Social factors influencing technology adoption in the rice industry

By Vaughan Higgins and Melanie Bryant
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AgriFutures Australia is the new trading name for Rural Industries Research & Development Corporation (RIRDC), a statutory authority of the Federal Government established by the Primary Industries Research and Development Act 1989.

Foreword

The rice industry in Australia has been and will continue to be subjected to an array of transformational changes requiring stakeholders and growers to continually adapt by adopting practices that can counter the effects of global, market-based and environmental shifts. Ongoing implementation of technology within the industry will play an essential role in successfully adapting to change. However, to ensure that the full potential of such technology is realised across the industry, a better understanding of grower adoption practices, particularly adoption of complex technologies such as precision agriculture (PA), is needed.

This report investigates the *social drivers* that influence technology adoption by rice growers. Such drivers include farmers' personal goals, knowledge and networks, to the broader cultural, environmental and economic context in which they make decisions. The research is important in providing knowledge of the complex issues relating to the uptake of technology that are not necessarily known or easily captured with existing research and practice. Significantly, it aims to benefit stakeholders at three key levels within the rice industry: (a) *strategic* – stakeholders engaged in the development of overall strategy; (b) *tactical* – stakeholders involved in the operationalisation of strategy; and (c) *operational* – stakeholders involved in the day-to-day implementation of strategy.

The research findings reveal five key issues that were reported as constraining or enabling adoption of technology. These include the perception of limited grower input into change priorities; trustworthiness of agents and organisations promoting new technology; the lack of compatibility and interchangeability of technology required for PA; emphasis by stakeholders on individual grower characteristics instead of institutional factors; knowledge gaps in the provision of technical information and the promotion of technologies; and, lack of clarity among stakeholders as to which technologies should be prioritised in the rice industry. The report makes five recommendations based on these findings that RIRDC and rice industry stakeholders can implement at strategic, tactical and operational levels to drive further change adoption. At a strategic and tactical level, the report recommends that a Rice Industry Strategic Plan for Technological Change be developed; that an industry-wide strategy for bottom-up input into industry change priorities be implemented and promoted; and, that workshops be developed for agronomists and other trusted change intermediaries so that they can play a more effective role in promoting industry technological change and priority technologies. At a tactical and operational level, the report recommends that a Change Champions Program be developed to foster sharing of technological knowledge among stakeholders and growers, and that a series of change workshops for industry stakeholders be developed to highlight different aspects of change management.

This report Rice R&D program is an addition to AgriFutures Australia's diverse range of over 2000 research publications and it forms part of our Growing Profitability arena, which aims to enhance the profitability and sustainability of our levied rural industries.

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Vaughan Higgins is an Associate Professor of Sociology at Charles Sturt University. Vaughan has a background in rural sociology with a particular emphasis on how programs seeking to change farming practices are implemented and adopted. He has been involved in a number of government and industry-funded projects investigating topics such as the implementation of market-based instruments for sustainable land management, emergency animal disease and farm biosecurity practices, peri-urban biosecurity in the Sydney Basin, the adoption of best practices for the management of Silverleaf Nightshade.

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- The extension agents, agronomists and private consultants who participated in this research
- The irrigation farmers across the Murray, Murrumbidgee and Coleambally irrigation districts, who participated in this research.

Abbreviations

CIA	Coleambally Irrigation Area
CSU	Charles Sturt University
MIA	Murrumbidgee Irrigation Area
NSW DPI	NSW Department of Primary Industries
PA	Precision Agriculture
R&D	Research and Development
RD&E	Research Development and Extension
RGA	Ricegrowers' Association of Australia
RIRDC	Rural Industries Research and Development Corporation
RRAPL	Rice Research Australia Pty Ltd

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Executive Summary

What the report is about

This report investigates the social drivers that influence technology adoption by rice growers. These drivers include farmers' personal goals, knowledge and networks as well as the broader cultural, institutional and environmental context within which they make decisions. The research is important in identifying constraints and enablers to adoption that are not necessarily known by industry stakeholders, or cannot easily be located within existing research and practice.

Who is the report targeted at?

The report is targeted at rice industry stakeholders including SunRice, RGA, RIRDC Rice Advisory Panel, RRAPL, NSW DPI, as well as agronomists and farm advisors located in the Murray, Murrumbidgee and Coleambally irrigation areas.

Where are the relevant industries located in Australia?

Rice is generally grown as part of a rice-based farming system that can include irrigated winter cereals and canola, summer crops such as maize, soybeans and cotton, and irrigated pasture for livestock production. The Australian rice industry is located mainly in the Murrumbidgee and Murray valleys in Southern NSW and Northern Victoria, specifically within the irrigation districts of Murrumbidgee, Coleambally and Murray. About 1,500 farms across these regions are capable of producing around one million tonnes of rice each year, although rice production is highly dependent on annual irrigation water availability. While the domestic rice market has been deregulated, SunRice is effectively the sole exporting agency. This research will benefit rice industry stakeholders involved in (a) the development of overall strategy for the industry (including SunRice, RGA, RRAPL, and the RIRDC Rice Advisory Panel); (b) the operationalisation of strategies within the industry (including SunRice, RGA, and NSW DPI), and (c) the day-to-day implementation of strategy at the farm level (including RGA, agronomists, private consultants, researchers and growers).

Background

The Australian rice industry has engaged in a number of change initiatives involving technologies aimed at increasing on-farm production efficiency, water use efficiency and environmental management. However, little is currently known about the range of influences on growers' adoption practices, including why and how they adopt or do not adopt, or the challenges that both stakeholders and growers face in implementing new technologies. This research makes an important contribution by investigating the social factors that influence rice growers' adoption of technology, and how the industry can work better with growers to ensure that the rice industry maintains and increases competitive advantage.

Aims/objectives

The main aim of this two-year project was to investigate the social factors influencing technology adoption by Australian rice growers across the Murrumbidgee, Murray and Coleambally Irrigation Areas. In doing so the project focused on four specific objectives:

1. Identify specific enablers that will encourage late or non-adopters to engage in change practices (Grower level);

2. Investigate the key social drivers that will enable increased technology adoption across the rice industry (Industry level);

3. Explore communication methods that growers use to become informed of changes in the rice industry, and provide recommendations as to whether or how current communication methods are effective;

4. Develop a set of priorities and recommendations that RIRDC and rice industry stakeholders can implement to drive further change adoption.

Methods used

The project used qualitative research methods consisting of semi-structured interviews undertaken in two concurrent phases. In the first phase, interviews were conducted with 20 key rice industry stakeholders, including farm advisors and agronomists as well as representatives from organisations such as Rice Research Australia, Ricegrowers Association of Australia, Rice Advisory Panel and NSW DPI. In the second phase, interviews were conducted with 59 rice growers from across the three main rice growing regions – Murray (25 interviews); MIA (25 interviews), and CIA (9 interviews). A purposive sampling technique was used to ensure that a diversity of enterprises and growers were represented.

Results/key findings

Objective 1

Grower input into change priorities: Stakeholders raised concerns about whether current mechanisms for growers to provide meaningful input and feedback into change priorities – particularly around the use of technology – were adequate and appropriate. Both stakeholders and growers also highlighted concerns that communication within the rice industry may continue to favour a top-down approach to disseminating information, with limited opportunities for grower input into change.

Trustworthiness of agents and organisations promoting new technology: Data from the grower interviews identified strong relationships and levels of trust between growers and local agronomists and the NSW DPI. These individuals and agencies were also identified as being the most impartial when working with growers on a range of farming issues. Consequently, local agronomists and agents from the NSW DPI are key influencers and can potentially play a wider role in promoting technology, and building the capacity of growers to adopt technology.

Compatibility and interchangeability of technology required for PA: Stakeholder and grower interviews highlighted a shared view that current platforms and technologies used by different manufacturers constrain technology adoption. However, constraints caused by incompatibility or interchangeability also provide opportunities for stakeholders and growers to work together to determine how to make advanced technologies such as PA work more successfully on-farm.

Objective 2

Emphasis on individual grower characteristics instead of institutional factors: Although structural constraints and enablers were identified by stakeholders, the majority of stakeholders attributed individual grower characteristics to rates of technology adoption. Focusing only on grower characteristics overlooks the institutional factors that influence adoption as well as the localised strategies that growers are already engaged in to reduce or work around the risks and constraints associated with technology adoption.

Knowledge gaps in the provision of technical information and the promotion of technologies: Two significant knowledge gaps were identified: (a) the lack of extension services and private agri-service providers with expertise in technologies such as PA; and (b)

gaps within existing agri-services providers who either do not have knowledge of specific technologies, or do not support them, and therefore do not promote their use to growers.

Objective 3

Lack of clarity amongst stakeholders as to which technologies should be prioritised by the rice industry: Data from grower and stakeholder interviews indicated that a clear message about technological priorities was not being communicated across the rice industry. While more advanced technologies such as PA, laser levelling and mapping were identified as priorities by some stakeholders, other technologies such as water efficiency technologies and new varieties were widely reported as being the technological priorities for the industry. This is indicative of a gap between research priorities for technology and the translation of these priorities into a farm technology strategy.

Objective 4

This report makes a series of recommendations based on these findings that can be implemented by the rice industry at a strategic, tactical and operational level.

Implications for relevant stakeholders

The findings from this research project have implications for the following stakeholders:

Industry: The findings have implications for the ways in which industry prioritise and promote the use of particular technologies, and develop strategies around change adoption more broadly. The findings also have implications for where further education and development around adoption might be aimed.

Communities: Strategies aimed at further enabling technology adoption have significant socio-economic implications for the communities in which rice is farmed. By engaging in innovative practices, farmers are also likely to benefit from whole-of-farm productivity gains, as well as be more likely to engage in change across different aspects of the farm. This has community benefits through increasing the viability of farming within the various rice-growing regions, which has financial benefits for the communities in which farmers reside.

Policy makers: Findings from the research demonstrate that one of the constraints to increased technology adoption is the decline in publicly funded extension and agronomy personnel. Although it is unlikely that policy makers can increase the number of publicly-funded positions to assist with technology adoption, further emphasis can be placed on increasing education and training within the agricultural sector.

Recommendations

The recommendations are targeted at all levels of the rice industry including SunRice, RGA, the AgriFutures Australia Rice Advisory Panel, RRAPL, NSW DPI, and agri-service providers in each of the main rice growing areas.

Summary of Recommendations

Recommendation 1

Development of a Rice Industry Strategic Plan for Technological Change to promote a consistent understanding among stakeholders and growers of industry technological change priorities, and key technologies that growers should be adopting.

Recommendation 2

Implement and promote an industry-wide strategy for bottom-up grower input into industry change priorities. A bottom-up grower input strategy could be included in the recommendation above (as part of a broader Rice Industry Strategic Plan for Technological Change), which would identify a number of formal avenues in which growers could provide feedback and input into technology change as well as ideas on innovation more broadly.

Recommendation 3

Development of regular (for example, bi-annual, or as needed) workshops developed for agronomists and other trusted change intermediaries that: (a) provides a consistent message from the industry regarding the technologies that growers should be adopting, (b) improves awareness and knowledge of new technologies being promoted in rice industry, and (c) provides agronomists with the confidence and skills to promote new technologies to growers.

Recommendation 4

Implement a Change Champions Program (CCP) to foster and formalise the sharing of technological knowledge among growers, and between stakeholders and growers, on (a) practical approaches to technology implementation on-farm, and (b) options and shortcuts for growers in adapting new technology to existing technology and equipment.

Recommendation 5

Develop and implement a series of change workshops for industry stakeholders that highlight different aspects of change management, including: effective change communication; the role of the stakeholder in change implementation; grower and stakeholder responses to change and interpreting what these different responses mean; implementing change within structural limitations; and other key issues as identified by stakeholders/different stakeholder groups

Introduction

The Australian rice industry has engaged in a number of change initiatives involving technologies aimed at increasing on-farm production efficiency, water use efficiency and environmental management. However, little is currently known about the range of influences on growers' adoption practices, including why and how they adopt or do not adopt, or the challenges that both stakeholders and growers face in implementing new technologies. Much of the research to date focuses on the scientific or technical aspects of new technologies, the potential implications of specific innovations for improving grower practices, or individual case studies where particular types of technologies – such as PA – have been implemented by growers (Subasinghe and Angus, 2009, Clampett et al., 2004, Beecher and Dunn, 2013, Precision Agriculture, 2016).

The aim of this project is to investigate the *social drivers* that influence technology adoption by rice growers. Research conducted by sociologists shows that social factors, ranging from farmers' personal goals, knowledge and networks, to the broader cultural, environmental and economic context in which they make decisions, have a significant impact on why and how innovations are adopted (Vanclay, 2004, Wilkinson, 2011, Pannell et al., 2006). This research project aimed to investigate such factors in the NSW irrigation areas of the Murray Valley (Murray), the Murrumbidgee (MIA) and Coleambally (CIA) to develop knowledge about what growers are already doing in response to market and environmental changes, and how the industry can work better with growers to maintain sustainable and competitive rice production in Australia.

Traditionally, the explanation of adoption behaviour was based upon the social-psychological 'diffusion of innovations' model, best represented by the work of Rogers (2003), which posited a five stage adoption process: knowledge, persuasion, decision, implementation and confirmation. Under this model it is assumed that innovations are economically beneficial and farmers are economically rational actors. Lack of adoption is explained by the lag time in communication of the innovation from the extension agency to the individual farmer, in how long an individual farmer takes to try out an innovation, and whether the farmer is psychologically an innovator or laggard (Vanclay and Lawrence, 1995). This approach has since been criticised for being too linear, blaming the individual farmer for failing to adopt an innovation, and downplaying the social and structural context in which farmer decisions take place. Further, this approach does not consider or draw upon the myriad of available research about change adoption from other bodies of knowledge, such as management and organisation studies, that has direct transferability to agricultural contexts.

More recent explanations have sought to take into account the complexity of adoption behaviour with a particular focus on exploring the wide variety of farming practices and styles, the symbolic value attributed by farmers to specific practices, and the 'knowledge-cultures' through which farmers define their identity and which underpin understandings of 'good' farming (Tsouvalis et al., 2000, Greiner et al., 2009, Burton, 2004). This 'social constructionist' perspective emphasises the socio-technical context that leads to particular adoption decisions being made, and also focuses on how farmer decision-making on technology is part of a broader social process involving a number of 'users' each of whom are attempting to impose their meanings of the technology on the others. In a comprehensive review of literature on the adoption of innovations, Pannell et al. (2006) draw upon a social constructionist perspective on adoption. They argue that there are two key issues that shape farmers' decisions whether or not to adopt innovations. The first is *relative advantage*, which refers to the extent to which an innovation/practice is better than that which it supersedes: this is shaped by 'a range of economic, social and environmental factors' and depends specifically 'on the landholders' unique set of goals and the biophysical, economic and social context where the innovation will be used' (Pannell et al., 2006, pp.1413-14). The second

feature is *trialability*, which is basically the extent to which an innovation/practice can be trialled on-farm, and the various factors – economic, social and environmental – that shape what a farmer can realistically learn from the trialling process. Trialling is a vitally important process, since it 'allows the landholder to avoid the risk of large financial costs if the practice turns out to be uneconomic or fails due to inexperience' (Pannell et al., 2006, p.1416). The concepts of relative advantage and trialability point to the need for researchers to take account of a range of context-dependent issues – not just financial benefits – in examining adoption processes. Another important aspect of the social constructionist approach is that it enables exploration of the role that stakeholders other than the farmer play in adoption. This has received limited attention to date in the adoption literature and provides an important focus for this project. For example, by viewing adoption as a social process, the influence of personnel such as agronomists on farmer decision-making and the day-to-day interactions and relationships between stakeholders and growers can also be explored (e.g., Sutherland et al., 2013, Ingram, 2008, Raymond and Robinson, 2013).

To develop further understanding of the role played by farmers as well as other stakeholders in adoption, it is important to draw from broader organisational change literature. For example, a criticism of organisational change studies is that individual resistance to change is often unfairly attributed to poor change adoption (Pardo del Val and Fuentes, 2003, Bryant and Higgins, 2010) without thorough investigation of the context in which change takes place, or of the interactions and relationships between change agents and change recipients (Ford et al., 2008). Further research has found that individuals may not sufficiently understand the need to adopt change, which has several implications for stakeholders engaged in change promotion. For example, if information about technology change is not communicated in a way that is meaningful to growers, understanding the need for adoption is less likely. Further, if individuals are not part of the consultation process they may not believe that change is important or relevant to them (Johannson and Heide, 2008). Finally, stakeholders' involved in the promotion and implementation of change can also play a significant role in adoption. For example, their rationale for driving technology change may differ or conflict with the rationale of growers. Furthermore, stakeholders who are not trained in change implementation may not have sufficient understanding of change priorities, or the necessary capability to assist growers with adoption (Ford et al., 2008). This can lead to unclear adoption priorities and strategies, as well as individuals feeling that change is being forced upon them rather than encouraging them to voluntarily adopt change in a way that meets their needs and takes their knowledge and practice into consideration.

Objectives

The main objective of this two-year project was to investigate the social factors influencing technology adoption by Australian rice growers across a number of examples including (but not limited to): new rice varieties; PA; water management technologies and electronic communication. In doing so, the project focused specifically on the following research objectives:

- Identify specific enablers that will encourage late or non-adopters to engage in change practices (Grower level);

In addition to economic factors, there are numerous social factors that have been attributed to change adoption. At an individual level (growers), change studies have found that responses such as fear, uncertainty or resistance contribute to a willingness to adopt. Further, perceived disruption to day-to-day routines and working practices can act as a barrier to technology change (Sargent et al., 2012). Such perceptions about change influence the level of change readiness across different individuals. Traditionally, readiness has been attributed to individual decision-making about whether or not to engage in change. However, more recent research has focused on the unconscious work routines individuals engage in (Holt and Vardaman, 2013) and how these are shaped by governing organisations and stakeholders. For example, industries that promote flexibility in their governance and work practices are more likely to develop a culture of innovation, while those that promote and strictly adhere to routine have been linked to lower levels of change adoption (Amis and Aïssaoui, 2013). Exploring such concepts in this research project, knowledge about the behaviours of individual, stakeholder and governing organisations and how they influence growers' decision-making around change can be obtained.

- Investigate the key social drivers that will enable increased technology adoption across the rice industry (Industry level);

While it is essential to understand growers' behaviours and decision-making around technology adoption, it is also important to explore current practices across rice industry stakeholders and governing organisations to determine the role that they can play in enabling further change adoption. By including stakeholders in the research, information such as current methods used to develop change strategies; how change is communicated and promoted; involvement of growers in change processes; key change priorities; and perceptions of grower best practice and limitations can be used to explore different ways in which technology adoption can be further enabled. Combined with knowledge obtained from growers, this information can also be used to determine which current practices are most effective and how others can be further developed to encourage an increase in technology uptake as well as develop new or existing training programs to build grower capacity.

- Explore communication methods that growers use to become informed of changes in the rice industry, and provide recommendations as to whether or how current communication methods are effective;

Research within organisational contexts indicates that communication and successful change implementation are inextricably linked (Lewis, 1999). While effective communication is likely to lead to increased change adoption, ambiguous and competing information, inadequately targeted or ineffective communication methods have been found to increase change resistance (Elving, 2005). To increase technology adoption, dissemination of information needs to be in a form that is accessible and useable to growers. Exploring growers' needs, preferences and limitations in terms of information access provides rice industry stakeholders with information about how effective current communication methods are in disseminating

information about agricultural technology to growers. This information can be used by the rice industry to introduce new methods of communication, increase the use of existing methods and channels that are working effectively, and review those that may not be as efficient.

- Develop a set of priorities and recommendations that RIRDC and rice industry stakeholders can implement to drive further change adoption.

Based on the information collected from growers and stakeholders, a fourth objective of the research project is to develop a set of key priorities and recommendations for RIRDC and other rice industry. These priorities and recommendations are developed from the results of the data and focus on specific changes that RIRDC and industry stakeholders can implement to further develop the technological capacity of growers across the three rice growing areas of Murray, MIA and CIA.

Why this research is important

The rice industry in Australia has been and will continue to be subjected to an array of transformational changes requiring stakeholders and growers alike to continually adapt by adopting processes that can counter the effects of global, market-based and environmental shifts. The industry has demonstrated significant capacity to adapt to transformational change in the form of climate change, as well as institutional changes such as the Murray-Darling Basin Plan and subsequent government-imposed water allocations, restructuring of the NSW DPI, and more locally implemented changes including the introduction of total channel control in the Coleambally region. Ongoing implementation of technology will play an essential role in future rice production in Australia. However, as previous research has argued, a better understanding of grower adoption practices, particularly adoption of complex technologies such as PA, is crucial in realising the full potential of such technology across the industry (Glyde et al., 2012).

Understanding the rationale to engage in technology adoption is complex and requires an understanding of social issues, as well as knowledge of change processes more generally. Research in the context of change implementation has demonstrated that it is not uncommon for those engaged in the development or promotion of particular types of change to either not have a thorough understanding of how to implement change successfully, or attempt to implement change based on assumptions that are not necessarily accurate or based on solid evidence (Palmer and Dunford, 2008). Both scenarios can lead to situations in which innovations that are highly beneficial to the rice industry are either implemented inefficiently, or experience low levels of commitment and adoption. Furthermore, an insufficient understanding of the social issues surrounding change adoption can lead to situations in which those involved in the promotion and implementation of change can unfairly blame change recipients for poor adoption (Ford et al., 2008), when broader social and structural factors might be the cause, as can the role of the change agent (Pettigrew et al., 2001). Within the agricultural context, widely cited theories such as those of Rogers' *Diffusion of Innovations* have provided templates for understanding how quickly ideas regarding new technologies are adopted, as well as different categories of adoption ranging from innovators to laggards. Rogers' ideas were developed in the 1960s and have been largely superseded by broader change research, yet they are still predominant in relation to technology adoption in agriculture (e.g., Zhang et al., 2002, Robertson et al., 2012, Bramley, 2009, Reichardt and Jurgens, 2009).

This research is important as it provides knowledge of the complex social issues that relate specifically to the uptake of technology adoption that are not necessarily known or easily located within existing research and practice. It also provides an evidence base for social issues surrounding technology adoption that can used for further decision-making and the

development of change strategies by different stakeholders engaged in the promotion and implementation of technologies at the strategic, tactical and operational levels.

Who may benefit from the research

This research is of benefit to stakeholders at different levels of the rice industry, particularly those at the following levels:

- Strategic: Stakeholders engaged in the development of overall strategy in the rice industry, particularly in response to market trends, environmental and institutional changes including (but not limited to) SunRice, RGA, and RRAPL.

- Tactical; Stakeholders involved in the operationalisation of strategies within the rice industry including (but not limited to) SunRice, RGA, and NSW DPI.

- Operational: Stakeholders involved in the day-to-day implementation of strategy at the farm level including (but not limited to), RGA, agronomists, private consultants, researchers and growers.

Methodology

To address the project objectives, the research adopted a social constructionist approach (Patton, 2015), which enabled the exploration of how individuals construct meaning and knowledge, and how this meaning and knowledge is shaped by specific social and cultural contexts. This approach is appropriate for the research as it allowed for detailed investigation of grower understandings of technology and its relevance to their everyday practices, and how specific federal, state, industry and regional cultures impact upon these understandings. This is particularly important for understanding grower decisions to adopt or reject particular technologies.

To explore the social drivers and enablers of change, qualitative research consisting of semi-structured interviews was undertaken in two concurrent phases. In the first phase, interviews were conducted with 20 key rice industry stakeholders, including farm advisors and agronomists as well as representatives from organisations such as RRAPL, Ricegrowers' Association of Australia, Rice Advisory Panel and NSW DPI (see Table 1). The aim of the interviews was to understand the role that rice industry stakeholders and governing organisations can play in enabling increased, as well as more effective, technology adoption across the rice industry (Project Objective 2). Participation by stakeholders was considered crucial in providing information on current methods used to develop change strategies; how technological change is communicated and promoted; involvement of growers in change processes; key change priorities; perceptions of grower best practice, and limitations of current approaches.

Table 1. Stakeholder Participant information

Participant code	Gender	Position/Occupation	Role in Change Process
1	M	Management	Development of broader change strategies across the industry
2	M	Management	
3	M	Management	
4	M	Consultant	Private consultancy in relation to technology (such as PA)
5	M	Consultant	
6	M	Consultant	
7	M	Consultant	
8	F	Agri-service delivery	Broader farming advice including technology adoption but also related to farming processes and business (e.g., agronomy and extension personnel)
9	M	Agri-service delivery	
10	M	Agri-service delivery	
11	M	Agri-service delivery	
12	M	Agri-service delivery	
13	M	Agri-service delivery	
14	M	Agri-service delivery	
15	F	Agri-service delivery	
16	F	Agri-service delivery	
17	M	Research/Policy	Research and development of new technologies; development and implementation of policy
18	F	Research/Policy	
19	M	Research/Policy	
20	M	Research/Policy	

In the second phase, interviews were conducted with 59 rice growers from across the three main rice growing regions – Murray (25 interviews); MIA (25 interviews), and CIA (9 interviews). A purposive sampling technique was used to ensure that a diversity of enterprises and growers were represented. The aim of the interviews was to (a) identify the main constraints to grower adoption of technology, and the enablers that will encourage late or non-adopters to engage in change practices (Project Objective 1); and (b) explore communication methods that growers use to become informed of changes in the rice industry as well as learn about new technology (Project Objective 3). Participation by growers was considered crucial in understanding their current use of technology; their awareness of, and the ways in which they receive information on, new technology; the technology that they see as most and least relevant to their farming practices; levels of support in adopting and using technology; enablers and constraints to technology adoption; and the input they have into technological change in the rice industry.

Findings

Outcomes from Stakeholder Interviews

The aim of the stakeholder interviews was to understand the role that rice industry stakeholders and governing organisations can play in enabling increased, as well as more effective, technology adoption across the rice industry (Project Objective 2). These interviews also aimed – in conjunction with the grower interviews – to investigate the communication methods that growers prefer and/or currently use to become informed of changes relevant to technology in the rice industry (Project Objective 3). Participation by stakeholders was considered crucial in providing information on current methods used to develop change strategies; how technological change is communicated and promoted; involvement of growers in change processes; key change priorities, and limitations of current approaches.

A number of key themes emerged from the stakeholder interviews. In summary, these themes surround the following four issues: (1) Ambiguity amongst stakeholders over which technologies the industry should be prioritising; (2) Knowledge gaps in the promotion of technology to growers; (3) Emphasis on grower behaviour in influencing technology adoption; and, (4) Communication of new technology and grower input into change priorities. Each of these themes is discussed in more detail below.

Ambiguity amongst stakeholders over which technologies the industry should be prioritising

A key theme that emerged from the stakeholder interviews was ambiguity in relation to which technologies were of most importance, and that the rice industry should prioritise. The majority of stakeholders reported that *new varieties* were the most important technological priority for the rice industry. This is consistent with the primacy of 'Rice breeding – varietal and quality improvement' in the 2012-17 Rice R&D Plan. The strong emphasis by stakeholders is not surprising given the significance of new varieties in responding to changing market demands as well as in delivering improved stress tolerance, grain quality and water productivity. For example, "far and away the most important technology is delivering improved varieties to growers. The reason that is so fundamentally important is that there is enormous competition for water" (1); "We need to keep making step changes in varieties … I think the other one is probably, we talk about aerobic rice and cold tolerance … And I know it's related to varieties, but if we can improve the cold tolerance … once we get to that, we may open up a whole lot more area that can be cropped and also marry in with other farming systems" (17). Further, "It's certainly varieties … [with] less water use, high yielding varieties, which are marketable. That would be our number one priority. The farmers here have developed a method called dry broadcast sowing. It's been a top yielding method here for the last two or three years. So I think the establishment of that [method] needs to be looked at [across the industry]" (4). Another reason why stakeholders emphasised the importance of new varieties is because they are in most cases straightforward for growers to adopt, and are taken up quickly. For example, "The most visible technologies and the one that we put the most money into is varieties, so new varieties. And growers take those varieties up very quickly … There's a great degree of trust that [a new] variety shall deliver" (20); and "[Growers] are always interested in varieties and that's where the bulk of the research dollar goes, into development of varieties. And so anything to do with varieties [growers] are always very interested in and they're always pretty quick at adopting" (9).

However, not all stakeholders viewed new varieties as the most important technology. Several stakeholders indicated that more complex technologies such as *precision agriculture, laser levelling, and mapping* were a priority for the industry: "Mapping is [the priority] but whether it's being used is another thing" (6); "the number one technology, after autosteer,

would be imagery … levelling [and] GPS guidance" (5). Further, "GIS is the most important [technology] … I think precision ag is probably the main driver at the moment" (11). In comparison, other stakeholders reported that technology adoption around *improving water efficiency* were the key priority for the rice industry. For example, "We know that there's less available water, so the technologies that are [aimed] at improving water use efficiency, improving the ability to use water … they're the key areas we've got work on" (17); "it's really important to look at things that improve water productivity" (19); "I think water efficiency technologies for rice are [the priority]" (18). Further, "delayed permanent water for the direct drilling is one of the most important technologies" (14); and "it's just all about per mega litre of water … just trying to get the best return per mega litre of water. Anything to do with water is a very complex story" (12).

Consistent with the 2012-17 Rice R&D Plan, rice varieties were viewed by most stakeholders as the main technology that the industry should be promoting. Nevertheless, under the R&D Plan, the industry is also seeking to achieve rice production efficiency gains through the application of PA and technologies for improving water footprints. A number of stakeholders see these technologies as an equally important priority. If there are differences among stakeholders over which technologies the industry should be prioritising, this may create confusion for growers concerning the technologies that they should be adopting. Equally, if most stakeholders are prioritising those technologies that are easier to adopt (such as new varieties), this may raise questions among growers over industry willingness or capacity to support adoption of those technologies, such as PA, which are more complex to adopt.

Knowledge gaps in the promotion of technology to growers

A second theme that emerged from the interviews concerns knowledge gaps in the promotion and implementation of technology. Three significant knowledge gaps were identified.

The demise of public extension through restructuring of the New South Wales Department of Primary Industries was identified as leaving a major gap in the provision of technical information to growers. For example: "[The fact that] government's pulling out of that space is a challenge. There used to be quite s network of DAs across the rice industry. It's not there anymore… The industry is filling that with extension people, but they're going to have to become actual agronomists and … they're going to have to be technical experts in the whole agronomic field" (9). In some areas – especially PA – this knowledge gap was perceived as not being replaced by an adequate network of private providers, with implications for growers' capacity to learn about and adopt new technology: "[Support for growers] depends on the technology … So something like precision ag there's a limited amount of consultants where [if] it's something like herbicides or nutrition, then you've got all the agronomists [who] are giving advice and support" (16); "I guess in a way [the few businesses in Australia] are partially a barrier [to adoption of PA] because growers haven't got that service for support, it's not there as there are not many companies offering that independent support" (6).

While a lack of extension agents with expertise in technology was identified as a limitation, a parallel issue that emerged from the interviews was lack of support among a number of private agri-services providers for particular technologies. Several stakeholders reported that if they do not support particular types of technology being used in the rice industry, they are less likely to encourage growers to adopt it. For example: "[Adoption] is more about us agronomists portraying to a farmer what he should be getting in touch with. I don't have faith in NIR so I don't encourage my farmers to go and use it. Until we get faith in [that], we're not going to encourage our farmers to … invest in it" (8); "I am a bit of a dinosaur as in I'm not necessarily interested in technology … From my point of view, I've been down the track a bit with the satellite imaging and we were aware of the whole process of the grower taking an image of his rice paddock and so on. I've been involved in that, it's a lot of work for not a lot

of monetary gain; it's still a service [that we provide] but it can really restrict your ability to get around [to other farmers]" (12); "I think the [PA] technology is difficult. I don't think it's been thoroughly demonstrated yet that there is an advantage …I don't think we quite know how to make use of the technology…. We don't yet [know] some of the questions, we don't know some of the answers; we don't know how you can make use of it to easily make improvements on the farm" (19).

For two stakeholders, support by agronomists and advisors for particular types of technology rather than others was linked to commercial demand: "A lot of commercial agronomists, there's money in selling chemicals and fertilisers; there's not money in selling information about precision ag; it's probably [something] they want to keep to themselves and do that with somebody who will … pay" (15). Other stakeholders reported that this lack of encouragement for certain technologies, and especially PA, was due to the fact that "A lot of agronomists are really time poor … not very many of them have the interest of sitting in front of a computer processing maps" (5), and agronomists "don't understand [the technology] so they don't push it so hard" (6). Regardless of these reasons, the lack of support for particular technologies, especially from agronomists who growers trust and with whom they have a close relationship, represents a challenge for the rice industry. Private sector agronomists and advisors are playing a more prominent role in extension, and this represents potential opportunities for the rice industry in working through these providers to improve technology adoption. However, if these providers are not promoting, or have doubts about, the use of particular technologies that the rice industry sees as important, the industry will face growing "knowledge fragmentation and information asymmetry (Sutherland et al., 2013, p.97) that may be counter-productive in encouraging more widespread grower adoption.

Finally, stakeholders identified knowledge gaps in the provision of PA services and technology. This was viewed as leading to challenges for growers in implementing and making PA workable on-farm. For example: "There does seem to be … a disconnect between the machinery dealers' understanding of what they're selling the farmer, and the machinery dealers have no appreciation of the agronomy, what actually happens with the data afterwards" (7); "[A] really, really big issue is the machinery dealers. Each different company seems to have their own program that they run with and everyone's different. So you might have [machinery from different companies] … and you've got to get them to talk to be able to [work together]. Okay, things are getting easier now but that was a massive barrier two or three years ago and it probably is still to some degree" (10); "The guys on the ground working at that retail level are frustrated also because they want to … provide a service to growers and they want to see it work for growers and get satisfied customers. But they work in very large organisations and they're big multinational companies, and the systems being developed at the very top of the organisation aren't necessarily relevant for the poor bloke who's trying to flog the stuff on the shop floor, so it's a difficult one to overcome" (20). These views suggest that PA technologies may in many cases have been "produced through developer push rather than user pull" (Lamb et al., 2008, p.4). Since PA is already complex technology for growers to adopt, the lack of alignment and compatibility between the technical norms inscribed in the technology and growers' existing machinery and practices raises further challenges for growers in adopting PA technology. If grower adoption of PA is a priority for the rice industry, such knowledge gaps need to be addressed in conjunction with extension support to growers.

Emphasis on grower behaviour in influencing technology adoption

Despite knowledge gaps related to institutional change being identified as playing a significant role in technology change adoption, it was evident from the data that stakeholders view individual attributes of growers as the most important factor in influencing change readiness. Across stakeholder reports, growers' change readiness was thematically organised in three ways: innovators, those likely to adopt easier changes, and laggards.

These positions tend to reflect linear patterns of change adoption that have been widely discussed and accepted within the agricultural context, and promoted by authors such as Rogers (2003).

Growers positioned as innovators were reported as being highly receptive to change and proactive in making decisions to look for new opportunities and adopt technology changes. For example, “there are some [growers] who are very proactive and who are actively looking not only amongst our own growing community, but looking overseas to see what people have done” (18). Other stakeholders provided specific examples of proactive change adoption: “[There is a family] who have opened a cotton gin and the number of crops they’ve grown is huge … And there are growers out there looking for new markets, looking to try new crops” (11); “We’ve got a couple of guys here who’ve set up ethanol plants as mini-collectives” (2).

In comparison, a second group of growers were positioned as those who are likely to adopt easy changes. This group were identified as being only likely to commit to changes that were trusted to be effective, have a known outcome, and involve low levels of risk: “A norm in the industry is that if there is a new technology, which is obviously more profitable, follow-on adoption times have been remarkably quick. But it has to be something that is easy to adopt and easy technology, risk-free, obviously something that is clearly profitable” (4). Adopting changes to growing systems and paddock layouts, or trialling new rice varieties were examples of the type of changes that growers in this category were likely to adopt. For example, “[change to] farm layouts would be something they would take up straight away … Variety changes, they are certainly quick to take those up … farmers are very slow at taking up precision agriculture and [similar] technology” (8). Further, “anything to do with simple adjustments to growing system, as long as they’re simple, farmers are likely to adopt that faster than they’re likely to adopt a big change” (17).

The final group of growers were positioned by stakeholders as laggards in that they were unlikely to commit to change in the form of new technologies, having a preference for traditional farming practices. Such growers were also positioned as conservative both in relation to their finances and in taking risks, even if it meant that their farms and farming practices were inefficient. For example: “One of the things becoming more obvious is that [growers] are sticking to traditional practices … what’s worked well. But equally that means their cost structure is too high. So why don’t [they] look at doing something different, a change in technology or equipment? Because there’s a cost involved and that scares them sometimes … There’s a conservative element in farmers” (3). A lack of willingness to engage in change was reported as being a source of frustration for a further stakeholder: “It frustrates me [when growers won’t spend money] because they could have a new bit of gear that doesn’t break down, they’re more efficient in what they do, yet they choose to keep fixing the old one” (13). Furthermore, “It’s all about the risk factor; if you’ve got a farm that’s running on the edge every year, you’re going to [do] something that’s safe” (8); “[New technology] is something that’s foreign and it’s a big commitment to swing out of something you’ve always done to something totally new … Some of my growers, they’re not really sure that it’s going to work for them or that they’ll … get a good result. And a lot of them are in a situation where they can’t afford a failure” (9).

Despite discussion of constraining and enabling factors, stakeholders commonly reported grower attributes as being central to their willingness to adopt change. For example, age was commonly linked to change readiness, with younger growers reported as having high levels of readiness in comparison to older growers: “Certainly the younger generation always push different change and different opportunities” (3); and “there’s always more of an appetite [for change] from the young guys” (20). Further: “The sort of people who take up technology [are] the younger people and they’re probably the sons of farmers” (15); “[technology such as] GIS is certainly a good fit for the younger generation of farmers who are more apt to wanting to get hold of technology” (8). In comparison: “I think as you get older, your appetite for change

decreases, you get wary of it. You've seen so much and it's yet another thing you've got to learn" (20); "if you're an older farmer, well why should I bother?" (2); "I think you'll find older growers are less likely to adopt new technologies. They're probably feeling quite tired by now" (19); and, "the older guys; I think they're just used to being in the field more often and they don't want to be behind a computer" (10).

While the diffusion of innovations model has been widely discredited (e.g., Röling, 1994), it is noteworthy that stakeholders continue to draw heavily on this approach when explaining grower adoption behaviour. From this perspective, the acceptance or rejection of an innovation is dependent on grower attributes, behaviours, and their overall willingness to change. The problem in relying on this model is that it emphasises grower attitudes and practices as the principal enablers or barrier to adoption. This risks overlooking the complex process of innovation, which involves "*interactions* of different people and their ideas; the *institutions* (the attitudes, habits, practices and ways of working) that shape how individuals and organizations interact; and *learning* as a means of evolving new arrangements specific to local contexts" (Rivera and Sulaiman, 2009, p.268, emphasis in original). It also overlooks the characteristics of the technologies themselves, such as "whether and how the characteristics of an innovation interact to affect its adoption" (Lundblad, 2004: 57), or whether promoted changes meet the needs of the target audience (Ford et al., 2008).

Communication of new technology and grower input into change priorities

Most stakeholders emphasised the need for a multi-level communication approach using methods tried and trusted in the rice industry to inform growers of new technologies. This included the importance of tailoring communication methods and learning platforms to meet the diverse needs of growers. For example: "It needs to be a whole range of communication methods because different methods will be more appropriate to certain farmer learning than others…. And [growers] pick and choose what suits them" (4); "[Present information] in 15 different ways, so tailoring the message seems like a key way of helping to … overcome some of those challenges [and moving away] from that one size fits all approach" (14); "I don't think any one system works best for everyone. So I think it is really, really important that you've got different delivery methods" (19).

Field days and discussion groups were viewed as being particularly effective in raising awareness of, and providing hands-on opportunities to evaluate the effectiveness of, new technology. For example: "If there was a lot more discussion groups, and those people running those were better linked to the development of the researchers then you'd actually have that feedback loop. So it would go both ways; on the one hand there'd be feedback that some technologies are being very well accepted and adopted, and there'd be other technologies not so well adopted, and together how can we improve the communication of this?" (4); "Most growers don't learn from reading, they learn from looking and discussing and hearing…. Field days are a good way for raising awareness about something that's happening, and for growers to have a look at it in the field" (9).

While field days and discussion groups were considered by stakeholders as important for raising awareness of new technology, *informal and one-on-one extension methods* were viewed as most effective for growers in learning about and becoming comfortable with technology: "I find that more face-to-face communication can be more beneficial than a reading-based communication. I find that at least then you've got that eye-to-eye contact and you can see whether they're understanding what you're putting across" (8); "Growers learn about technology over the fence or in less structured forms…. Putting some sort of a loose framework in place that at certain times of the year you bring people together on a host's farm and just share experiences [is important]. That's going to continue in my view to be an important part of getting new technology across and adopted, particularly … for the 20 percent that are less technically inclined" (1).

A key constraint raised by stakeholders in improving communication on technology to growers, and utilising more participatory extension methods, was believed to be the continued dominance of top-down approaches to information provision. Consequently, there was the perception of limited opportunities for most growers to provide meaningful input into industry change priorities relating to technology. For example: “The thing that’s lacking I think, is a loss of information flow from the growers to representatives on [the Rice R&D] committee…. That’s where I think it falls down a bit. And so a lot is left to the discretion of the grower” (9); “[Growers] do have an input [but] I think we’ve probably focused on information top-down so far…. I don’t sense dissatisfaction [from growers] but I do sense that people say, ‘look I’ve been banging on about this issue and I’m not being heard’” (20); “The Rice Research Committee, as I understand it at the moment, is a very top-down committee…. I think that a lot of the decisions are being just made by that committee, and I suspect that those decisions are not on the basis of wide consultation with, say service providers … or the farmers” (4). Top-down communication flows are a characteristic feature of the diffusion of innovations model where information on innovations are transferred from scientists through extension agents to growers (Rogers, 2003). Under this model there is limited scope for grower input into, or participation in, technology development. The rice industry has long recognised the value of extension methods such as field days and discussion groups that promote interactive and participatory approaches. However, the effectiveness of these methods in contributing to improved technology adoption may be undermined if there are not the mechanisms in place for meaningful grower input into technological change priorities for the industry.

Outcomes from Grower Interviews

The aim of the grower interviews was to (a) identify the main constraints to grower adoption of technology, and the enablers that will encourage late or non-adopters to engage in change practices (Project Objective 1); and, in conjunction with the stakeholder interviews, (b) explore communication methods that growers use to become informed of changes in the rice industry as well as learn about new technology (Project Objective 3). Participation by growers was considered crucial in understanding their current use of technology; their awareness of, and the ways in which they receive information on, new technology; the technology that they see as most and least relevant to their farming practices; levels of support in adopting and using technology; enablers and constraints to technology adoption; and the input they have into technological change in the rice industry. A number of key themes emerged from the interviews. In summary, these themes surround the following issues: (1) Constraints to technology adoption; (2) Adoption and adaptation strategies; and, (3) Trusted sources in influencing adoption decisions. Each of these themes is discussed in more detail below.

Constraints to grower adoption of technology

At face value, the constraints reported by growers align with the reports of stakeholders as well as ‘barriers’ that have been widely documented in adoption research. These barriers to adoption include: the perceived high costs associated with adoption of new technology, lack of prospective benefit from adoption, unwillingness to bear the financial risk of being early adopters, and incompatibility between the technical and data demands of new technology and the farming operation (Zhang et al., 2002, Robertson et al., 2012, Bramley, 2009, Reichardt and Jurgens, 2009). Consistent with this research, growers viewed four factors as most important in restricting their capacity to adopt new technologies. Of most significance was the *cost effectiveness* (cost versus expected financial returns) of new technology. For example: “Capital is always an issue, and doing the sums on whether it’s going to return adequately. Some of it requires a fair bit of adaptation to old machinery…. So there’s a cost involved there” (MIA, Grower 12); “I look at new technologies as is it going to make the job easier, is it going to make it more cost effective, those sort of things. And will it return us a decent amount of money to warrant spending money on it in the long term” (Murray, Grower

23); “There’s an economic return and an agronomic return. I still think we’re in a situation that everything has to be justified” (Murray, Grower 14).

The *lack of time and/or desire to trial and interpret the information* generated by new technology was a further constraint raised by growers: “I listen to the young tigers all the time and engage with them but I’m not prepared to go down that track because I’ll waste too much time adopting…. As long as I’m making a profit and getting good yields and selling the cattle at good prices or getting 95 per cent conception, that’s fine and the rest will come along” (MIA, Grower 3); “We use all these technologies [but] we haven’t actually got time to sit down and read the results. I think the technology is speeding up our lives. Consumption of your time and … knowing how to deal with it is a challenge in adopting new technologies” (Murray, Grower 19).

The *age of rice growers* was also identified as a potential challenge in technology adoption. Older growers were perceived as slow adopters, but not necessarily less likely than younger growers to adopt new technology. For example:

> “I’m a slow adopter; I mean some of it’s to do with my age…. I think the reality is that it’s the 25 to 40 year olds who are going into farming, who are going to adopt that stuff a lot quicker…. I think when you’re 25 … you have a much different view of risk and how you analyse things, and what you adopt. But I suppose I’m fortunate enough, or unfortunate enough to have been through the cycle a couple of times now, of ups and downs, and it changes your view of how you assess that [risk]”. (Murray, Grower 4)

Growers also expressed concerns about the challenges in adopting specific technologies – especially PA. These concerns related firstly to the *lack of locally demonstrated and proven benefits*: “You’ve got to understand what the benefit is to you, and there’s got to be a clear benefit to you…. There’s a lot of technology that’s out there that’s trying to sell itself, that maybe doesn’t have quite as clear and easily quantifiable benefits. And that’s why people are sceptical” (Murray, Grower 4); “We do a bit of [PA], as far as aerial or satellite imaging as far as sampling goes with the rice. But … I really haven’t seen a lot of demonstration of precision ag with rice farming benefits. [Therefore] things are really focused on what’s tried and proven and what makes sense financially” (Murray, Grower 17); “The main challenges [in adopting technology] are just making that initial decision I suppose. [I’m] fearful of going down the wrong path. And being an early adopter you’d have to wear that. [So] you just wait for the early adopters to make the mistakes. I’m happy doing that” (MIA, Grower 24).

While the constraints reported above are consistent with previous research, and are already known issues within the rice industry, less widely documented are the broader institutional influences on grower adoption of technology, and especially the competing platforms of machinery manufacturers. Similar to stakeholders, growers reported that compatibility between the platforms of different technology/machinery manufacturers represented a challenge in effectively integrating new technologies, such as PA, into their farming system. This contributed to confusion and frustration for those who had invested, or who were considering investing, in PA technologies: “And that’s one of the challenges you’ve got too is that a lot of the systems you have there’s probably three, maybe four key systems and they’re not always all compatible with each other. So the marketing of these products sort of tries to lock you in to their proprietary product; and that’s a frustration” (Murray, Grower 14); “Retailers, a lot of them will tell you we’ll do this and do that and like we bought another tractor that had a GPS in it last year and it won’t talk to our boom spray but the system we’ve got will talk to our boom spray and this other one’s meant to be a new flash modern technology but it won’t talk to our boom spray, whereas our old one will. Just simple things like that [are frustrating]” (CIA, Grower 6).

Problems with compatibility contributed to cynicism by growers in the commercial motives of machinery companies, and concerns about the corporate appropriation of personal

information. For example: “[PA is] being ambushed by retailers, marketers, and it’s not serving the purpose that we want it to be serving, a purpose that they’ve determined they can use…. It’s manipulation of your communication device to help them sell stuff. And that becomes a marketing tool” (CIA, Grower 4); “A lot of the information that you generate from what you’re doing is not just yours. The provider of the hardware and the software claim that to be their data as well, and I’ve got a real issue with that whether you should be able to opt out…. So they’re mining your personal information and the catch is that you can’t use their technology unless you agree to it. So I don’t like that” (Murray, Grower 20).

Unlike constraints such as cost, time, and age, lack of compatibility and interchangeability are challenges over which growers have limited control, and which make integration of PA into their farming system more difficult. While the rice industry also has limited control over technology development in multinational machinery firms, there is considerable scope to work more closely with growers in developing ways of working around and adapting new technology to existing machinery and farming systems.

Grower strategies for adopting and adapting technology

Despite the reported constraints and challenges noted above, growers were generally interested in and amenable to adopting new technology. In other words, in contrast to the assumptions of a diffusion of innovations approach, these constraints did not represent barriers to adoption. Growers used a range of strategies to reduce, or work around, the perceived risks – particularly lack of demonstrated benefit, cost vs return, time and cost involved in trialling new technology, and technological compatibility – associated with technology adoption. These strategies included firstly *informal learning about technology from other growers* and particularly early adopters. Other growers were viewed as significant in terms of their experiential knowledge about what worked for them, and what did not, as the following quotes illustrate:

> “If I know someone who’s got a machine with something in it, I’ll ring them and have a yarn to them and ask them whether they’ve had trouble with this or that and they’ll say yes or no. And then you ring the bloke up the road who’s got the same machine and he might tell you something different and then you can fit somewhere in-between, that’s the main way I work…. And it always is good to look over the fence because you can get stuck in your own rut and you just do things because that’s the way you do things, but it’s not necessarily the right way to do it; someone might be doing it better” (MIA, Grower 21).

> “I think you learn a lot from what happens over the fence. You start to see a neighbour use a certain amount of certain technology, and … it’s word of mouth really…. Like a farmer will tell you, nuh, that doesn’t work, that’s crap. Straight away that bit of technology is probably not going to be used. Where if they say, yeah, that’s good, that’s worked, well it’d probably have 95 per cent uptake in my age group” (Murray, Grower 25).

A second strategy used by growers was *adaptation of new technology to make it compatible with existing machinery and systems*. For the growers in this study, adaptation was crucial in working around the frustration of dealing with incompatible platforms from different manufacturers, or pursuing the costly option of purchasing all equipment from one brand: “With the current climate in farming, like commodity prices and the water, it’s just not justified [to upgrade to new machinery with GPS]. So we try and adapt to the main machinery that we use, that’s all I’ve done, is adapt it to the main machinery and we put up with the other stuff” (Murray, Grower 25); “It doesn’t really matter whether it’s IT type technology, precision ag stuff, or whether it’s the hard physical stuff, shift the dirt, move the water stuff, the same rules apply. You fiddle with it for a while, you bend it to suit yourself” (Murray, Grower 11).

The third strategy growers used was the use of technology/equipment owned by contractors or neighbours. For example: “As much as I’d love to have a lot of that stuff it’s not financially practical for me to adopt a lot of it. We find that in a lot of regards there’s always a contractor or there’s someone that’s going to hire a bit of gear or there’s a neighbour that’s got it that you can actually get your hands on it to do the job” (MIA, Grower 18); “[I bring] in contractors who’ve got the technology … rather than buy the technology. So that works” (MIA, Grower 14); “We try and minimise our equipment and we use contractors…. Contractors are reliable … we’re not keen on buying equipment if we can do it that way” (Murray, Grower 18). Whereas technology adaptation is aimed primarily at working around the incompatibility between technologies, these quotes illustrate that the use of machinery owned by other people is an explicit cost-saving measure that enables growers to only use technology when it is needed, and thus avoid the often high costs associated with the purchase of new equipment.

While the rice industry is already aware of the main challenges experienced by growers that limit the adoption of new technology, less well known are the strategies growers use to address these diverse challenges. Growers are receptive to new technology, but they must balance this with managing multiple pressures, risks and other priorities. In this context, growers learn from other farmers, adapt new technology to make it compatible with existing systems and practices, and use equipment from neighbours or contractors. For rice growers, ‘successful’ adoption involves working with and around existing risks and pressures so that technology is workable within their farming system. Consequently, for the rice industry to improve the effectiveness of technology adoption, greater emphasis needs to be placed on working with what growers are already doing to make technology workable on-farm. Emphasising the different short-cuts and options for growers enables more effective engagement with and implementation of new technology.

Trusted sources influencing grower decision-making

Trust is a crucial element in the adoption process, yet at industry level it is often something that is taken-for-granted. Research shows that a high level of trust in those promoting an innovation contributes to greater willingness on the part of farmers to engage with that innovation (Pannell et al., 2006). Thus, if a technology is being promoted by an individual or organisation that farmers trust, they will be more likely to consider using that technology. At the same time, farmers are more likely to place their trust in service providers who are perceived as impartial or actively ‘pro-agriculture’ (Sutherland et al., 2013). Consistent with previous research, trust was central to the adoption process for rice growers interviewed as part of this project. Most important were local agronomists with whom growers had established a long working relationship.

For growers, agronomists represented one of the trusted sources of information, primarily due to their local knowledge, the fact that they are often from that region and know growers on a personal basis, and the impartiality of the information/advice. For example: “These blokes, because I know them, because I’m from here and grown up with these guys. I trust them, like the agronomist to give me an honest opinion. And also because they’ve got no interest, they don’t sell the technology, so they’re not going to give you a bias there” (MIA, Grower 20); “[I trust] my local agronomist because you get a one-on-one relationship with your agronomist, whether you’re working through a cooperative or a business or a private” (MIA, Grower 16); “Probably agronomists rate pretty high [in terms of trust]. I have one retail agronomist who covers all of the crops…. We’ve got to trust each other pretty well…. It’s in their best interest for you to do well as well. If you’re not doing well they’re not doing well” (MIA, Grower 21).

The NSW DPI were also considered by growers to be trustworthy. Despite extensive recent restructuring and loss of staff, the DPI was considered a trusted source due to their

perceived independence and impartiality in research and extension: “[I trust the] DPI because they’re the most impartial” (CIA, Grower 8); “I’d definitely trust DPI the most. I feel like they’re impartial, very impartial. I’m a big supporter of the rice industry but I’m very much aware of any agronomic or any advice we get from the rice industry will be all about the rice industry. So no, I’d always say DPI” (Murray, Grower 17); “Well it’s like anything, you get to learn who to trust and who not to trust. Obviously I trust … the likes of Brian Dunn and the rice breeders at [the DPI] Yanco, we trust them implicitly” (MIA, Grower 3).

In general, growers also trusted the research, trialling and information disseminated by the rice industry. For example: “The people that do our R&D in the industry, they’ve got their finger on the pulse of all those things…. So in some ways you’ve got to trust the people doing the research that they’re giving us the stuff that they think is the best” (MIA, Grower 8); “I would trust RGA, like Rice Growers Association, or RIRDC and those different groups, I would trust them to trial” (Murray, Grower 19). Only one grower reported a loss of trust in the industry, although this same grower also did not trust the DPI: “I used to trust SunRice, but I’ve lost faith. Having two new release varieties that have been given with well-intentioned but poorly informed information is how I would describe it. They told us what they would like it to be rather than what it is actually had been tested. So it’s not who do you trust, it’s your own, it’s probably only yourself” (CIA, Grower 4).

Finally, other growers were generally viewed as more trusted than those who sell and market technology. However, unlike other sources of trust, growers were expressed more mixed views on trust in other growers. For example: “I trust a lot of farmers actually more than I will the people that sell [technology]. Your best point of reference is someone that’s already involved in it…. You gain a lot from that because they’re hands on, they’re using it, they can see, they come up with the pitfalls and whether it works or doesn’t” (Murray, Grower 23); “[I trust] other farmers. More so than the retailers’ (CIA, Grower 6); “Other farmers, I wouldn’t trust their advice. I like watching them over the fence. But farmer surveys on what they did in the season, they’re pretty patchy at best” (MIA, Grower 24); “You don’t trust your neighbours because they just want to brag about how good their crop is and it’s always been like that so you don’t take any notice of your neighbours” (CIA, Grower 8).

Local agronomists and the NSW DPI are the most trusted sources of information concerning technology and therefore have a crucial potential influence on growers’ adoption practices. In an environment where greater responsibility for extension is being shifted to the rice industry, more extensive use of ‘key influencers’ such as local agronomists and the NSW DPI is essential in promoting uptake of new technology. Working with and through these influencers provides an effective means of engaging a broader cohort of growers in technology.

Conclusions and Implications

This research project sought to address four specific objectives, three of which are re-listed below accompanied by key conclusions drawn from the qualitative data. The fourth objective was to develop a set of priorities and recommendations that RIRDC and rice industry stakeholders can implement to drive further change adoption. This specific objective is detailed in the Recommendations section of this report.

Objective 1: Identify specific enablers that will encourage late or non-adopters to engage in change practices (Grower level)

Several specific themes were derived from the interviews that were commonly reported as constraining or enabling adoption of technology:

- **Grower input into change priorities**: Growers and stakeholders commonly reported that the rice industry is proactive in using a multi-media approach to communicating with farmers (for example, through field days, discussion groups, newsletters etc.). However, stakeholders also raised concerns about whether current mechanisms for growers to provide meaningful input and feedback into change priorities – particularly around the use of technology – were adequate and appropriate. The qualitative data across both stakeholders and growers also highlighted concerns that communication within the rice industry will continue to favour a top-down approach to disseminating information, with limited opportunities for grower input. While this is currently viewed as a constraint to technology adoption amongst late or non-adopters, strategic and tactical level mechanisms for grower input into change priorities across the rice industry are outlined in the recommendations section.

- **Trustworthiness of agents and organisations promoting new technology:** Data from the grower interviews identified strong relationships and levels of trust between growers and local agronomists and the NSW DPI. This is partially due to longstanding relationships that some growers have with their agronomists. However, local agronomists and the NSW DPI are also identified as being impartial when working with growers on a range of farming issues, as opposed to promoting specific farming methods or technologies. This finding indicates that growers are more likely to work with trusted stakeholders and will be more likely to consider adopting technologies promoted through these individuals/organisations. Consequently, local agronomists and agents from the NSW DPI are key influencers and can potentially play a wider role in promoting technology, and building the capacity of growers to adopt technology.

- Compatibility and interchangeability of technology required for PA: Evidence from both stakeholder and grower interviews highlight a shared view that current platforms and technologies used by different manufacturers constrain technology adoption. For example, different machinery manufacturers commonly use different technology platforms that are unable to be used in tandem or interchangeably. This creates situations in which growers seeking to add to current machinery either purchase technology that is incompatible with existing equipment, or are faced with the expense of purchasing new equipment to engage in more advanced technologies such as PA. However, constraints caused by incompatibility or interchangeability also provide opportunities for stakeholders and growers to work together to determine how to make advanced technologies such as PA work more successfully on-farm. For example, further opportunities to informally learn about new technologies from other growers could be pursued, as could opportunities for learning about adaptation of new technology to make it compatible with existing machinery and systems, and the use of technology/equipment owned by neighbour or contractors. Recognising these practices as a central part of the adoption process is an

essential starting point for the industry in promoting options for growers that improve their engagement with and uptake of PA technology and potentially addressing other perceived constraints from growers such as cost and lack of time.

Objective 2: Investigate the key social drivers that will enable increased technology adoption across the rice industry (Stakeholder level)

Data collected from the stakeholder interviews provided evidence of two key social issues that have the capacity to constrain and enable technology adoption across the rice industry:

- **Emphasis on individual grower characteristics instead of institutional factors**: Evidence from the interviews with stakeholders demonstrates that although structural constraints and enablers are identified by stakeholders, the majority of stakeholders attributed individual grower characteristics to rates of technology adoption. For example, grower attitudes, behaviours and demographic characteristics such as age are reported as the dominant barriers and enablers to adoption. In attributing grower characteristics to technology adoption, the institutional factors that influence adoption that growers have little or no control over are downplayed. Furthermore, focusing only on grower characteristics overlooks the localised strategies that growers are already engaged in to reduce or work around the risks and constraints associated with technology adoption. An additional risk of attributing grower characteristics to rates of adoption is that it assumes that the broader social system in which stakeholders and growers operate is the same and as such, there is a shared assumption about how change is and should be experienced (Cinite et al., 2009). This does not allow for consideration of the unique characteristics or elements of the various organisations, agencies, stakeholders and growers within the rice industry and how the pressures and boundaries of each impact on adoption of technology (Lundblad, 2004).

- **Knowledge gaps in the provision of technical information and the promotion of technologies:** Knowledge gaps were identified by stakeholders in two specific ways. The first knowledge gap was reflected in reports of the lack of extension services and private agri-service providers with expertise in technologies such as PA. With the demise of extension services as a consequence of restructuring of the NSW DPI, the development of an adequate network of private providers is crucial in promoting and supporting technology adoption at the farm level. The second knowledge gap evident in the data refers to gaps within existing agri-services providers who either do not have knowledge of specific technologies, or do not support them, and therefore do not promote their use to growers. For example, an agronomist who does not believe in the use of particular technologies will encourage growers to engage in more traditional or *tried and tested* farming practices. As key influencers, agronomists play a crucial role in the adoption process. If the rice industry is to work more closely with agronomists and other agri-service providers in promoting and encouraging on-farm adoption of technology, greater attention needs to be given to: (a) the technological literacy of those providers; and (b) ensuring that these providers are receiving a consistent message on the priority technologies that should be promoted to growers.

Objective 3: Explore communication methods that growers use to become informed of changes in the rice industry, and provide recommendations as to whether or how current communication methods are effective.

Overall, communication media used across the rice industry were well received by stakeholders and growers as the use of multiple communication channels means that individuals with different communication preferences were able to adequately receive information. As already identified under Objective 1, both growers and stakeholders indicated a lack of opportunities for growers to input into discussions about change priorities, indicating that top-down communication methods may be used more in practice than bottom-up

approaches. Further to this, evidence from the data indicated that the content of communication to growers about technology (as opposed to the ways in which information is communicated) was somewhat ambiguous:

- **Lack of clarity amongst stakeholders as to which technologies should be prioritised by the rice industry**: Data from grower and stakeholder interviews indicated that a clear message about technological priorities was not being communicated across the rice industry. This was evident in themes from grower data such as a lack of knowledge of or understanding of specific technologies such as PA. It was also evident in stakeholder interviews when participants were asked about the most important technologies for the industry. While more advanced technologies such as PA, laser levelling and mapping were certainly identified as priorities by some stakeholders, other technologies such as water efficiency technologies and new varieties were widely reported as being the technological priorities for the industry. This is indicative of a gap between research priorities for technology and the translation of these priorities into a farm technology strategy. Thus, while the development of new rice varieties has primacy as a *research* priority in the 2012-17 Rice R&D Plan, there is no equivalent *strategic* plan on which technologies should be prioritised for grower promotion and implementation. Such a gap has the potential to create doubts amongst growers who may be cautious in relation to technology adoption. It can also create confusion for those seeking to adopt technologies, i.e., they may be unsure of which technologies to invest in and which can be trusted to deliver on-farm benefits.

The findings from this research project have implications for the following stakeholders.

Industry

The findings have implications for the ways in which the rice industry promotes the use of, and prioritise, particular technologies, and develop strategies around change adoption more broadly. At industry level, technology adoption could be enhanced through the development and implementation of a strategic plan specifically designed around technological change. This strategy should also include opportunities for bottom-up change initiatives, which can be initially developed through formalised avenues for grower input into technology and broader change priorities. The findings also have implications for where further education and development around adoption is aimed. Such programs are often aimed at recipient/grower level. However, the research findings demonstrate that mid-level stakeholders, such as agronomy and extension personnel, play an important role in grower decisions about technology adoption as a result of the high levels of trust that growers have for such stakeholders, yet are possibly overlooked in adoption efforts. Addressing such issues can have significant benefits for the rice industry overall on the basis that further emphasis on the strategies, skills and capabilities of trusted stakeholders involved in the promotion and implementation of technology adoption is likely to lead to increased adoption levels.

Communities

Strategies aimed at further enabling technology adoption have significant socio-economic implications for the communities in which rice is produced. Increased technology adoption is aimed at decreasing time and labour associated with farming, while simultaneously increasing productivity and yield. By engaging in innovative practices, farmers are also likely to benefit from whole-of-farm productivity gains, as well as be more likely to engage in change across different aspects of the farm. This has community benefits through increasing the viability of farming within the various rice-growing regions, which has financial benefits for the communities in which farmers reside. Developing an innovative farming culture within the regions can also lead to further community benefits through developing communities of practice, through running demonstrations of technology, increased numbers of workshops or field days that will attract people from outside of the local community. An innovative industry

is also likely to attract more overseas interest and field visits, which also benefit local economies. High levels of innovation can also be utilised for succession planning. That is, if rice growing communities have a reputation for being highly innovative, they will be more likely to attract new people seeking to work in agricultural industries into the communities, as well as retain local farmers. In this sense, the social impact and benefits of a highly innovative industry can be considerable for sustaining dynamic communities.

Policy-makers

Findings from the research demonstrate that one of the constraints to increased technology adoption is the decline in publicly-funded extension and agronomy personnel. To improve levels of technology adoption, the rice industry is dependent upon addressing issues to do with shortages of skills and labour to assist with increasing innovation in the rice industry. This is also important to counter the ongoing effects of climate change and water availability. Although it is unlikely that policy makers can increase the number of publicly funded positions to assist with technology adoption, further emphasis can be placed on increasing education and training within the agricultural sector. For example, increased university and training places aimed at agriculture, agribusiness and technological innovation could be part of a solution to addressing the need for further skills in the rice industry. Policy makers could also introduce scholarship schemes aimed at increasing potential students into agricultural education. Policy makers involved in environmental reform could also provide further incentives to growers/groups of growers through the introduction of restructured grant schemes aimed at increasing innovation opportunities that are deemed to have a broader industry or community benefit.

The recommendations outlined in the following section of this report focus primarily on changes that can be made by *rice industry stakeholders* to increase adoption of technology by growers. However, implementation of those recommendations is likely to yield benefits for the communities in which rice production is based, and can form the basis for industry efforts to lobby for changes in government policy to support technological innovation in the rice industry.

Recommendations

Based on the major findings identified in the Conclusions section, a set of priorities and recommendations that RIRDC and rice industry stakeholders can implement to drive further change adoption have been identified. These have been divided into three specific categories: strategic, tactical and operational.

Strategic level

Strategic level priorities and recommendations are those that are aimed at stakeholders engaged in the strategic planning and development within the rice industry. This could include (but is not limited to) stakeholders based in organisations/agencies such as SunRice, RGA and RRAPL, and could include growers involved in additional R&D, board or management roles.

Tactical level

Tactical level priorities and recommendations are aimed at stakeholders who are specifically engaged in operationalising strategy, that is through interpreting and transforming strategy into tangible outcomes for other stakeholders as well as growers. Tactical level priorities and recommendations can be aimed at stakeholders such as SunRice, RGA, and NSW DPI. However, some agronomists, private consultants, and innovative growers, as well as growers involved in additional R&D, board or management roles are also likely to be engaged in the operationalisation of strategy.

Operational level

Operational level priorities and recommendations are aimed at stakeholders, such as RGA, agronomists, private consultants and researchers, as well as growers involved in the day-to-day implementation of strategy outcomes at the farm level. It could also include stakeholders as listed in the strategic and tactical categories who are also farmers.

Strategic and tactical level recommendations

Recommendation 1

Development of a Rice Industry Strategic Plan for Technological Change to promote a consistent understanding among stakeholders and growers of industry technological change priorities, and key technologies that growers should be adopting. The Plan should be developed by the RGA and SunRice in consultation with other key stakeholders such as the NSW DPI, RIRDC Rice R&D Advisory Committee, RRAPL, as well as agronomists and other agri-service providers in each of the three rice growing regions.

Recommendation 2

Implement and promote an industry-wide strategy for bottom-up grower input into industry change priorities. Although there are some avenues available for growers to provide input into change, these are reported as being informal and ad hoc. A bottom-up grower input strategy could be included in the recommendation above (as part of a broader Rice Industry Strategic Plan for Technological Change). This could identify a number of formal avenues in which growers could provide feedback and input into technology change as well as ideas on innovation more broadly. It is possible that growers are not aware of all of the avenues for input available, so formalisation through a broader strategic plan could provide further knowledge to them. A further recommendation for promoting grower input is to develop a flyer that provides quick and easy-to-access information about the ways in which growers

can provide feedback and input into technology change priorities. This information could be developed by the researchers in conjunction with relevant stakeholders such as RGA.

Recommendation 3

Development of regular (for example, bi-annual, or as needed) workshops developed for agronomists and other trusted change intermediaries that: (a) provides a consistent message from the industry regarding the technologies that growers should be adopting, (b) improves awareness and knowledge of new technologies being promoted in rice industry, and (c) provides agronomists with the confidence and skills to promote new technologies to growers. The training program should be developed in consultation with SunRice Grower Services, and agri-services providers identified by the RGA as having a high level of technological literacy/expertise and/or are involved in providing current technological extension services to growers.

Tactical and operational level recommendations

Recommendation 4

Implement a Change Champions Program (CCP) to foster and formalise the sharing of technological knowledge among growers, and between stakeholders and growers, on (a) practical approaches to technology implementation on-farm, and (b) options and shortcuts for growers in adapting new technology to existing technology and equipment. Based on the successful Environmental Champions Program, the CCP would be developed by RGA in consultation with other industry stakeholders to assist growers in implementing more complex technologies – such as PA – on-farm and, in particular, improve the capacity and confidence of late or non-adopters to engage with new technology.

Recommendation 5

Develop and implement a series of change workshops for industry stakeholders that highlight different aspects of change management. This could be developed and conducted by the researchers as part of the output of this RIRDC-funded project and provide further information on various aspects of change including: effective change communication; the role of the stakeholder in change implementation; grower and stakeholder responses to change and interpreting what these different responses mean; implementing change within structural limitations; and other key issues as identified by stakeholders/different stakeholder groups. They key points covered in each of these workshops could also be developed as a quick and easy-to-access flyer in conjunction with stakeholders such as RGA.

References

AMIS, J. & AÏSSAOUI, R. 2013. Readiness for change: An instutitional perspective. *Journal of Change Management,* 13**,** 69-95.

BEECHER, G. & DUNN, B. 2013. *Approaches to Managing Variability of Rice Growth and Yield,* Canberra, Rural Industries Research and Development Corporation.

BRAMLEY, R. G. V. 2009. Lessons from nearly 20 years of Precision Agriculture research, development, and adoption as a guide to its appropriate application. *Crop and Pasture Science,* 60**,** 197-217.

BRYANT, M. & HIGGINS, V. 2010. Self-confessed troublemakers: An interactionist view of deviance during organizational change. *Human Relations,* 63**,** 249-277.

BURTON, R. J. F. 2004. Seeing through the 'good farmers's eyes: Towards developing an understanding of the social symbolic value of 'productivist' behaviour. *Sociologia Ruralis,* 44**,** 195-215.

CINITE, I., DUXBURY, L. E. & HIGGINS, C. 2009. Measurement of Perceived Organizational Readiness for Change in the Public Sector. *British Journal of Management,* 20**,** 265-277.

CLAMPETT, W. S., WILLIAMS, R. L. & LACY, J. M. 2004. *Improvement in Rice Grain Quality,* Canberra, Rural Industries Research and Development Corporation.

ELVING, W. 2005. The role of communication in organisational change. *Corporate Communications,* 10**,** 129-138.

FORD, J., FORD, L. & D' AMELIO, A. 2008. Resistance to change: The rest of the story. *Academy of Management Review,* 33**,** 362-377.

GLYDE, S., GRAY, I., OVENDEN, B. & DUNN, T. 2012. *Extension in the Rice Industry: A Report of the Review of the Development, Delivery and Prioritisation of Extension in the Australian rice industry,* Canberra, Rural Industries Research and Development Corporation.

GREINER, R., PATTERSON, L. & MILLER, O. 2009. Motivations, risk perceptions and adoption of conservation practices by farmers. *Agricultural Systems,* 99**,** 86-104.

HOLT, D. & VARDAMAN, J. 2013. Toward a comprehensive understanding of readiness for change: The case for an expended conceptualization. *Journal of Change Management,* 13**,** 9-18.

INGRAM, J. 2008. Agronomist-farmer knowledge encounters: an analysis of knowledge exchange in the context of best management practices in England. *Agriculture and Human Values,* 25**,** 405-418.

JOHANNSON, C. & HEIDE, M. 2008. Speaking of change: Three communication approaches in studies of organizational change. *Corporate Communications,* 13**,** 288-305.

LAMB, D. W., FRAZIER, P. & ADAMS, P. 2008. Improving pathways to adoption: putting the right P's in precision agriculture. *Computers and Electronics in Agriculture,* 61**,** 4-9.

LEWIS, L. 1999. Disseminating information and soliciting input during planned organisational change: Implementers' targets, sources, and channels for communicating. *Management Communication Quarterly,* 13**,** 43-75.

LUNDBLAD, J. 2004. A review and critique of Rogers' diffusion of innovation theory as it applies to organizations. *Organization Development Journal,* 21**,** 50-64.

PALMER, I. & DUNFORD, R. 2008. Organizational change and the importance of embedded assumptions. *British Journal of Management,* 19**,** S20-S32.

PANNELL, D. J., MARSHALL, G. R., BARR, N., CURTIS, A., VANCLAY, F. & WILKINSON, R. 2006. Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture,* 46**,** 1407-1424.

PARDO DEL VAL, M. & FUENTES, C. 2003. Resistance to change: A literature review and empirical study. *Management Decision,* 41**,** 148-155.

PATTON, M. 2015. *Qualitative research & evaluation methods,* Los Angeles, Sage.

PETTIGREW, A., WOODMAN, R. & CAMERON, K. 2001. Studying organizational change and development: Challenges for future research. *Academy of Management Journal,* 44**,** 697-713.

PRECISION AGRICULTURE 2016. *Precision Agriculture in Rice Production: Implementation and Grower Insights,* Canberra, Rural Insustries Research and Development Corporation.

RAYMOND, C. M. & ROBINSON, G. M. 2013. Factors affecting rural landholders' adaptation to climate change: insights from formal institutions and communities of practice. *Global Environmental Change,* 23**,** 103-114.

REICHARDT, M. & JURGENS, C. 2009. Adoption and future perspective of precision farming in Germany: Results of several surveys among different agricultural target groups. *Precision Agriculture,* 10**,** 73-94.

RIVERA, W. M. & SULAIMAN, V. R. 2009. Extension: object of reform, engine for innovation. *Outlook on Agriculture,* 38**,** 267-273.

ROBERTSON, M. J., LLEWELLYN, R. S., MANDEL, R., LAWES, R., BRAMLEY, R. G. V., SWIFT, L., METZ, N. & O'CALLAGHAN, C. 2012. Adoption of variable rate fertiliser application in the Australian grains industry: status, issues and prospects. *Precision Agriculture,* 13**,** 181-199.

ROGERS, E. M. 2003. *Diffusion of Innovations,* New York, Free Press.

RÖLING, N. 1994. Platforms for decision making about eco-systems. *In:* FRESCO, L. O., STROOSNIJDER, L., BOUMA, J. & VAN KEULEN, H. (eds.) *Future of the Land: Mobilising and Integrating Knowledge for Land Use Options.* Chichester: John Wiley and Sons.

SARGENT, K., HYLAND, P. & SAWANG, S. 2012. Factors influencing the adoption of information teachnology in a construction business. *Australasian Journal of Construction Economics,* 12**,** 72-86.

SUBASINGHE, R. & ANGUS, J. 2009. *Increasing Productivity and Water Use Efficiency in Australia's Rice Industry through Nitrogen Management,* Canberra, Rural Industries Research and Development Corporation.

SUTHERLAND, L., MILLS, J., INGRAM, J., BURTON, R. J. F., DWYER, J. & BLACKSTOCK, K. 2013. Considering the source: commercialisation and trust in agri-environmental information and advisory services in England. *Journal of Environmental Management,* 118**,** 96-105.

TSOUVALIS, J., SEYMOUR, S. & WATKINS, C. 2000. Exploring knowledge-cultures: precision farming, yield mapping, and the expert-farmer interface. *Environment and Planning A,* 32**,** 909-924.

VANCLAY, F. 2004. Social principles for agricultural extension to assist in the promotion of natural resource management. *Australian Journal of Experimental Agriculture,* 44**,** 213-222.

VANCLAY, F. & LAWRENCE, G. 1995. *The Environmental Imperative: Eco-Social Concerns for Australian Agriculture,* Rockhampton, Central Queensland University Press.

WILKINSON, R. 2011. The many meanings of adoption. *In:* PANNELL, D. & VANCLAY, F. (eds.) *Changing Land Management: Adoption of New Practices by Rural Landholders.* Canberra: CSIRO Publishing.

ZHANG, N., WANG, M. & WANG, N. 2002. Precision agriculture - a worldwide overview. *Computers and Electronics in Agriculture,* 36**,** 113-132.

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