not computer literate, took a more traditional role of wife to their grower husbands, focusing on the personal care (home and food) of husband, children and workers. Younger, educated women who were computer literate often undertook most of the financial work and record keeping in family farming enterprises. These women may have been wives of sons who farm with their fathers. One of our respondents was a young woman working with her father and uncle on the family farm. This was quite rare and we located her through the process of theoretical sampling. It is worth noting that this young woman had no brothers. It was more common for sons-in-law to be working on family farms than for the daughters they were married to. This is consistent with other findings for family farms in Australia (Whittenbury 2003).

All respondents reported the importance of family values, which they felt were enhanced by a farming and rural lifestyle. Respondents in family farming enterprises also stressed the importance of self reliance and 'being their own boss'. Such values underpin motivations and goals. Values are held by individuals and, as such, may be considered subjective however such culturally based values transcend individuals and form part of the local socio-cultural context (Bourdieu 1990).

Neighbours also operate as a socio-cultural influence. Growers reported being influenced by neighbours. If growers were not sure whether to commence irrigating they would check if their neighbours had started irrigating. Similarly an irrigator's neighbour might have technology or equipment that provides information that can be utilised by the irrigator.

IMPLICATIONS FOR THE FUTURE OF IRRIGATION FARMING

We asked respondents about their thoughts on the future their irrigation enterprises and the future of irrigation farming in the locality13. Of the twenty-seven irrigator respondents who were involved in family farming enterprises the overwhelming majority said that they did not see a future in farming for the next generation of children growing up in farmer-irrigator families. Nor did the three respondents from 'corporate' vineyards see a future for their children in farming. One respondent from a corporate vineyard said he felt his children may have a future in the wine industry, although not necessarily in the Griffith locality. As water availability in the Murray-Darling basin substantially decreases, irrigation dependent industries and associated rural communities may undergo significant decline. There has been suggestion, by a senior Victorian Government bureaucrat, of a mass exodus of people from irrigation dependent communities resulting in Australia's own 'climate change refugees' (Ker 2009).

[13] Responses to this question are not directly relevant to the focus of our project: day-to-day irrigation scheduling decisions. They are however relevant to perceptions of the future of irrigation industries and may influence decisions about long-term investment. We found evidence of different investment practices occurring for a property that was on the market for sale and properties that were expected to remain in the family for future generations.

4. DISCUSSION

This project was undertaken to explore irrigators-decision making around their day to day scheduling as distinct from previous research into irrigators' decision-making, which has largely focused on the adoption of tools, technology and practices (Whittenbury and Davidson 2009). While the adoption or take-up of innovative technology and practices is important, it still leaves us unclear as to the decision process at a day to day level. In support of previous work we found that:

1. Irrigators might use tools in a variety of ways and might use a tool for a limited time;
2. socio-cultural factors or frameworks serve to mediate possible decision alternatives and interpretation of consequences;
3. irrigators will verify data from a tool using already known approaches;
4. irrigators are reluctant to cede control of decision making;
5. associated with the former point irrigators will prioritorise experiential knowledge; and
6. different goals exist across the researcher / producer community.

Previous research into irrigators' decision-making has tended to focus on adoption decisions (for example Carey and Zilberman 2002; Inman-Bamber, Webb and Verrall 2006; Everingham, Jakku, Inman-Bamber, Thorburn, Webster, Attard, and Antony 2006; Kaine et al 2005; Montagu et al 2006; Pannell et al 2006; Webb, Inman-Bamber and Mock 2006) often with the aim of identifying 'barriers' to adoption (Stanley et al 2006). This approach is premised on a belief that farmers will adopt environmentally beneficial practices and technology if identified barriers to adoption are addressed (Montagu et al 2006; Pannell et al 2006; Stanley et al 2006). Barriers to adoption are complex and multi-faceted and identified barriers have been consistently difficult to overcome (Whittenbury and Davidson 2009).

The project and overall research program is driven by the goal to reduce water consumption but interestingly saving water was not a decision factor for irrigation scheduling mentioned by our respondents and other authors have noted that it is possible that environmental objectives including more efficient use of available irrigation water can be met without adoption and continued use of new technology (Everingham et al 2006; Jakku and Thorburn 2008). Our findings support Jakku and Thorburn (2008) suggesting that learning and practice change resulting in less water used can occur without adoption and continued use of a specific tool. We found in some instances, the tool is initially adopted and used then discontinued as the grower incorporates the learnings acquired in their farming practices.

Reflecting on the decision making process itself irrigators' socio-cultural factors or framework serves to mediate possible decision alternatives and interpretation of consequences. Our grower-irrigator respondents reported using multiple data sources when making irrigation related decisions which are filtered and interpreted before inputting into the decision model (Figure 3). This data can be classified as being predominantly objective, predominantly subjective or as having both objective and subjective aspects. Objective influences include structural factors that frame the

context in which decisions are made and may directly influence those decisions. In sociological terms structural factors are those that arise from the social relationships, organisations and institutions around us; or patterned social relationships (Germov & Poole 2007). Included here then are the financial markets, costs and prices over which grower-irrigators have little control and yet exercise significant influence on their decisions. Irrigator respondents all reported the importance of economic factors in influencing decision-making yet a number of respondents also noted that farming was a lifestyle choice they made and that if the decision (to farm) was based on purely financial criteria, they would be financially better off doing something other than farming. That is, the socio-cultural (individual and community context) of valuing a farming lifestyle becomes a lens through which to identify practice alternatives, and assess those alternatives. As suggested by Pomerol and Adam (2006) those decision alternatives which are not explored are unlikely to be taken up. Whilst many tools are designed to assist in the exploration of practice alternatives growers are most likely only using a tool within their existing social framework, that is, using the tool to explore a set of alternatives consistent with their personal framework and not the full range of possible alternatives.

Growers report that tools, including technology and information, are used as a guide and that information provided by tools is considered along with other factors when making irrigation scheduling decisions. The soil moisture or evapotranspiration data is used as just one set of data to be considered with others such as cost of power, weather, stage of plant and so on. The majority of irrigators needed to verify the information they were receiving from a new and mechanical source such as the soil moisture monitors, indeed they were displaying a lack of 'trust' toward new tools. For some, the new information needed to be 'calibrated' with their own experience before the farmer was confident that they understood the new information. For example, one farmer adopted the soil moisture monitors and consequently reduced the volume of water applied. In a particularly dry period he reduced the applied water again as he would have done in previous times, unknowingly putting the plants in a stressed state. In their previous approach the plants would have coped with the reduced water application because of surplus water in the soil, which doesn't accumulate in the more accurate approach using soil moisture monitors. The farmer now understands what occurred and has returned to use the irrigation tool. The need to verify might also be, as Leith (2006) suggested, a desire to be independently responsible.

In support of Leith (2006), McCown (2002) and Matthews et al. (2008) we found that irrigators did not want to cede control over their decision making. The experienced grower has a sense of familiarity with the crop factors and pride in their ability to assess the needs of the crop. What we propose here is that farming is possibly as much about the intellectual challenge as it is about the lifestyle and satisfaction of 'seeing things grow'. Decision Support Systems and other tools possibly diminish the satisfaction of intuitive or logical problem solving, changing the work place from 'artisan workshop' to 'factory floor'. Several grower-irrigators suggested that scheduling tools may be more useful to new growers or growers new to the crop or irrigation system eg converting from flood to drip. Some respondents also suggested that scheduling tools may be more useful to operators of larger enterprises who are unable to physically inspect their entire property/properties. This indicates that as growers are not one homogenous group, some tools may be more useful to some growers than others, but more importantly decision making is possibly one of the satisfying components of the farming workplace. Other socio-cultural considerations may also come to bear here. All respondents reported the importance of family values, which they felt were enhanced by a farming and rural lifestyle (see Gray and Lawrence 2001; Poiner 1990). Respondents in family farming enterprises also stressed the importance of self reliance and independence. They reported that farming and rural living provided a good basis

for raising a family and generally a decent 'respectable' lifestyle[14]. That is, farmers operate in a culture of self reliance and independence suggesting that the reluctance to relinquish decision making control is about personal satisfaction as well as social norms.

Irrigators assess the alternatives available to them and make a decision that is partly about risk management and in this process, even though objective information such as that provided by tools is used by irrigators, their responses indicate that, ultimately, their experiential knowledge is the overriding factor in determining when to irrigate. For example, their memory of water stressing plants, or perhaps a rule of thumb passed on from their father, ensures that they will always tend to over water rather than under water. In the face of unknown likelihood of either over watering or under watering, the growers are opting for the option that will have the lesser consequence. As such we find that we reinforce Leith's (2006) Queensland study of graziers who prioritorised their experiential knowledge.

An interesting finding in this study is that, at the time of interviewing, none of the irrigators mentioned the motive of reducing water consumption as an influencing factor over their irrigation practices, be they long term or short term decisions. And yet, greater efficiency and sustainability has been the researchers and government goal for several years (COAG 1994). The key drivers (or motives) for the farmer are making a living from the farm, doing so and supporting a reasonable life style, and using the farm in a sustainable way for future generations or future sale. At the time of the study the economic cost of the power to pump the water had a greater influence over scheduling decisions than the cost of the water itself. The farmers perceived themselves as having already made the change to water efficient systems and now water scheduling was determined by their interpretation of the plants water requirements and their ability to deliver this in a way that minimized financial or lifestyle costs. The continued drought and higher profile of climate change might well have changed the general attitude to water saving, but is more likely to result in decisions to change crops or reduce area under production rather than invest in water saving technology. These different goals or motives place growers and researchers in clearly different starting places which may hinder a joint problem solving approach. In principle we advocate participatory process in tool development but a truly joint process needs to be driven by a joint or common goal.

The irrigator's decision making processes can be mapped against the Theory of Planned Behaviour which suggests that the likelihood of a particular decision outcome is a result of: attitudes to behaviour, subjective norms, and perceived control leading to the intention or direct behaviour (Armitage & Conner 2001) (Figure 4). Scheduling decisions and behaviours are a response to the irrigator's **attitude** toward that behaviour such as choosing to irrigate on weekends, or week nights or installing automatic systems because of a negative (understandable) attitude to manually controlling the water at unsociable hours. They are also a response to the **social norms** associated with that activity and so whilst being absent from weekend activities because of irrigation commitments was once the 'norm' there is now an acceptable alternative of using automatic scheduling. (Remember Burton's (2004) study which demonstrated the power of the social norms even in a clearly productivist environment.) Scheduling in order to reduce water consumption therefore will be associated with different attitudes to those linked to lifestyle. Irrigators will be unlikely to consider a practice which they don't see as within their sphere of **control**. Arguably

[14] Such values have been well theorised in Rural Sociology and have given rise to the concept of "the rural idyll" (see Gray and Lawrence 2001).

DSS and other tools are designed to make available a broader range of behaviours (alternatives) for irrigator's by providing access to controlling factors that were not previously possible. For example, irrigators previously relied on digging the soil to assess its soil moisture content and designing their irrigation schedule according to this data. Now soil moisture probes provide data at a different level of the soil and facilitate an alternative irrigation schedule (alternative behaviour). However, because irrigators still don't trust the data (need to verify) the irrigation tools are often not changing the perceived behavioural control element of the irrigator.

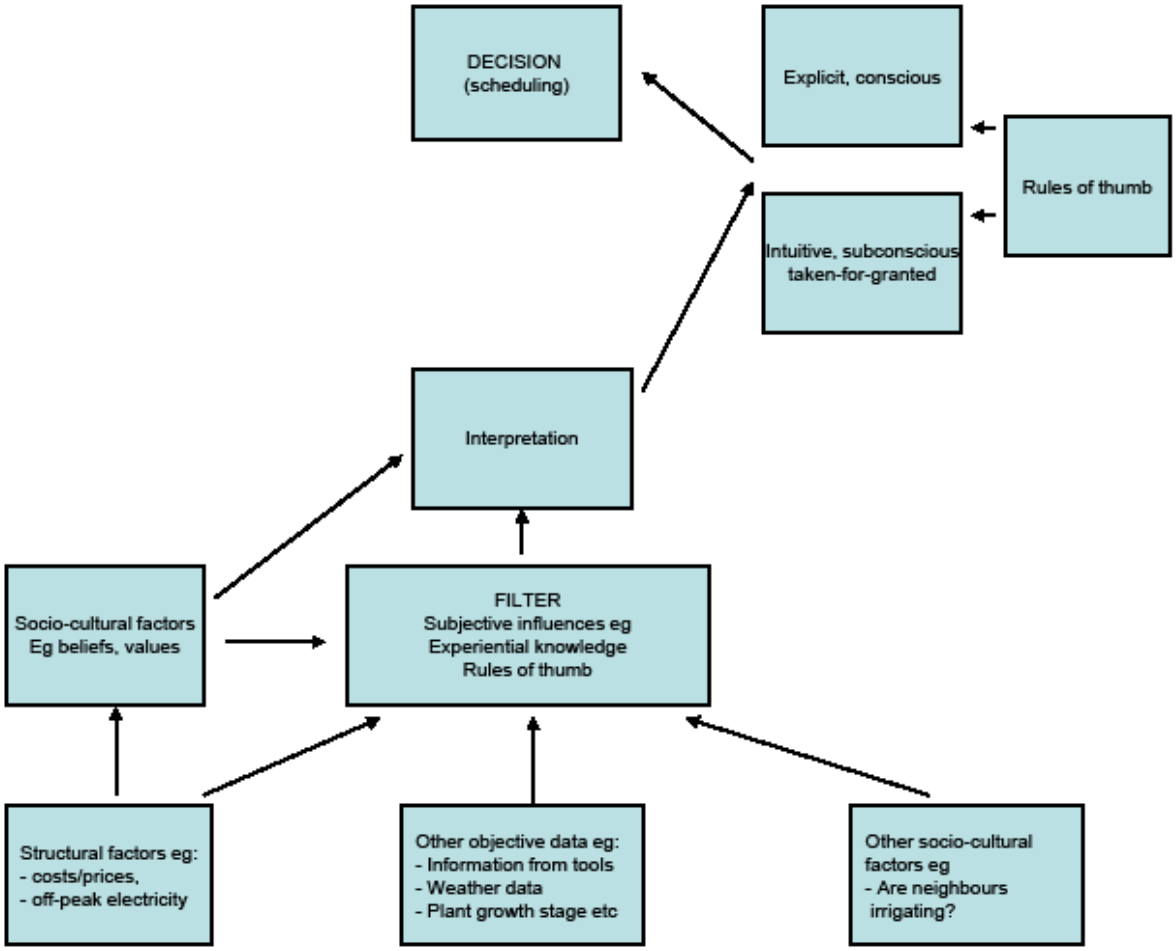

Figure 3: Irrigator-grower decision making model

Socio-cultural factors, comprised of both objective and subjective aspects, also influence irrigators' decision-making with family values, cultural heritage and perceptions of 'good' farming influencing a decision-maker's value system that, in-turn, influences decisions made. French social theorist Pierre Bourdieu's (1990) notion of

the habitus provides a useful theoretical perspective in understanding the relationship between objectivity and subjectivity, which, Bourdieu argues, have a dialectical[15] relationship (Whittenbury 2003). The habitus refers to a set understandings and predispositions that individuals internalise through their cultural history. The habitus is shaped by the interaction of the individual with social and cultural structures (Baker and Brown 2008). The habitus includes the way an individual 'knows' and understands the world and comes to be taken-for-granted as 'natural' or 'common-sense. People are strongly influenced by the values and expectations of the habitus. The habitus provides an important basis for an individual's world view and how that individual interprets external, or objective, phenomena (Whittenbury 2003). In the context of our study, irrigator respondents reported similar beliefs and values regarding the nature of farming and the importance of family, which they described as personal beliefs. Yet these beliefs were articulated by almost all respondents, indicating the influence of socio-cultural factors in shaping an individual's belief and value system as internalised in the habitus. Similarly, rules of thumb, while being subjective attributes of individuals are influenced by the broader socio-cultural and structural context.

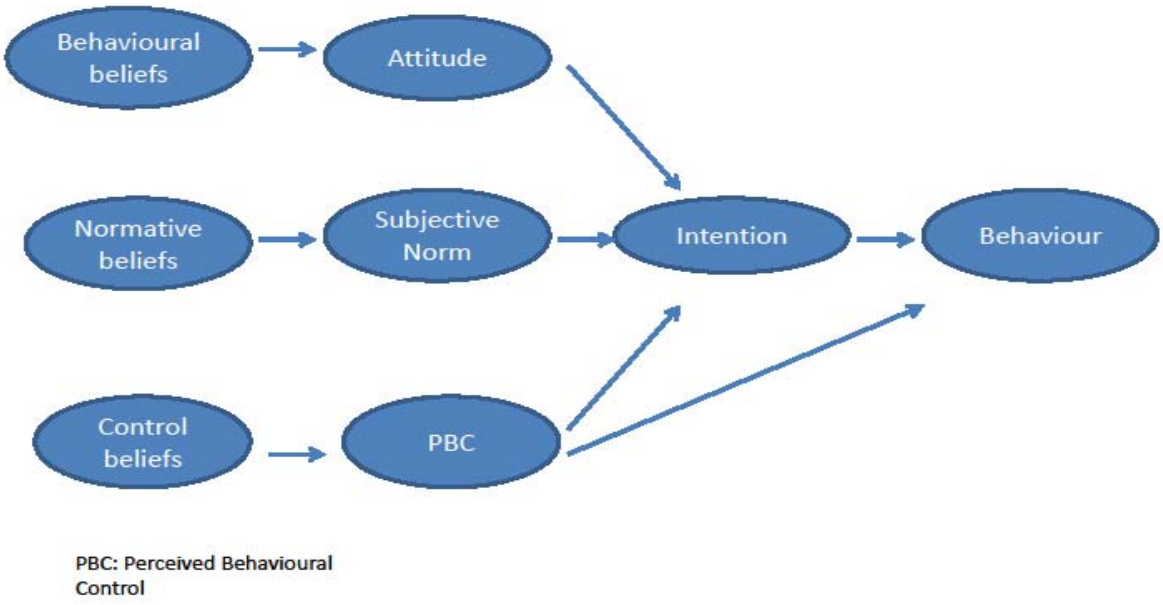

Figure 4: The Theory of planned behaviour
Source: (Armitage & Conner (2001)

[15] In this context, a dialectical relationship means that each of the two phenomena influences the other and each is influenced by the other: subjectivity is influenced by and influences objectivity and vice-versa.

IMPLICATIONS FOR 'TOOLS' RESEARCHERS

Our findings indicate that in many cases there are different people making investment (in technology) decisions from those who make scheduling decisions. Researchers and others promoting the use of irrigation scheduling technology will need to consider this in their promotion strategies.

The primary aim of this project was to explore irrigators' decision-making and to share our learnings with other researchers in related CRC Irrigation Futures projects. We conducted three forums with CRC IF Tools researchers and interested practitioners in which we outlined our findings and sought feedback from researchers on their perceived implications of our findings. One forum was conducted at Griffith with researchers who work with irrigators reflective of our respondents. Another forum was held at Tatura with researchers working with a different group of irrigators. The third forum was conducted at Toowoomba and included researchers and practitioners working with diverse groups of irrigators.

The researchers and other participants in the findings forums were well aware of the three key elements of grower-irrigators decisions to adopt a new tool or practice. Nevertheless, the participating researchers considered it important to remind themselves, and new tools researchers, of the importance of the three key points:

- cost - value/affordability
- labour/time savings
- ease of use/availability

These three elements are well known regarding adoption and farmer behaviour (Pannell et al 2006: Montagu et al 2006). Whilst they're well known, and obviously important to the irrigator they are still factors that are considered in light of an overall complex situation. Of themselves they provide the researcher with relatively little guidance, for example what constitutes an 'easy to use' tool? What constitutes affordability? Grower-irrigators vary in their ability to understand and utilise technology so what is simple for one grower may be incomprehensibly complex to another.

The findings forums highlighted differences between the irrigators' approach and that of the researchers; awareness of these differences can help the researcher understand the irrigator's perspective. They include:

- Tools have been largely developed in the research setting, with a subsidiary goal of later commercialisation. Researchers tend to 'want to know everything', which has resulted in many tools being highly complex. Where this occurs the tool may not meet the grower's requirement for a simple to use tool.

- Different aims, or goals, for researchers and growers.
  In the context of the CRC IF the aim of researchers is to reduce water use: the aim of growers is to make a profit. Researchers are focussed on water use whereas grower-irrigators are focussed on a more complex picture where water use is just one of a number of factors. Water savings may not lead to increased profits (see Kaine et al 2005). One of the additional factors influencing growers is electricity pricing for the operation of irrigation pumps. Many irrigator respondents reported scheduling irrigation to specifically target off-peak priced electricity. Many reported that their drip irrigation systems were designed with off-peak electricity usage in mind. However, tools researchers noted that targeting of off-peak priced electricity may lead to using more electricity and higher electricity costs because using pumps specifically at off-peak times may

lead to higher usage. Large capacity needs to be built in to water delivery systems if they are only being used at certain times, for instance at night, thereby requiring higher flow rates and more energy to pump. If lower flow rates are used, even if more frequent or constant, the overall energy use, and cost, may be lower because less energy is required for a smaller capacity system that does not have to meet high demand load. This is particularly pertinent to collective pressurised water schemes. While the focus of CRC IF researchers is water use efficiency, researchers remain aware of overall environmental issues and expressed concern about water savings occurring at the expense of increased energy consumption. The different goals between irrigators and researchers need to be explicitly recognised and taken into consideration in the research and tool development process.

Tool researchers suggest that tools have tended to be used for routine monitoring. In this way a tool may be discarded by growers who think that the tool is no longer useful. Researchers suggest it may be better to target tools toward 'exception monitoring' – that is, to recast the benefit of the tool to decision making and to be constantly used in order to alert growers when something is wrong. Tool researchers commented that this would require a major shift in how tools are incepted.

It is the (tool) researcher's role to focus on the question in hand and to interact with growers on aspects of farming/irrigation relating only to their research – researchers do not necessarily deal with growers in the broader gambit of their entire enterprise and broader family and community lives. And yet our findings indicate that whilst there are dominant and generalisable factors pertaining to grower decision-making, the social context in which that decision is made is important to understanding the grower need, and possible use of any tool. To facilitate greater awareness of the broader context of decision making we have developed a social research methodology tool, 'Farmer-irrigator Familiarisation Questionnaire' (Whittenbury and Davidson forthcoming) for technical researchers and others to use in order to develop an understanding of farmer-irrigators and the issues that impact on them.

5. CRITICAL REFLECTIONS

Tools used for 'exception monitoring'

In response to our finding that growers may use a tool for an initial period then discontinue its use researchers at the findings forums suggested that tools could be used as 'exception' monitoring. In this way the tool would function similarly to a warning light in a motor vehicle – it would alert the irrigator when something is wrong. This differs from a more routine use of tools. There is some tension between the differing rationales underpinning these two uses of tools. Researchers have found that desired practice change has occurred as a consequence of tool usage, even when usage is discontinued (Jakku et al 2007). The comments of some of the researchers at our findings forums indicate that researchers are committed to their tools being in continued use. It is important to remain cognisant of the underpinning rationale for tool development, or the 'big picture', which is more effective use of irrigation water. There may be a number of ways to achieve better water use effectiveness, with continued use of a specific tool only one element of a multi-faceted approach. – what should the researcher do with this knowledge?

The big picture

It is important to remember the overall goal is of improved water-use efficiency leading to environmental benefits16. A narrow focus solely on water consumption in one sector may have negative environmental consequences in other ways such as using drip irrigation to save water resulting in increased electricity consumption and demand because drip irrigation requires energy for pumping. In a perverse consequence this could result in increased water consumption for the generation of electricity required to power the drip irrigation pumps.

The focus of this project was on horticultural, specifically wine-grape, growers in the Griffith, NSW area. These irrigators have high security water entitlements and have mostly received their full entitlements17 during the time of this study. These growers may not have been as motivated to save water as other growers elsewhere who faced severe limitations to their water allocation. During the 2007-2008 irrigation season many general security irrigators received no allocated water. We interviewed a small number of general security irrigators and there was a tendency for them to be quite innovative in their water use. As mentioned above, some were 'converting' general security entitlements for high security entitlements and subsequently diversifying into high value crop production. It is likely that some very different findings about irrigator decision-making could emerge from a sample of such respondents.

Similarly, attendees at our findings forums were sceptical of our findings being applicable in other irrigation contexts. Our qualitative research findings are not directly

---

[16] Bearing in mind that there may be some tension/conflict between this goal and the goal of grower-irrigators to make a profit.

[17] Those who did not receive full entitlements still had enough water to irrigate their crops. If high security growers had insufficient irrigation water, this was usually because they had sold too much of their allocation.

generalisable to other contexts. However, the themes generated may be relevant and the research methodology applicable. As our research was exploratory, our findings will provide a useful starting point for researching irrigator decision-making in other irrigation contexts. We envisage that the Farmer-irrigator Familiarisation Questionnaire developed as an outcome of this project would be relevant, perhaps with some minor modifications, to more diverse groupings of farmer-irrigators.

6. FUTURE RESEARCH DIRECTIONS

Possible future research directions include:

- Exploration of innovative approaches to water-use and water-saving being developed/utilised by growers themselves such as the approaches being undertaken by a small number of broad acre/general security growers in our sample.

- Further refinement and testing of the Farmer-irrigator Familiarisation Questionnaire. This could occur in other irrigation contexts. A similar tool could be developed for farmers in general (not only irrigation farmers), which may have broader application in policy settings.

- Adaptation of the Farmer-irrigator Familiarisation Questionnaire to identify 'market segments' of grower-irrigators.

- Further research investigating saving water at the cost of increased energy consumption. There is some international research that supports this thesis (see Nicol et al (Water Down Under Conference and the Canadian Water Resources Journal) and Bjornlund et al (Agricultural Water Management and the 2008 Sustainable Irrigation Conference).

- Exploration of irrigators' views about water trading.

7. REFERENCES

ABS (2008) 7104.0.55.001 - Agriculture in Focus: Farming Families, Australia, 2006 viewed 8 Sept 09, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/7104.0.55.001Main%20Features32006?opendocument&tabname=Summary&prodno=7104.0.55.001&issue=2006&num=&view=

ABS (2009) 4618.0 - Water Use on Australian Farms, 2007-08 Latest ISSUE Released at 11:30 AM (CANBERRA TIME) 26/05/2009, viewed 8 Sept 09 http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/4618.0Main%20Features22007-08?opendocument&tabname=Summary&prodno=4618.0&issue=2007-08&num=&view=

Allan, C 2004, 'Improving the outcomes of adaptive management at the regional scale', PhD thesis, Charles Sturt University, Albury, NSW.

Allan, C & Curtis, A 2004, 'Learning together: the Billabong PRA experience', Qualitative research as interpretive practice conference proceedings, Centre for Research into Professional Practice, Learning and Education (RIPPLE), Bathurst, pp. 212-219.

Alston, M. and Bowles (2003) *Research for social workers: an introduction to methods*, 2nd Edition. Allen and Unwin, Crows Nest, NSW

Armitage, C.J. & Conner, M. (2001) Efficacy of the Theory of Planned Behaviour: A meta-analytic review. *British Journal of Social Psychology* 40: 471-499.

Baker, S. and Brown, B. J. (2008). Habitus and Homeland: Educational Aspirations, Family Life and Culture in Autobiographical Narratives of Educational Experience in Rural Wales. *Sociologia Ruralis*, Vol 48, (1) 57-72.

Berg, B. (2004). *Qualitative Research Methods for the Social Sciences*. 5th Edition. Pearson: Boston.

Bourdieu P. (1990). *In other words: Essays towards a reflexive Sociology*. Translated by Matthew Lawson. Polity Press: Cambridge.

Burton, R. J. F. (2004). "Seeing through the 'good farmer's' eyes: Towards developing an understanding of the socil symbolic value of 'productivist' behaviour." *Sociologia Ruralis* 44(2): 195-215.

Carey J. and Zilberman, D. (2002). A Model of Investment under Uncertainty: Modern Irrigation Technology and Emerging Markets in Water. *American Journal of Agricultural Economics,* 84(1) 171-183

Council Of Australian Governments (1994) Water reform framework. *Extracts from Council of Australian Governments: Hobart, 25 February 1994, Communiqué***.** Environment Australia.

Douthwaite, B., de Haan, N. C., Manyong, V. & Keatinge, D. (2001) Blending "hard" and "soft" science: the "follow-the-technology" approach to catalyzing and evaluating technology change. *Conservation Ecology* Volume, 13 DOI:

Dunn, T., Humphreys, L., Muirhead, W., Plunkett, M., Croker, N., and Nickl, M. (1996) Changing paradigms for farmer-researcher-extensionist relationships: Exploring methods and theories of farmer participation in research. *European Journal of Agricultural Education and Extension,* 3(3), 167-181

East, R., Wright, M. & Vanhuele, M. (2008) *Consumer Behaviour: Applications in marketing.* Sage, Los Angeles.

Everingham Y., Jakku, E., Inman-Bamber G., Thorburn P., Webster T., Attard S., Antony G (2006). *Understanding the Adoption of Knowledge Intensive Technologies in the Australian Sugar Industry – A Pilot Study*. Proc. Aust. Soc. Sugar Cane Technol., 28:76-85.

Fairweather J and Klonsky K (2009) Response to Vanclay *et al*. on Farming Styles: Q Methodology for Identifying Styles and its Relevance to Extension. *Sociologia Ruralis,* Vol 48, (2) 189-198.

Farmar-Bowers, Q. & Lane, R. (2009). "Understanding farmers' strategic decision-making processes and the implications for biodiversity conservation policy." *Journal of Environmental Management* 90(2): 1135-1144.

Finucane, M. L., Alhakami, A., Slovic, P., & Johnson, S. M. (2000) The affect heuristic in judgments of risks and benefits. *Journal of Behavioral Decision Making*, 13(1), 1-17.

Germov, J & Poole, M (2007) *Public sociology: An introduction to Australian society*. Allen and Unwin: Crows Nest.

Giddens, A. (1984). *The Constitution of Society: Outline of a theory of Structuration*. University of California Press: Berkeley.

Gray, I. & Lawrence, G. (2001). *A future for Regional Australia: Escaping Global Misfortune*. Cambridge University Press: Cambridge.

Inman-Bamber, N.G., Webb, W.A. & Verrall, S.A. (2006). *Participatory irrigation research and scheduling in the Ord*: R&D. Proc. Aust. Soc. Sugar Cane Technol. 28, 155-163

Jakku E., Thorburn P., Everingham Y. & Inman-Bamber G. (2007). *Improving the participatory development of decision support systems for the sugar industry*. Proceedings Australian Society Sugar Cane Technologists, 29, 41-49.

Jakku, E. & Thornburn, P.J. (2007) A sociological framing of the participatory development of agricultural decision support systems. Paper presented to TASA & SAANZ Joint Conference, 4-7 December 2007, Auckland, New Zealand.

Jakku, E. & Thorburn, P.J. (2008). A sociological analysis of the participatory development of agricultural decision support systems. In: Hatfield-Dodds, S. Van Kerkhoff, L. and Proctor, W. (eds) *Reflecting on integrated mission directed research: learning from experience in environment and natural resource management*, Elsevier IDEA series (Elsevier: The Netherlands), accepted for publication.

Kaine G., Bewsell D., Boland A., & Linehan C. (2005). Using market research to understand the adoption of irrigation management strategies in the stone and pome fruit industry. *Australian Journal of Experimental Agriculture*, 45, 1181-1187.

Ker Peter (2009) Exodus fears for Murray towns. *The (Melbourne) Age* March 18, 2009.

Kloppenburg, J. (1991). Social theory and the de/reconstruction of agricultural science: Local knowledge for an alternative agriculture. *Rural Sociology* 56(4), 519-548.

Leith, P. (2006). Conversations about Climate: seasonal variability and graziers' decisions in the eastern rangelands. University of Tasmania, Hobart. Accessed on line 13 August 2009 url: http://www.utas.edu.au/ruralcommunities/graziers_climate/images/Conversations_Leith_P_2006.pdf.

Loewenstein, G. & J. S. Lerner (2003). The role of affect in decision making. *Handbook of affective sciences*. 1st edn. R. J. Davidson, K. R. Scherer and H. H. Goldsmith. New York, NY, US: Oxford University Press

Matthews, K.B, Schwarz, G. Buchan, K. & Rivington, M. & Miller, D. (2008) Wither agricultural DSS? *Computers and Electronics in Agriculture*. 61(2): 149-159.

Mazur, N., Curtis, A., Thwaites, R. & Race, D. (2008). *Rural landholders adapting to climate change: social research perspectives*, Landscape Logic Technical Report No. 5, Landscape Logic, Department of the Environment, Water, Heritage and the Arts, Canberra.

McCown, R.L. (2002) Changing systems for supporting farmers' decisions: problems, paradigms, and prospects. *Agricultural Systems* 74(1): 179-220.

Mesiti, L. & F. Vanclay (2006). "Specifying the farming styles in viticulture." *Australian Journal of Experimental Agriculture* 46: 585-593.

Milne, M., Stenekes, N. & Russell, J. (2008). *Climate risk and industry adaptation. Canberra*, Bureau of Rural Sciences, Australian Government.

Montagu, K., Thomas, B., Thomas, G., Christen, E., Hornbuckle, J., Baillie, C., Linehan, C., Smith, P., Gallo, F., North, S., Meyer, W., Stirzaker, R. & Cornish, P. (2006) *Understanding Irrigation Decisions From Enterprise Planning to the Paddock*. Cooperative research centre for Irrigation Futures. Irrigation Insights Number 6. Land and Water Australia, Canberra.

Neuman, W. L. (2003). *Social Research Methods; Qualitative and Quantitative Approaches*. 5th Edition. Pearson: Boston.

Orlikowski W, & Baroudi, J.J. (1991) 'Studying Information Technology in Organizations: Research Approaches and Assumptions', *Information Systems Research.*

Ortner, S. (1994). Theory in anthropology since the Sixties. In Dirks, N., Eley, G. and Ortner, S. (eds), *Culture / Power / History: A Reader in Contemporary Social Theory.* Princeton University Press: New Jersey.

Pannell, D., Marshall, G., Barr, N., Curtis, A., Vanclay, F. and Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture* 46(11), 1407-1424.

Patton, Michael (2002). *Qualitative research and evaluation methods*. 3rd edn. Sage Publications, Thousand Oaks.

Phillips-Wren, G., Mora, M., Forgionne, G.A., Garrido, L. & Gupta, J.N.D. (2006) A multicriteria model for the evaluation of intelligent decision-making support systems (iDMSS) in J.N.D. Gupta, G.A. Forgionne & M. Mora (eds) *Intelligent decision-making support systems: Foundations, Applications and Challenges*. Springer, London. 3-24

Poiner, G. (1990). *The Good Old Rule: Gender and Other Power Relationships in a Rural Community*. Sydney University Press: Sydney.

Pomerol, J. & Adam, F. (2006) On the legacy of Herbert Simon and his contribution to decision –making support systems and artificial intelligence. in J.N.D. Gupta, G.A. Forgionne & M. Mora (eds) *Intelligent decision-making support systems: Foundations, Applications and Challenges*. Springer, London. 25-43.

QSR International Pty Ltd 2007 NVivo7

Rogers, E. M. and F. F. Shoemaker (1971). *Communication of innovations: a cross-cultural approach.* New York, The Free Publisher.

Sarantakos S (2005) *Social Research* 3rd Edition, Macmillan, South Yarra Victoria.

Stanley, J., Clouston, B and Baker., R. (2006). Understanding Land Manager constraints to the Adoption of Changed Practices or Technological Innovations: Literature Review. Working Paper No. 1 from the Project "Impediments to the Uptake of Market Based Instruments", Charles Sturt University, Bathurst.

Tversky, A. & Kahneman, D. (1974). Judgement under uncertainty: Heuristics and biases. *Science*, 185, 1124-1130.

Vanclay F, Mesiti L, & Howden P (1998) Styles of farming and farming subcultures: Appropriate concepts for Australian rural sociology *Rural Society* 8, 85-107.

Vanclay F, Howden P, Mesiti L & Glyde S (2006). The social and intellectual construction of farming styles. *Sociologis Ruralis* 46, (1) 61-82.

Van Wagner, Kendra (nd) Heuristic - What is a heuristic? *Psychology*. The New York Times Company. Accessed on line 6 October 2009, url: http://psychology.about.com/od/hindex/g/heuristic.htm

Webb, W., Inman-Bamber, N. G., & Mock, P. (2006) *Participatory Irrigation Research and Scheduling in the Ord:* Extension. Proc. Aust. Sugar Cane Technol., 28:164-172.

Whittenbury, K. (2003). Exploring the taken-for-granted: Cultural and structural influences on men's and women's perceptions of family life in a rural community. PhD thesis. Charles Sturt University. Wagga Wagga, NSW.

Whittenbury and Davidson (2009) Beyond adoption: The need for a broad understanding of factors that influence irrigators' decision-making. *Rural Society* Vol 19 (1) 4-16.

8. APPENDICES

Appendix 1: Irrigators' decision-making: an exploratory study Interview Guide

Appendix 2: Summary of Rules of Thumb reported by grower-irrigators including quotations

APPENDIX 1: INTERVIEW GUIDE

IRRIGATORS' DECISION-MAKING: AN EXPLORATORY STUDY

Interview Guide

PREAMBLE

There are no right and wrong answers. I am interested in your own opinions, views and perceptions. This research is endeavouring to understand your own views about irrigators' decision-making.

I am a sociologist, and, while I am familiar with dry-land farming, I had little knowledge of irrigation farming before joining this project. I may ask for clarification of information that seems specialised or technical to me – even though this information may seem quite basic to you. I hope you will bear with me.

Do not feel that you have to rigidly answer my questions. The questions are a guide to assist in uniformity of the type of information obtained and are not intended to restrict your opinions or viewpoint. If you are uncomfortable with answering any particular question just let me know and if you wish we can skip that question.

The information you provide will be treated confidentially and no identifying information will be published or released to any other organisation.

You have been approached for an interview because of your experience and involvement in an irrigation enterprise. You are the expert in your field – not me. Your views and suggestions will help us to explore how irrigators make their irrigation decisions.

QUESTIONS

Irrigation/farming enterprise

- I want to ask you about your farm
- Locality of farm
- Type of farm – crops?

  – livestock?
- Size (hectares/acres)
- Type of water security licence
  - Usual (normal) allocation
  - Proportion of allocation expected this year
  - Received last year, year before,
- How many people work on the farm?
- Who does what?
- What is the ownership management structure?
- How did you come to be involved in the farm enterprise?
  - What is your background?
- What is your role in the farm?
- Do you work off the farm?
  - What about contract work?
  - Contract harvesting?
- Does someone else involved with the farm work off the farm?
  - What about contract work?
  - Contract harvesting?
- Tell me what you actually do on/with the farm?
  - Activities?
  - Responsibilities?
- What sorts of irrigation systems do you have?
  - Current systems?
  - Past systems?

    - Planned (future) systems?

- If connected to pressurised water delivery system:
    - What are your experiences and views about the system?

- If drip/automated system, what influenced you to adopt the system?
    - If time saving – what do you do with the time saved?

- Do you use any tools or devices to help you decide when to irrigate?

- Do you have any irrigation scheduling systems?
    - Current?
    - Past?
    - Planned?

- If so, what influenced you to adopt the system?
    - If time saving – what do you do with the time saved?

- How do you know when to irrigate?

- How do you know how much (irrigation) water to apply?

- When did/will you irrigate for the first time this season?
    - How many subsequent irrigations do you envisage for this season?
    - When will they occur?
    - How much water will you apply?

- Do you have an irrigation/water plan?

- Do you use a water budget or other method of accounting for your water use/consumption?

- Have you been involved in water trading?

- What are your views on water trading?

<u>Irrigation related decision-making</u>

- I am going to ask you about irrigation-related decisions. I understand that because of the drought, this year's activities may be very different from your usual, or normal, irrigation practices. When I ask about your usual practices, it may help to answer based on what happened in more 'normal' irrigation times.

- Firstly, what are your main goals as an irrigator/farmer?
    - What is important to you about farming?
    - Why are you farming?

- What sorts of irrigation-related decisions need to be made
    - In your farm/enterprise?
    - In other farm/enterprises?

- Are there important differences between types of decisions? Eg
    - Longer term
    - Medium term
    - Short term
    - Other?

- Who makes irrigation decisions?
    - Does this differ depending on the nature/type of decision?

- How do you (or other decision-maker) make your irrigation decisions?

- Do you have any 'rules of thumb' that you use for deciding when to irrigate?
    - Eg there may be a particular spot, or plant, that you use – when that spot looks dry it is time to irrigate
    - Eg there may be some weather features
    - Eg there may be a 'benchmark' unit (paddock/bay etc) that acts as a 'trigger' for an irrigation cycle

- What is the procedure you use for ordering your irrigation water?
    - How much notice is required when ordering?
    - How do you order your water?

- What are some of the influences on irrigation decision-making
    - Other people/players?
    - Type of enterprise?
    - Water supplier issues?
    - Biophysical?
    - Economic?
    - Other?

- What were the main things you considered last year/year before in determining when to irrigate?

- Where do irrigation tasks/activities 'fit' relative to your other responsibilities and activities?
    - Priorities?

<u>Irrigation scheduling</u>

- Do you think your irrigation scheduling is optimal?
    - Possible improvements?

- How precise or accurate do you have to be regarding:
    - irrigation timing?

    - application rates?

- Are you familiar with irrigation scheduling systems or tools? Some such systems may be called Decision Support Systems/tools. Examples include:
  - Soil moisture monitoring equipment
  - Enviroscan
  - Plant based monitoring
  - Remote sensing
    - Possible benefits of irrigation scheduling systems/tools
    - Possible limitations of irrigation scheduling systems/tools

- What would be useful to you in such a system/tool?

- What would it take for your enterprise to adopt an irrigation scheduling system?
  - What about for other growers/farmers?

- Do you use available information/data to help you make irrigation decisions?

- If so, what? Eg
  - Weather data/information
  - ET (evapotranspiration information)
  - Other?

- Is this information:
  - Easy to obtain?
  - Easy to understand?

- Does the cost of electricity for pumping affect irrigation scheduling?
  - Cost of diesel/other fuels?
  - Do you use off-peak/time-in-use electricity to lower the cost of electricity for pumping?

- What are your views about automatic (timer) pumps for irrigation?
  - What would you want in such a device?

- Do you use computer-based systems for your farm enterprise?

- Would you use computer-based systems for irrigation scheduling?

- Would you require training in computer-based systems?

- Would you use a mobile phone based system for irrigation scheduling?

<u>Drought</u>

- How has the drought and water shortages impacted on the farm?
    - On your irrigation practices/decisions?
    - On the family?

    - On the community?
    - Other impacts of the drought?

Demographic information

- Hand respondent age sheet and ask them to nominate a category

- Gender

- Qualifications/education

- Family circumstances eg
    - Partner
    - Children – ages
    - Partner's occupation

- Do you think any of your children will take up farming?
    - Would you want them to?

Conclusion

- Anything else you wish to say

- Anything else that might be relevant to the topic?

Thank participant for the interview

APPENDIX 2: SUMMARY OF RULES OF THUMB

Summary of Rules of Thumb reported by grower-irrigators including quotations

Below are the main rules of thumb reported by grower-irrigators. The underlined headings are the researchers', the details in italics are quotes from growers.

Weather;

Hot weather

Increase irrigation if hot weather forecast/expected

> *If you are coming up for a week of forty degrees then you need to get these, I'd be putting on more irrigation, instead of putting fifteen you might go twenty five hours to give them a bigger resilience.*

Frost prevention

> *Irrigate late September/early October for frost prevention.*
>
> *If irrigating for frost prevention, flood irrigation is better – cannot get the amount of water necessary out of drip.*
>
> *With drip trying to do frost prevention is not really where with flood where you're wetting the whole service it does work and I used to do it too when I had flood it's probably one of the disadvantages of the drip*
>
> *That frost prevention one we do that with the flood.*

Management of vines trees relating to stress caused by under-watering;

> *Vines are more tolerant of stress than citrus. As soon as citrus stresses it drops its fruit.*
>
> *The trigger point for us is do not let them stress out. As soon as they start to stress – there is a classic example where people do that, as soon as you stress it you lose your fruit size, you lose your tonnes to the acre and that's a key thing. Grapes it can tolerate a little bit more stress but again comes back to tonnes per acres if you stress it.*

With drip I think you've got to be ahead of the water use, if you get behind it's very hard to catch up, it's like the other one I showed you before, where the irrigation we're putting on there is not getting down to the thirty and the fifty. Once the soil gets really dry it's very, very hard to wet it up again.

You're better off to keep it moist.

Yeh the main tools in the red and your whites I guess if your tendril is dropping it's stressing your vine – you don't want to stress the whites ever.

<u>Plant requirements/plant indicators;</u>

Rules of thumb:

Four times when you need optimum moisture in the soil:

1 start of season – bud burst – Sept/Oct

2 End of flowering – berries set (balling) – Nov

3 Veraison – berries start to colour – Christ/New Year – not so much lots of water needed at veraison but critical to monitor water at this time

4 After harvest – vine exhausted, depleted of nutrients – need to irrigate and fertilise.

Yes generally if you drive around you look at the grass, it's a good indicator if there is grass under the row which is wilted a little bit or you know that's there's no water left in the top levels. You look at the vines if they're starting to turn a little bit or the leaves are puckering a little bit you know that they are starting to stress, especially if they're 1.05.14 you don't' want that to happen at all.

Yeh the main tools in the red and your whites I guess if your tendril is dropping it's stressing your vine – you don't want to stress the whites ever.

After they have been picked they have been knocked around, like running a marathon and not having a drink after so you give them a big drink and hope they suck it in and settle down.

Yeah some people have the theory that once you finish picking the grapes that's it you don't have to water anymore where I have the theory that after you've picked the grapes that's when you should be piling the water on and putting the fertilizer on to build up

Seasonal factors

I know as a general rule that as we get to the end of November all sub soil moisture is depleted and the success of the vines growing will depend entirely on the amount of water I am able to supply cause up til November there is a lot of sub soil moisture from the winter and year in and year out I am noticing that at the end of November it's all gone and then it depends on what we are applying with water because we have three things that is happening: one the soil moisture is depleted, two the canopies have grown really big so they are starting to use .65 water and also the berries are starting to grow, the crop is starting to grow and if you can imagine a thousand berries all expanding a millimetre a day they need water to fill them up so those 3 things are all happening at the end of November….

No. The only rule that I have got, that I believe in is that I like to put my vines to sleep with nice wet feet.

Big irrigation at the end of the season after you harvest, after you pick, give them a big irrigation.

The big water on the drip at the end of the season so you put them to sleep with a fully belly just in case it doesn't rain.

After they have been picked they have been knocked around, like running a marathon and not having a drink after so you give them a big drink and hope they suck it in and settle down.

Yeah some people have the theory that once you finish picking the grapes that's it you don't have to water anymore where I have the theory that after you've picked the grapes that's when you should be piling the water on and putting the fertilizer on to build up

We always water after harvest and we usually give them a decent water after harvest and then we might, if it stays warm and dry, we like to keep watering them a bit until they go to sleep.

Yes as soon as the water comes on we turn the pumps on and walk away for five days to fill your profile. Don't worry about what the water is doing, just turn your pump on.

We like to water early as soon as the water comes on … Late August early September. Depending on winter rain. If it's been wet during winter it's not such a problem but if it's been dry we like to water early and that usually is a big water. If we can we try to fill up the subsoil to get it wet because it's dry and then we might not water much. For frost prevention it is really only help if you have flood making it damp but when you have drip it's not… it's mainly that the vines have reserve water down there to kick off.

Emerging rule of thumb/change of practice

Water every night – smaller more frequent watering

Israel experience recommends nightly irrigation (& fertilise) rather than twice a week Grower went to talk by Ron Seligman. Did this at home vineyard and on the vineyard he was looking after for another grower's family (nightly irrigate – not sure about fertilise suspect not). On other vineyard it resulted in more consistent baume levels.

We initially would do a big weekend one because we had cheaper electricity and a top up mid week but we don't tend to do that now. We always water at night so we don't have any evaporation and we tend to give them, sometimes only three hrs per shift just to top up – depending on the weather, if it's hot we would give them six. We don't probably water as much as a lot of people do but do it more often than less so they have always moisture there but not sending it down deep anymore.