Partnerships and Understanding Towards Targeted Implementation – PUTTI Final Report

Conditions underpinning the voluntary adoption of sustainable land management practice


December 2009
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For more information about Water for a Healthy Country Flagship or the National Research Flagship Initiative visit www.csiro.au/org/HealthyCountry.html


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Description: Rainbow over fields, Central West region NSW
Photographer: ARCWIS staff member

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EXECUTIVE SUMMARY

This is the final report of the Partnerships and Understanding Towards Targeted Implementation (PUTTI) project. PUTTI was commissioned to help Catchment Management Authorities (CMAs) prioritise and implement on-ground actions to meet the objectives of Catchment Action Plans (CAPs). The research was conducted in the Central West and Lachlan CMA regions with a particular focus on four sub-catchments: the Bell and Cudgegong in the Central West; and the Mandagery and Humbug in the Lachlan.

The primary research aim of the PUTTI project was to understand the motivations of dryland farmers and identify the social and psychological factors that influence their land management decisions so that effective intervention programs to improve sustainability could be implemented. This is critically important because to date incentive programs and education measures have not led to widespread adoption of conservation practices by landholders. Voluntary and sustained adoption of improved land management practices is important to help manage dryland salinity and halt on-going land degradation. In addition, the findings were to inform a behavioural change program aimed at overcoming the barriers, designed and implemented in concert with the catchment community.

Incentive programs are the primary mechanism used by CMAs to influence landholders to modify their land management practices. They focus on the provision of financial assistance to motivate landholders to change practices relating to salinity, water, soils, vegetation, biodiversity, people and community and cultural heritage. Engagement with communities to gain their trust and facilitate the voluntary adoption of promoted natural resource management practices is a key part of the CMA’s role. The CAPs document targets for each of the theme areas. They state that an adaptive management approach will be utilised to achieve the targets in accordance with the process advocated by the State Natural Resources Commission in their Standard for Natural Resource Management (NRM).

The research followed a mixed methodological approach where the formulation of research questions, research methods, data collection and analysis, conceptual model development and scientific interpretation and inference relied on both qualitative and quantitative behavioural science methodologies (Teddie & Tashakkori, 2009). The specific techniques employed included:

- qualitative analysis of interview transcriptions, to understand the context, features, culture and operating constraints for dryland farmers in the study area;
- surveys to gather data on attitudes and values underpinning practice;
- structural equation modelling to develop and refine predictive behavioural models of the key factors influencing the land management practices of farmers;
- Social Network Analysis to understand the source and influence of information on farming practice within the catchment community and
- Causal Layered Analysis to understand the deeper socio-cultural meanings of sustainability and farming in rural communities that need to be taken into account in developing practice change processes that emerged from the Landscapes and Livelihood workshops.

The PUTTI research involved three phases to allow:

- application across multiple study areas, starting from the Central West in the first year and moving into the Lachlan region in the second year, with the final year covering both areas
- the iterative development and refinement of a behavioural model predicting key influences on land management practice and
an investigation of the primary requirements for change expressed by the affected catchment communities through the conduct of a series of Landscapes and Livelihoods workshops

The final round of behavioural modelling incorporated a monitoring and evaluation component to identify changes that may have occurred over the three year term of the project. A model of the psychological and social determinants of best practice land management was developed with good predictive capacity, explaining 38% of the variance in land management behaviour. The model identifies the factors found to have the most influence on land management practice:

- Having a sense of being in control over events and outcomes (i.e. having an internal locus of control), which is in turn influenced by perceived access to resources. Locus of control influences whether a landholder is likely to undertake property planning. It is also reciprocally related to the levels of risk and innovation that a landholder demonstrates with respect to their production techniques.
- Valuing native animals and plants
- Trusting and being influenced by agronomy professionals
- Perceiving oneself as being influential to other farmers, which is also related to the level of risk and innovation

(Leviston et al, 2009)

The exploratory Social Network Analysis, aimed at assessing the relative importance of characteristics of the information networks of landholders, indicated that:

- Landholders with more desirable land management practice were connected to owners of multiple properties, irrespective of the number of properties they themselves owned or managed.
- Age of participants in the network influences sustainable land management practices.
  - Older farmers are less likely to engage in sustainable land management
  - Being connected to older farmers significantly reduces the chances of a farmer engaging in sustainable land management practices.
- Connections to others in the same geographic region were important to sustainable weed management. Those who were more active in the network overall were more likely to score well, and inactive people more likely to score poorly. However, there appears to be a point at which people can have too many connections, with participants who were very active in the network less likely to engage in sustainable weed management
- Being isolated, that is having few connections to others, makes land managers less likely to engage in sustainable land management practices.

The key findings emerging from the Landscapes and Livelihoods workshops were:

- participants have different values, worldviews, myths and metaphors that influence and underpin farming practices and responses to NRM initiatives
- there are discrepancies between how landholders and CMA staff conceptualise NRM issues and solutions
- landholders possess a heightened sense of connectedness to community and towns. NRM issues are perceived to relate to broader social and cultural issues such as diminishing population numbers, changing land use practices (e.g. the emergence of hobby lots and corporate farming enterprises)
- both landholders and CMA staff feel there are significant areas over which they have little control, with perceptions that broader social, cultural, economic, environmental and governance processes/events place them under additional pressure and often prevent changes from taking place.

The PUTTI research demonstrates the influence of internal locus of control on the capacity and willingness of landholders to adopt improved land management practice. The importance of
understanding how the worldview of landholders and others involved in NRM, affects their conceptualisations of sustainability issues and hence their interpretation of proposed solutions including the potential impact on their livelihood and community, can not be under-estimated. The research suggests that the baseline for awareness among landholders of conservation measures commonly used in the scientific or land management literature is relatively low compared with the expectations of the CMA and other agencies.

The current paradigm in regional natural resource management supports a command and control approach where pre-determined actions and solutions are promoted as the way to manage environmental issues. There is little, if any space for discussion, exploration of different perspectives, listening and adjustment or modification of strategies outside of the confines of the management agency. Educational and knowledge sharing opportunities are restricted as extension is no longer regarded as a legitimate role for regional resource agencies leading to a greater dependence on fewer consultants and commercially sponsored agricultural professionals.

The findings of the PUTTI research and the conduct of the study itself has highlighted the intrinsic connection between knowledge of the catchment from different perspectives (individual property to region) and process (social and cultural as well as biophysical) in achieving positive outcomes in community, cultural and environmental sustainability. The research identifies a number of fundamental issues for catchment management across different scales. The following recommendations arise from the research:

- **Efforts should be made to address the lack of confidence evident across the catchment, from the landholder to individual actors at the institutional level as it severely limits individual and collective ability to adapt to changing conditions and has an ongoing impact on sustainability.**

- **The effectiveness of catchment management would benefit from the inclusion of indicators related to process, transformative learning and problem solving. This would offer significant value particularly to track change in attitudes, development of consensus and accommodation of different perspectives when seeking solutions or developing management strategies.**

- **Any development of behavioural change indicators must address the conceptual disparity between the worldviews of scientists, catchment managers and landholders of sustainability.**

- **Due consideration and reflection by the CMA, on how the imposition of changes in practice might be interpreted and implemented, and an increased awareness of the self efficacy levels of landholders is essential for the success of such initiatives.**

- **The CMAs have an opportunity to develop trust and the self-efficacy of landholders and other members of the catchment community by engaging in tailored social learning opportunities like the LSAP and Footprint activities.**

- **Community engagement cuts across all areas within the jurisdiction of CMAs and should be regarded as integral to their effective operation.**

- **Transformational change needs to occur among landholders, scientists and natural resource agency staff to accommodate co-management in anticipation of an adaptive co-management approach to catchment management.**

- **CMAs have the potential to act as “bridging organisations” creating links with other organisations operating at the same or higher governance levels. This would create opportunities for sharing knowledge and representing alternative views about the equity and implications for rural communities of federal and state government policy.**
The importance of social networks in the communication of information and adoption of land management practices leading to both positive and negative environmental outcomes needs to be understood and utilised.

Programs aimed at supporting the ability of landholders resident in areas that have been affected disproportionately by the drought such as the Humbug and women more generally, are likely to result in more positive land management practices and improved self-efficacy.

In summary, CMAs are well placed to embrace the opportunity to take leadership in regional NRM and transform themselves into bridging organisations whereby they can

- explicitly describe and explain their role to the catchment community as an agency focussed on facilitating social learning
- begin a program of incremental change by working with landholder groups on a small number of well defined ‘sustainability’ projects that provide space to move through the observation-planning-action-outcome cycle and enhance the perceived self-efficacy of participants
- develop vertical and horizontal connections with relevant agencies to form an information sharing network which enables the downward filtering of information to the catchment community and upwards to the policy level
- influence NRM policy by demonstrating and promoting the advantages of reflective adaptive management and arguing for the inclusion of targets that attest its value.

This report is one of a series that provides details of findings from the PUTTI research. In addition to the reports on the first and second phases of the project (Porter et al. 2007; Bates et al., 2008) the following research reports are available:


1. INTRODUCTION

1.1. Rationale for Project

The Partnerships and Understandings Towards Targeted Implementation Project (PUTTI) was established following recognition by the NSW Joint Steering Committee (JSC)\(^1\) and Chairs of several Catchment Management Authorities (CMAs) that their ability to develop effective programs to engage the catchment community in incentive programs designed to encourage conservation practices was constrained by a lack of data on the attitudes and values underlying the land management decisions of landholders. In Australia and across the world NRM programs aimed at addressing sustainability tend to favour biophysical over socio-cultural elements reflecting a deficiency in the conceptualisation of sustainability issues (Pahl-Wostl, 2002; Pretty, 1995; Stratford & Davidson, 2002). Regionally based NRM programs that motivate landholders to voluntarily adopt more sustainable land management practices for sustained periods of time are important to help manage dryland salinity and halt on-going land degradation within catchments. However, incentive programs and education measures have failed to achieve the widespread adoption of conservation practices by landholders. The primary research aim of the PUTTI project was to understand the motivations of dryland farmers and identify the factors that influence their land management decisions so that effective intervention programs to improve sustainability could be implemented. PUTTI was funded as a state level project, sponsored by the Central West CMA, through the former NAP/NHT initiative, under a collaborative funding agreement with CSIRO. The project is focussed on landholders engaged in dryland farming within the Central West of NSW, covering the regions managed by the Central West and Lachlan CMAs.

This report is the final report for the PUTTI project and provides an overview of the research including a summary of the component activities. The report does not reproduce all of the material covered in earlier project reports. This final report should be read in conjunction with the component reports listed in the executive summary to understand the project and its outcomes in entirety.

1.2. Background

The PUTTI research project commenced in 2006 for a term of three-years. It builds on earlier research particularly the TARGET project (Tools to Achieve landscape Redesign Giving Environmental / economic Targets), an initiative of the NSW Salinity Strategy and the Murray Darling Basin Commission. TARGET highlighted the importance of understanding the social and economic context of catchments for the delivery of successful management outcomes (Earl, 2004)

The project adopts a mixed methodological approach that includes both qualitative and quantitative research such as interviews, workshops, surveys and predictive behavioural modelling using Structural Equation Modelling. The strength of this approach is the opportunity for consolidation and confirmation of research findings offered by complementary research methods. The implementation process included three stages or phases commencing in the Central West CMA in year one of the project, progressing into the Lachlan CMA during year two and consolidation, monitoring and evaluation across both CMAs in the final year. The design facilitated interaction between research activities with earlier research informing the development, interpretation and analysis of later research activities. As shown in Figure 1, activities throughout the project occurred in parallel with opportunities for feedback.

\(^1\)The JSC is a joint Australian and New South Wales Government Steering Committee current during the term of the PUTTI project. It was established to oversee the delivery of the National Action Plan for Salinity and Water Quality (NAP) and the Natural Heritage Trust (NHT) in New South Wales.
PUTTI was commissioned to help CMAs prioritise and implement on-ground actions to meet the objectives of Catchment Action Plans (CAPs). The CAPs address state-wide targets for NRM investment in the areas of biodiversity, water, land and community. Accountability for investment made by CMAs, is supported by the Standard for Quality Natural Resource Management and the associated guide for its use, developed by the Natural Resources Commission (NRC, 2005) and adopted by the NSW government.

The prime NRM issue for the project on initiation was dryland salinity. Dryland salinity has been identified as a major issue in both the Central West and Lachlan regions. Both areas were included in the 21 priority regions in Australia identified through NAP as most affected by salinity and water quality problems (NSW NAP Bilateral Agreement, 2002). NAP block funding was allocated to each of these priority regions. Intergovernmental Agreements across Australia, (such as the NSW NAP Bilateral Agreement), specify the implementation strategies for the NAP. At the catchment level much of the effort to address salinity issues has been integrated into land, soil

Figure 1. Schematic of PUTTI research activities.
and water management targets (and a specific salinity theme in the Central West CMA) in line with the NSW State Salinity Strategy.

PUTTI was funded as a state level regional project because it was anticipated that the results would have applicability across scales from individual property to catchment scale and also more broadly for dryland farming areas across the state. For the purposes of the PUTTI project, dryland farming was defined as agricultural activities that occurred within the study areas that were not dependent on irrigation.

As PUTTI addressed dryland salinity issues from a social science perspective, some perceived that the project had a primary focus on research that supported CMA efforts to address the state-wide targets for *community* embodied in the NSW State Plan i.e. that natural resource decisions contribute to improving or maintaining economic sustainability and social well-being; and that there is an increase in the capacity of natural resource managers to contribute to regionally relevant natural resource management. However, the impacts and consequences of dryland salinity are not confined to community. Consequently, PUTTI adopts an integrated approach, given that the community targets are inextricably linked to all others, and uses the state-wide targets for biodiversity, water and land in addition to those for community (NRC, 2007), to frame the research and provide greater contextual relevance for the CMAs. This approach is consistent with findings that there is little general awareness by farmers of salinity as an issue on their properties (Curtis, Byron & McDonald, 2003) and further, that a single issue approach to NRM is unlikely to be effective (Paton, Curtis, McDonald & Woods, 2004). Rather than take a single issue approach, research conducted in PUTTI, considered attitudes and decision making for land management practices relating to broader catchment management targets including soil; native vegetation; perennial pasture; weed and stock management.

### 1.3. Aims and Objectives

The objectives of the study are to:

1. Identify individual psychological and social barriers to the adoption of improved agricultural practices;
2. Identify possible measures to overcome the barriers, including communication and education for targeted attitudinal change;
3. Use the understanding of the social context to identify where to implement on-ground works and the need for biophysical investigations to support implementation;
4. Create and facilitate a genuine partnership between catchment managers, scientists and the catchment community to develop and implement an ongoing program to encourage community change and build trust between community members, scientists and decision makers;
5. Characterise the social drivers across a broader scale to assess spatial and temporal differences;
6. Identify the areas within the sub-catchment where potential intervention is likely to have the largest impact on natural resource management targets in the study areas;
7. Design a program to evaluate the specific change indicators at the individual farm/farmer level as well as at the catchment/community level;
8. Extend the process to cover additional CMA’s and sub-catchments to develop and validate the framework and ensure that it has wider applicability across the state.

The original proposal contained a further objective as follows:

9. Evaluate whether land use changes suggested by land owners will achieve the targets set in the CAP, and assess the magnitude of the land use change needed to achieve targets. The evaluation will include impacts on the water and salt balance and economic impact at...
the farm and sub-catchment scale conducted in association with biophysical investigations by other projects.

However, this objective was dependent on hydrological modelling colleagues attracting funding to enable a linked biophysical project to proceed. As funding for the linked project was not secured, and other research activities in the region could not fulfil the same purpose, attainment was compromised and the objective was withdrawn. Collaboration with colleagues from the proposed linked project was also essential to enable progress on objectives 3 and 6. Therefore, findings from the behavioural science research and collaboration with CMA staff were used to guide connection with on-ground works and interventions likely to have impact on NRM targets in the study areas.

2. RESEARCH CONTEXT

The PUTTI project was undertaken at a time of on-going change in the NRM scene in NSW. Many countries, like Australia, are experimenting with governance models that shape the formulation of policy, the development of structures to support the implementation of policy, and the unfolding of participatory and adaptive processes that enable the effective involvement of multiple participants in NRM. The following sub-sections outline in brief the key features of the context in which the PUTTI project was conducted including some theoretical perspectives of particular relevance.

2.1. The ‘Regional Delivery Model’ of NRM

Governmental policies to address land degradation issues have been a feature in Australia since the 1930’s particularly in the area of soil conservation. These approaches evolved into catchment and community based NRM in the early 1980’s from foundations in the Victorian and Western Australian state-based programs later to become the National Landcare program (NLP) in 1989. Total catchment management (TCM) approaches gathered momentum in NSW, enrolling Landcare such that the programme was seen to involve “natural resource management in a TCM framework at the local level of decision making and action” (NSW Landcare Working Party 1991, as cited in Lawrence, Vanclay & Furze, 1992, p. 187). Since 1990, successive Commonwealth Governments have introduced ‘new’ and expanded programmes for sustainable NRM, providing greater support for activities delivered through a regional model with relevance at a landscape scale. The programs, including NHT1 (1997); NHT2 and NAP (2001) and the new Caring for Our Country (2008/09) represent an investment in excess of A$6.51 billion (Hajkowicz, 2009).

Commentary on programs over the last two decades has highlighted both the strengths and challenges of implementing the regional governance model in Australian NRM but point to a lack in demonstrable benefits over this period (see Griffith, 2009, p11-12 for a summary). Despite frequent review, a characteristic that has persisted through multiple iterations of Commonwealth NRM policy, is the tension that emerges in the system due to a top-down administrative, bureaucratic practice that continues even though there is a reliance on participatory and collaborative processes to achieve environmental management (Lawrence et al., 1992; Lockie & Higgins, 2007; Lockwood, Davidson, Curtis, Stratford & Griffith, 2009; Marshall, 2008a; Wallington & Lawrence, 2008).

The PUTTI project commenced under the NHT2/NAP program where CMAs, through their CAPs (an accredited regional plan required by the bilateral agreement) set out catchment level objectives on biodiversity, native vegetation, water and aquatic systems, land management, people and the community. Under the bilateral agreement, the lead agency in NSW with primary responsibility for NRM acts as an intermediary while the Natural Resources Commission (NRC) provides independent advice on managing the state’s natural resources. The view of the NRC with respect to the relationship between CMAs and their catchment communities is reflected in their statement that

“...a key part of the CMAs’ role is to engage with their communities, gain their trust, build their ownership of the regional CAP and targets and then ‘help them to help themselves’ by
voluntarily adopting sound NRM practices and acting as stewards of the natural resource assets on their land.” (Natural Resources Commission 2008, p. 3).

2.2. Challenges of Community Based NRM

Under the institutional arrangements supporting the devolution of responsibility for NRM to regional levels, CMAs are compelled to foster a sense of shared accountability for environmental problems among farmers and other members of the catchment community. To achieve this CMAs need knowledge of biophysical processes affecting NRM at the local to regional scale backed by sound science and a skill set inclusive of diplomacy, facilitation, coordination, conflict resolution, lobbying, empowerment, networking, fiscal management, contract management, monitoring, evaluation, reporting, adaptability, leadership, communication and so on. (Aslin, Mazur & Curtis, 2002; Morrison & Lane, 2006; Robins & Dovers, 2007) It is unrealistic to assume that CMAs would be well-equipped to handle the complexities inherent in the regional governance model with less than four years operational experience. Similarly, the capacities required of members of the catchment community overlap with those of the CMA and include adaptability, responsiveness, leadership, confidence, farm planning, resource management, financial management, succession planning, coordination, negotiation and so on. Further, skill levels and capacities among members of the catchment community vary widely adding to the complexity of collaborative management.

Capacity building as a philosophy is entrenched in NHT/NAP through the National Natural Resource Management Capacity Building Framework, which specifies four major areas for investment at the regional level: awareness, information and knowledge, skills and training, and facilitation and support (Commonwealth of Australia, 2002). In addition the incentive programs developed by CMAs must operate within investment guidelines imposed by government. As an indication, during the term of PUTTI, the investment rules for the Central West meant that 80% of their budget was allocated to on-ground activities i.e. actions that achieve priority resource condition outcomes; 15% to coordination and support i.e. developing people’s decision-making capabilities and motivating involvement in NRM and 5% to monitoring, evaluation and reporting i.e. achieving systematic monitoring, review and improvement of project works and activities. (T. Gardiner, personal communication, October 14, 2006). The opportunity for capacity building under these operating guidelines is limited at best. Further, expectations about how easily community based NRM can be implemented and how quickly the flow on benefits begin to accrue appear optimistic. The assertion that NRM governance arrangements have been devolved to the regional level has been questioned. It would be expected that under such an institutional arrangement, a multi-governance system would emerge. However there is a sense that in functional terms, control remains centralised and there is a substantive lack of subsidiarity (Marshall, 2008b; Robins, 2008; Wallington & Lawrence, 2008). The principle of subsidiarity is commonly perceived as an essential element of effective governance across multiple levels and refers to the idea that both decisions and responsibility for tasks occurs as close as possible to the level of the people that are affected by the decisions and have the requisite capacity and competence to assume responsibility.

The regional delivery model established by policy adheres strongly to the ideal of ‘civic regionalism’ (Lane, 2006) and adaptive co-management. Under adaptive management, multiple public and private catchment members engage in the collective management of natural resources, and periodically re-assess and modify management strategies and objectives in response to changes in the political, economic and environmental scene and scientific advances. Adaptive co-management is an attractive idea, but the practical and operational reality is that it is quite difficult (but not impossible) to overcome the impediments arising from different stakeholder agendas, variations in knowledge levels and differences in readiness and or capacity to respond to changing circumstances that characterises most regional structures. Figure 2 illustrates one representation of a co-management network indicative of catchment management situations where there are multiple interactions on different tasks (A-F in the figure) between individuals and groups from the private sector and government.
Adaptive co-management or collaborative management relies on concepts of partnerships, power sharing, social capital, social learning and social networks to function effectively. Carlsson and Berkes suggest that it is fruitful to understand the functional rather than the legal and formal side of such arrangements as “co-management is a continuous problem-solving process, rather than a fixed state, involving extensive deliberation, negotiation and joint learning within problem-solving networks” (Carlsson & Berkes, 2005, p 65).

Figure 2. A co-management network with multiple interacting participants and tasks (from Carlsson & Berkes, 2005, 69)

The concept of social capital has long been associated with collective action and the efficacy of community based NRM (Agrawal & Gibson, 1999; Gruber, 2008; Paavola, 2007; Pretty & Ward, 2001; Westermann, Ashby and Pretty, 2005). Putnam (1993) defined social capital as social organisation like “networks of civic engagement” (p167) with features like trust, reciprocity and norms, which improve their efficiency by facilitating coordinated actions. Social capital, arising from and strengthened through social relationships, is regarded as an important resource on which communities can draw to build greater awareness of environmental issues, support opportunities for social learning and facilitate collaborative action. The trust that develops between individuals and groups through repetitive interaction reduces transaction costs and “lubricates action” (Pretty and Ward, 2001). However, an issue that is sometimes not fully recognised is that building social capital to achieve NRM outcomes by minimising diversity of views may not necessarily have the desired outcome. Rather focussing on “ambiguity and difference” to examine disparate worldviews and identify acceptable compromise solutions sometimes provides a useful way forward (Boxelaar, Paine & Beilin, 2007).

The NRM objectives of CMAs are explicit in their CAPs, as is the need for community engagement. However, the priorities of landholders and CMAs are not always well aligned. Partnerships are key to the achievement of catchment and management targets. Linkages, both horizontal (between groups at the same level) and vertical (across different levels – both up and down) provide the necessary connections with participants, government agencies and Landcare groups for example, that facilitates interaction and knowledge sharing. Generally, some type of formalised arrangement is necessary to support the functioning of collaborative partnerships. For CMAs, incentive programs act as a bridging mechanism between the goals expressed in the
CAPs and on-ground achievements. To encourage change in land management practice on private land to benefit the resource condition in the broader catchment, incentives are offered to landholders. Still, many of these programs are either under-subscribed or do not yield the anticipated benefits. Some of the reasons past studies give for the lack of uptake are provided below (section 2.3). A prime motivation for the PUTTI research was to provide further insight into the conditions underpinning the uptake of environmentally sustainable land management practices by members of the catchment community and so identify potential opportunities for beneficial intervention.

2.3. Factors Influencing Broad Capacity for Change in Australian Rural Areas

Critiques of extension practices and constraints to the adoption of innovations in rural areas are available in the literature (Black, 2000; Barr & Cary, 2000; Cary, Webb & Barr, 2002; Pannell et al, 2006). A discussion of factors influencing the adoption of environmentally sustainable practice with particular relevance to the PUTTI project can be found in Leviston et al, Section 2 (2009). Research findings from the PUTTI project specific to land management and change are amalgamated with other findings later in this report. Material in this section deals more briefly with the operating environment of landholders in rural Australia today.

Extension practitioners apply techniques ranging from “linear ‘top-down’ transfer of technology; participatory ‘bottom-up’ approaches; one-to-one advice or information exchange; and formal or structured education and training” (Black, 2000, p493). In Australia as in most parts of the world, those involved in encouraging landholders to adopt environmentally sustainable practices generally rely on a combination of strategies. Adoption rates continue to be a source of frustration even though it is recognised that “adoption depends on a range of personal, social, cultural and economic factors as well as on characteristics of the innovation itself” (Pannell et al, 2006, p1407).

In recent times, both the environmental and social sustainability of communities in non-metropolitan Australia have been affected by changes in population and political influence, the emergence of international markets and production contracts, the escalation of debt levels and a gradual shift from a landscape dominated by family farms to one with a greater percentage of corporate enterprises and hobby or lifestyle farms (Drought Policy Review Expert Social Panel, 2008, Green et al., 2009, Stone,1992). The extent and relative advantage or disadvantage acquired by any community as a result of these factors has not been uniform. Variation in impact across rural areas has been driven for example by proximity to metropolitan areas, access to water, and the age profile and income distribution of the population. It is important to recognise however, that these changes are happening at a time when many rural people feel they are in crisis while other parts of the country are prospering (Green et al., 2009). Confidence that urban Australia values the contribution of agriculture as indispensable has faded. Societal expectations about the roles of farmers as land stewards as well as agricultural producers constitute an additional pressure for farmers (Cocklin & Dibden, 2005). The combined influence of all these factors on the preparedness of rural landholders to embrace change can not be underestimated.

An additional set of factors that affect the capability of rural landholders to change practice is the complexity of institutional arrangements that operate within rural areas. As well as the three tiers of government, there are multiple programs on offer addressing different aspects of land management. Each has a different application process and reporting or compliance requirement. There have also been many organisational restructures with state agencies shuffling portfolios and names within the environment domain to such an extent and with such frequency that landholders are not sure of the correct contacts for a given management topic. Landholders are also adjusting to the privatisation of extension services, the pace of which has accelerated in recent years (Marsh & Pannell, 2002). This has not only placed increased demand on private
agronomists, but has increased uncertainty about how to interpret advice provided by agricultural product providers who may not be in a position to give objective recommendations due to their affiliation with manufacturers.

2.4. Dryland salinity: A Persistent Environmental Issue

Soil salinisation, the surface or near surface expression of salt caused by the evaporation of saline groundwater, is a major land degradation issue in Australia. While primary salinity is a “natural part of the landscape such as saline marshes and salt scalds” (Eberbach, 1998, p79), secondary salinity is often referred to as ‘human-induced’ because the salt discharge occurs as a result of land use or land management such as the clearing of deep rooted native vegetation for shallow rooted annual agricultural crops (Kingwell, John & Robertson, 2008). The impacts not only affect natural ecological systems but also productive and sustainable land use.

Key findings from the National Land and Water Resources Audit (2001) estimate that 5.7 million hectares of Australia’s land is at high risk from dryland salinity and predicts that this area will increase to 17 million by 2050. While some suggest that the estimates overstate the areas at risk (Pannell & Ewing, 2006), there is general agreement that the extent of this problem has created a major challenge for governments, industry and the community to develop management approaches which protect vulnerable environmental and human assets; address the problem of rising water tables; and make productive use of saline resources (National Land and Water Resources Audit, 2001).

Governmental responses to the salinity issue have been substantive. The National Dryland Salinity Program (NDSP) was established in 1993 by the State Governments of NSW, Queensland, Victoria, South Australia and Western Australia along with Land and Water Australia, the National Landcare Program, and the Murray Darling Basin Commission to take a coordinated approach to salinity research (Robins, 2004). This was followed in the early 2000’s by the National Action Plan for Salinity and Water Quality (NAP) with a specific National Salinity Program. Supplementing this initiative, the Cooperative Research Centre for Plant-based Management of Dryland Salinity operated from 2001 to 2007. These efforts have provided significant insight into the hydrological processes driving land and water salinisation. This has been augmented by greater education and extension activities, the development of new and improved, salt-tolerant plant species for use in new farming and grazing systems that support biodiversity outcomes and insight into the economic and policy implications of proposed interventions.

Salinity is no longer a prime focus of the Australian NRM agenda. This is at least in part due to a re-direction towards dealing with the impact of the drought in south-eastern Australia and lack of confidence that actions to counter-act salinity were feasible or effective. In addition debate amongst scientists and agri-business professionals has lead to confusion making it more difficult for landholders to determine appropriate implementation strategies at the farm level. Robertson et al (2009) assessed the constraints expressed by landholders on the management of dryland salinity in the central wheatbelt region of Western Australia. The majority of landholders stated that lack of knowledge of appropriate actions at the property scale was a prime issue affecting their capacity to manage salinity. While this study found that wide-scale adoption was dependent on the economics associated with implementation, it was the finer detail surrounding implementation such as uncertainty about where on the property to undertake a mitigation option that became the limiting factor.

Each ‘solution’ comes with its own strengths and weaknesses, which add to the complexity of the problem. Pannell & Ewing (2006) detail some of the possible farm management responses, which include:
- having more productive annuals (deep roots, increased water use),
- having the right perennials for the right systems and rainfall (e.g. herbaceous perennial pastures or woody shrubs and trees),
- understanding the commercial production value of perennials,
- introducing the right salt tolerant plants to fenced off saline and water logged areas,
- considering engineering options (e.g. shallow surface drainage) as an alternative or supplement to vegetation management but taking into consideration the cost effective and safe disposal of the discharge,
- understanding that perennials need to be planted at a proportion that is higher than present and therefore need to be commercially attractive/profitable for farmers.

Conacher and Conacher (2000) suggest ‘band-aid’ approaches such as fencing and establishing salt tolerant species have additional advantages in that they may improve aesthetics of salt scald, reduce erosion and provide some grazing for sheep. They also highlight the disadvantages of deep drains for stock and machinery movement and associated excavation costs, as well as the problems with disposal particularly for neighbours and on pristine riparian areas.

Overall, the problem is recognised as complex and one that requires a variety of solutions (Conacher & Conacher, 2000; Pannell, 2000; 2001). Site specific remedial measures have to be considered (Conacher & Conacher, 2000) as well as the viability of options to be adopted by farmers (Pannell, 2000). It has also been recognised that it is important not to assume that we already have all the answers (and that they just haven’t been adopted), as more research and development is required to understand what will work best in different locations (taking into account different topography and soil types) as well as acknowledging different farming systems (Pannell, 2000).

The programs specifically aimed at combating salinity all shared an important commonality in that they promoted community based approaches as the way to overcome land degradation (Kingwell et al., 2008). The strengths and weaknesses of the community based approach to salinity management are outlined by Kingwell et al. (2008). They argue that such an approach in Australia has been successful at raising awareness and providing education about the problem but the approach was flawed when it failed to recognise that the groups alone could not combat the problem. Other weaknesses of the community-based approach include:

- operational logistics of groups (e.g. conflict),
- volunteer burn-out,
- ageing farming population,
- lack of technical and research staff,
- lack of commitment and rigour to monitor the effectiveness of salinity management options.

Pannell (2000) highlights another weakness, suggesting that there was unnecessary pressure placed on regional groups to make high level decisions about how to prioritise spending within a limited budget. In addition, he suggests that the continuation of the community based approach draws heavily on the “good will” of farmers, many of whom have already made personal and financial sacrifices for little reward.

As part of the PUTTI project, the landscapes and livelihoods component included engagement with specific local level intervention activities focussed on heightening awareness of salinity potential in the landscape developed by the CMAs in association with the (then) NSW Department of Environment, Climate Change and Water (see Green et al., 2009).

2.5. The Protracted Drought

The study areas for the PUTTI project fall within South-Eastern Australia, south of 33.5°S and east of 135.5°E (see Figure 3). This area experienced one of the driest decades (1996 – 2006) on record due to significant rainfall deficits (Murphy & Timball, 2008). While other areas in Australia as a whole are experiencing above average rainfall, the long-term rainfall deficits have not only continued but worsened in South-Eastern Australia over the three year period from May 2006 to
May 2009 (Timbal, 2009). In addition, there have been changes in the seasonality of the rainfall decline, with an evolving situation where rainfall deficiencies are occurring throughout the usual 8 month wet season, between March and October (Timbal, 2009).

Australian farmers are subject to a number of stressors that cumulatively contribute to psychological distress which can lead to maladaptive coping, particularly in times of drought (Staniford, Dollard & Guerin, 2009; Caldwell & Boyd, 2009). The definition of drought is contested. Botterill (2003) suggests that drought is socially constructed and not simply a function of rainfall deficiencies or meteorological and hydrological conditions. Rather, drought is a state in which the need for water outstrips availability, thereby negatively impacting communities and socio-economic conditions. Perceptions of drought in rural communities are affected by declining agricultural terms of trade which mean that farmers need to increase production to make a living, requiring more water (Botterill, 2003; Heathcote, 1994; Alston & Kent, 2004).

It is of concern that Australian data shows a link between declines in agricultural terms of trade and increases in suicide rates of Australian male farmers, which is now double that of the broader male population (Fragar, Kelly, Peters, Henderson & Tonna, 2008).

Ongoing drought has been identified as the most significant pressure on Australian farmers and their families (Hossain, Eley, Coutts & Gorman, 2008); however, most studies of Australian drought focus on the costs to regions and sectors, with few providing estimates of the economic impacts to farmers (Edwards & Gray, 2009). In times of drought, poverty and resultant geographic mobility extends beyond farm families to people in rural communities that are not directly employed in agriculture (Edwards & Gray, 2009). In recognition of the growing costs of the prolonged drought across Australia to farming families and communities numerous studies and reports have recently focused on the psycho-social impacts of drought, particularly within NSW (Alston, 2006; Alston & Kent, 2004; Dean & Stain, 2007; Fragar et al. 2008; Hossain et al., 2008; Sartore, Kelly, Stain, Fuller, Fragar & Tonna, 2008a; Sartore, Kelly, Stain, Albrecht & Higginbotham, 2008b; Staniford, Dollard & Guerin, 2009; Stayner & Barclay, 2002).

The ‘Social Impacts of Drought’ report was contracted by NSW Agriculture and the Premiers department (Alston & Kent, 2004). A number of serious drought impacts were identified in the report including: health and welfare issues such as depression, suicide and stress; increased workloads, rural poverty and isolation; and reduced services and educational opportunities. These impacts contribute to an overall destabilisation of inland rural communities which experience declining population and reduced social cohesion. The authors also conclude that farm families in more remote and inland areas, like Condobolin, are particularly negatively affected and that the drought is a ‘gendered experience’ which differentially affects men and women. In times of drought, rural women are often involuntarily separated from their households in order to obtain off-farm income. In this context, paid employment is usually undertaken in addition to their domestic chores, farm duties and community obligations (Alston, 2006; Alston & Kent, 2004).

Other stressors experienced by Australian farmers and exacerbated by drought include: uncontrollability of events; work pressures; interpersonal problems; ageing rural populations; and the difficulty of tasks associated with adoption of technology and policies (Hossain et al., 2008; Staniford, Dollard & Guerin, 2009; Sartore et al. 2008b). A lack of sufficient coping strategies in times of drought can lead to depressive and physical symptoms in farmers impairing their work and experience of life (Staniford, Dollard & Guerin, 2009). Economic stressors and stress symptoms, like those experienced in drought, can impair farmers’ performance, contributing to accidents and injuries (Glasscock, Rasmussen, Carstensen & Hansen, 2006). The ability of a farming family to cope with stressors such as drought and to undertake appropriate adaptation depends on their access to resources and their individual traits. Caldwell and Boyd (2009) identified a number of coping mechanisms that farming families in NSW employ in times of drought including: expansion and diversification; optimism and hard work; putting things in
perspective; denial, cognitive dissonance and avoidance; seeking support from family and community; drawing on a sense of history.

The psychosocial costs of drought that are detailed in the literature are typically framed in terms of mental health and service provision with minimal focus on environmental impacts of psychosocial issues linked to drought. Decrements in psychosocial resources reduce the likelihood of farmers undertaking adaptive behaviours to mitigate environmental degradation on their properties (Van Haafken, Zhenrong & Van de Vijer, 2004; Van Haafken & Van de Vijver, 1996a; Van Haafken & Van de Vijver, 1996b). Furthermore degradation in the physical surroundings of farming families can lead to anxiety and feelings of helplessness (Sartore et al., 2008b). As such, more research may be required on the link between drought, psychosocial factors and land management practices.

3. METHODS

3.1. Study area

The PUTTI project was conducted in the Central West and Lachlan CMA regions with a particular focus on four sub-catchments: the Bell and Cudgegong in the Central West; and the Mandagery and Humbug in the Lachlan (see Figure 3). These areas were selected by the CMAs on the basis of pre-existing dryland salinity issues; interest in encouraging greater community awareness of the link between individual land management practices and catchment management targets; and a desire to extend community engagement efforts in these areas.

Both the Central West and Lachlan catchments support a diverse range of land use with agricultural production related to dryland cereal production and livestock grazing the main enterprises. Other industries comprise mining, intensive viticulture and horticulture. The Central West covers an area of 92,000 km² and has a population of 185,515. Major towns include Bathurst, Orange, Mudgee and Dubbo. The Lachlan has an area of 84,700 km² with a population in excess of 106,000. The major towns include Crookwell, Cowra, Young, Forbes, Parkes, Condobolin, West Wyalong and Hillston. Both catchments include ecosystem assets of national importance: the Macquarie Marshes and privately owned “Wilgara” wetland in the Central West and Lake Cowal, the Boorigal Wetlands and the Great Cumbung Swamp in the Lachlan. NRM issues of prime significance in both catchments include dryland salinity, surface water quality, native vegetation, riparian and wetland ecosystems and soil resources with loss of biodiversity further identified as a threat in the Lachlan catchment (Central West Catchment Management Authority, 2006; Lachlan Catchment Management Authority, 2006). Further details of the agricultural and demographic characteristics of the sub-catchments in the PUTTI study are included in reports for Phase one (Porter et al, 2007); Phase two (Bates et al, 2008) and the component reports that accompany this final report (see Executive Summary for citation details).

3.2. Study design

The PUTTI research project set out to elaborate the psycho-social factors that affect landholders in their decisions to adopt or reject promoted best practice in dryland farming in the central west of NSW. The aim was to study at least two CMA regions over the course of the project to identify any differences and or similarities between regions and over time. The findings were to inform a behavioural change program designed and implemented in concert with the catchment community. The study approached land management behaviour from both an individual and collective level though the focus was to use substantive understanding of factors influencing the decisions made by individual farmers gained from qualitative enquiry and quantitative analysis of survey data as the basis for later interactions aimed at inducing or supporting change.
The research followed a mixed methodological approach where the formulation of research questions, research methods, data collection and analysis, conceptual model development and scientific interpretation and inference relied on both qualitative and quantitative methods (Teddie & Tashakkori, 2009). The two strands of enquiry were closely integrated in an iterative sequential mixed design defined as “the analysis of data from a sequential study that has more than two phases” (Teddie & Tashakkori, 2009, 277). For example, individual interviews with members of the Central West catchment community during the scoping phase were used to inform the development of a survey instrument that gathered data for statistical analysis and the development of a behavioural model predicting the land management behaviour of dryland farmers.
Figure 3. Study area: Bell, Cudgegong, Humbug and Mandagery sub-catchments in the Central West and Lachlan CMA regions of NSW
A strength of this type of research design is that inferences drawn from the two strands (qualitative and quantitative) sometimes reveal deficiencies in the conceptualisation of the research questions that can then be addressed in a subsequent phase. Throughout the term of the project members of the investigative team went back and forth between statistical and thematic analysis to broaden the study areas, refine the behavioural models and develop a deeper understanding of the needs of the community to underpin sustainable change. Figure 1 outlines the research activities undertaken during the project; further details of the mixed model design and integration between different stages and components of the research is shown in Figure 4.

3.3. Research and analytical techniques

As indicated above, the research conducted in PUTTI utilises both qualitative and quantitative methods. While it is not appropriate to provide a comprehensive overview of the analytical methodologies employed in this report, a brief description is provided to facilitate understanding of the research.

3.3.1. Thematic analysis

Qualitative research is generally “engaged with exploring, describing and interpreting the personal and social experiences of participants” (Smith, 2008, 2). The PUTTI project makes extensive use of data gathered through individual or group interviews with members of the catchment communities within the study areas involved in or associated with dryland farming. By far the majority of participants are landholders, although the inclusion of agribusiness professionals, State agency employees, CMA staff and academics or researchers has provided a broader view of farming in rural areas. The transcripts of these interactions have been analysed using thematic analysis, an inductive technique whereby emergent patterns, themes and categories are documented. Thematic analysis makes use of the similarity principle where information within a transcript with similar content is grouped into a theme or category (Teddie & Tashakkori, 2009). By conducting semi-structured interviews or workshops in different dryland farming regions and completing thematic analysis, emergent themes can be compared or contrasted. Marked differences in attitudes, perceptions or practice become apparent and may reflect either different or similar experiences, aspirations, worldviews or even physical settings. As indicated in Figure 4, thematic analysis was utilised throughout the PUTTI project.

3.3.2. Behavioural modelling

While qualitative analysis provides rich data on the land management practices of landholders it does not facilitate the identification of the relative importance (in a quantified sense) of factors that influence the likelihood that landholder’s management practices are positive. The behavioural modelling activities allowed for the iterative improvement of a statistical model showing the relative importance of a set of factors (variables) on land management practice. The modelling process reveals those factors that potentially offer the most promise for targeting by intervention strategies. Variables initially included that did not reach statistical significance are eliminated in the analytical process. However, it is important to note that the modelling results are balanced by consideration of outcomes arising from the other components including scoping interviews, Landscapes and Livelihoods workshops and Social Network Analysis.

Data for the behavioural modelling was obtained from a series of surveys of dryland farmers. Knowledge gained from field activities and subsequent thematic analysis was utilised in conjunction with the outcomes of literature reviews and previous research by CSIRO to identify a set of variables postulated to influence the land management decisions of
Figure 4. Schematic depicting the iterative, sequential mixed method design utilised in the PUTTI project.
landholders. A survey instrument was designed to gather data on the identified variables. The questionnaire underwent review and refinement over the course of the project.

To investigate the influence of the variables contained in the questionnaire on land management practice scores, regression modelling using Structural Equation Modelling (SEM – see Glossary) was employed. The structural model produced by SEM specifies the causal relationships among the latent variables, describes the causal effects, and assigns the explained and unexplained variance of each latent variable.

SEM was chosen for several reasons. Firstly, SEM allows the estimation of multiple and interrelated dependence relationships. It was hypothesised that there would be considerable overlap between some of the socio-psychological variables of interest; therefore a method that accounted for shared variance between these variables and allowed for the identification of relative contributions was preferred.

Secondly, SEM is able to represent directly unobserved or hypothetical constructs (called ‘latent’ variables). For instance, a concept such as ‘locus of control’ cannot be directly measured (one cannot ask a person directly to determine whether they have an internal or external locus of control), rather it is indirectly measured through a range of questionnaire items all designed to subtly measure where a respondent believes locus of control to lie. All of these items and their associated variances can be included in the model, meaning that a more accurate account of the relationship between latent variables can be calculated.

Thirdly, SEM accounts for measurement error in the estimation process (Hair, Anderson, Tatham & Black, 1998). There are some concepts for which it is harder to design reliable measures than others. For example, a respondent’s land management practice is more difficult to capture accurately than their age bracket. SEM allows these limitations in reliability and validity for latent variables to be factored into the analysis.

The behavioural score assigned to survey respondents served as the basis for the modelling in this study. Details on the score calculation are provided in Section 3.4.4. The accuracy of the behavioural measure assigned to each respondent as a result of survey responses depends on the reliability of the scales developed to measure the psycho-social constructs identified as variables within the model, the reliability and relevance of the questions included in the survey instrument and the validity of the interpretations of the numerical data made by the project team. Comprehensive scoping activities and thematic analysis ensured the reliability and relevance of the questions included in the survey. Iterative review was undertaken to modify and refine the questions in successive surveys to maintain relevance. The interpretation of data was undertaken in consultation with CMA staff to ensure that the aggregated score correctly reflected whether the practices and associated motivations of each respondent were likely to result in positive or negative environmental outcomes. A description of analysis undertaken to ensure scale reliability is provided in Section 3.4.1.

3.3.3. Social Network Analysis

Social networks are a familiar construct in everyday life as the relationships people build throughout their lives are often associated with work, social events like sporting clubs or experience like old school ties. Social scientists have been interested in the function and structure of social networks for hundreds of years while advances in analytical methodologies like graph theory and sociometry since the 1970’s have afforded greater opportunities for analysis. Social Network Analysis (SNA) is primarily interested in the relations between individuals (actors or nodes) rather than attributes of the individual themselves. As stated by Knoke and Kuklinski “the structure of relations among actors and the location of individual actors in the network have important behavioural, perceptual and attitudinal consequences both for the individual units and

Attitudinal modelling and monitoring of factors influencing land management practice in the Central West and Lachlan Catchments
for the system as a whole” (Knoke & Kuklinski, 1982, 13). Individual attributes assume more importance when analysis is considering the influence relationships have on behaviour.

SNA has been used in a diverse range of fields including politics, business, health and economics as well as the behavioural sciences. In the environmental domain, research has focussed on the impact of social networks on the effectiveness of natural resource management. When assessing the relevance of SNA in NRM, it is useful to consider the fundamentals that set social network analysis apart from other approaches. These are

- there is a focus on relational aspects of interactions
- there is an interdependency between actors and their actions
- the linkages between actors are channels for the transfer of resources or ideas
- the network structure provides opportunities for or constraints on individual action
- the structure of networks are conceptualised as “lasting patterns of relations among actors”

Wasserman and Faust (1994, 4)

The PUTTI project investigated the potential importance of social networks as a facilitating process for the spread of innovative practices in farming regions. Snowball sampling was used to gather data on the connections or ties related to sources of farming advice between members of the catchment community involved in agriculture. A technique known as social influence modelling was used to investigate the influence of these relationships including structural properties and the attributes of individuals within the network on the land management practice of participants. “Social influence occurs when an individual adapts his or her behaviour, attitudes or beliefs to the behaviour, attitudes or beliefs of others in the social system” (Leenders, 1997 as cited by Robins, Pattison & Elliot, 2001, 162). This is sometimes known as contagion. In this case the attributes included the attitude of individuals embedded in the land management practice behavioural score.

3.3.4. Causal Layered Analysis

Causal Layered Analysis (CLA) is a qualitative analytical technique that interprets transcript data according to four different layers or levels each of which affords a deeper understanding of the underlying causes or supporting reasons for attitudes and actions including the emotive dimensions of a problem or issue (Inayatullah, 2004). This method was considered particularly relevant and useful for identifying factors that needed to be taken into account in a change program from the collective community perspective as it delved deeply into the worldview of landholders and their fears, aspirations and preferences for the future of rural communities and environmental, cultural, economic and social sustainability.

The method consists of analysing data on four levels: litany – stated issues, problems, trends; social structural – systemic causes for issues; discourse/worldview – reflects interests and deeply held convictions; and metaphor/myth – deep stories or assumptions. Metaphors may either reveal or conceal factors operating in any situation, and their exploration may provide insight into how individuals making environmental decisions perceive the context of pertinent issues or how enthusiasm might be harnessed for future action (Ison, 2005). Table 1 provides a summary of each layer and an example drawn from the dryland farming context and expressed in conversations with participants.
Table 1 Summary of Causal Layers and their focus (from Green et al., 2009, 7)

<table>
<thead>
<tr>
<th>Layer</th>
<th>Focus</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litany</td>
<td>Identifies the surface level issues and is akin to conducting a thematic analysis whereby you look for common or irregular themes.</td>
<td>Farming practices such as stubble retention.</td>
</tr>
<tr>
<td>Social Structural</td>
<td>Identifies social processes, interactions, structures or relationships, to identify the context in which people live.</td>
<td>Changes in the demographic of the community with many younger people seeking employment opportunities in cities or larger towns.</td>
</tr>
<tr>
<td>Worldview/Discourse</td>
<td>Identifies the language that people use when talking about a particular issue or their world more generally, and, how what they say and how they say it helps depict their perspective or worldview.</td>
<td>Different perceptions of sustainability as a term. Can be limiting when describing actual practices in context.</td>
</tr>
<tr>
<td>Myth/Metaphor</td>
<td>Identifies metaphors, stories, myths and symbols about the topic of analysis.</td>
<td>During hard times, the challenge of farming is like a ‘battlefield’.</td>
</tr>
</tbody>
</table>

3.4. Research process

The research project comprised three phases: Phase one - year one, conducted in the Cudgegong and Bell sub-catchments of the Central West; Phase two – year two, conducted in the Mandagery and Humbug sub-catchments of the Lachlan; Phase three - year three, conducted in all four sub-catchments. The research design included stages nested within both phases one and two where:

- **Stage 1: Scoping Study**
  Semi-structured interviews with members of the study area community to understand landholders’ attitudes, beliefs and values relating to farming practices and decision-making;

- **Stage 2: Community Survey**
  A survey of landholders in the study areas to collect additional data and identify the key psycho-social drivers of farming practices and decision-making on landholder’s properties.

An overview of the process followed for the conduct of the PUTTI research during each phase is provided in the following sections.

3.4.1. Overview of steps in the behavioural modelling

Behavioural modelling undertaken during the course of the project facilitated the identification of the relative significance of observed and latent variables on desirable land management practice of landholders. Data for the modelling was obtained from surveys conducted in successive phases of the project. This allowed for an iterative refinement of the behavioural model.

The surveys utilised a series of scales (made up of a set of questions or attitudinal statements) to measure attitudes and values. Some refinement of the scales occurred during the course of the research. A statistical technique was used to assess the scale reliability (internal consistency), that is, the degree to which all the items making up the scale measure the same underlying construct. As a result of this analysis a correlation value, Cronbach’s alpha (see Glossary) is obtained with values ranging from zero to one with scores closer to one indicating that items within a scale are more internally consistent. Appendix C contains details of the assessment of scale reliability for the final survey as an example of the process and outcomes of reliability analysis. A Principal Components Factor Analysis (see Glossary) was performed on the attitude
statements used in the final questionnaire to establish which statements were measuring the same concepts. This analysis revealed that the attitude statements in the questionnaire statistically grouped together to form scales in a manner that was consistent with previous research reported in Bates et al., 2008 (see Leviston et al. 2009, Appendix 4 for the correlation matrix).

The modelling process used for each study area in the Central West and Lachlan followed the same protocol. An hypothesised model was constructed containing a set of variables postulated to influence land management practice. Following this, investigation was made of the causal relationships between the components of the hypothesised model using the robust maximum likelihood estimation method in LISREL 8.72 (Joreskorg, Sorbom, du Toit & du Toit, 2000). All non-significant relationship pathways to the dependent variable (land management practice) were removed. The estimated model shows the relationships between the latent variables and their respective indicators. The estimated model is then simplified by removing the indicators to show statistically significant pathways (relationships) between variables and their respective strengths.

3.4.2. Central West study areas – Cudgegong and Bell sub-catchments

Research activities commenced in July 2006 with the selection of focal sub-catchments by the Central West CMA. The research process for this first phase involved regional visits and the conduct of scoping interviews in August/September, 2006 (Cudgegong, n = 42; Bell, n = 37; total n = 79) designed to familiarise the research team with dryland farming issues specific to the area and to investigate the values, attitudes and beliefs of landholders and agribusiness professionals about on-ground land management practices in particular and broader management level actions like farm planning. Phase one continued with the design of a survey instrument and an hypothesised model of land management practice for the Bell and Cudgegong areas based on analysis of the scoping interviews, learnings from previous research by the PUTTI team and a comprehensive review of the international and local literature on the adoption of agricultural innovations including the psycho-social elements impacting on the ability of landholder's to adopt new practices. Both the hypothesised and predictive model of land management practice were intended to be preliminary with the study design allowing for review and refinement over time.

For the Central West study areas, the exploratory hypothesised model contained 16 variables including a number that were latent (unobserved variables, factors or constructs) thought to predict the dependent variable – land management practice. The variables included in the exploratory model were: farm size; farm experience (number of years practicing as a dryland farmer); age; lifestyle (farming as a lifestyle choice as opposed to a business); agricultural qualifications; community engagement (membership of community groups); farm plan (respondents use of a formal farm plan); environmental values (general views of and interaction with the environment); succession planning; science and technology (respondents belief in science and technology as a source of solutions to land management issues); perceived barriers to change; perceived environmental condition (respondents perception of property and region’s condition); trust in and influence of information sources; social norm (the extent that the views of other farmers in the area influence the respondents’ behaviours); perceived effectiveness of behaviour (the extent that respondents believed that stated land management practices are effective components of overall good land management) and innovator (the extent that respondents report that they are innovative). See Appendix A for the Central West hypothesised model and further description of the variables.

Following pre-testing a phone survey was conducted in February 2007 with a target of 400 respondents from the two focal sub-catchments. Participants were randomly selected from

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2 Note that non-significance here does not necessarily imply non-importance. It means simply that, relative to the other variables in the model, these variables did not contribute significantly (in a statistical sense) to improving the model’s predictive power.
telephone lists and interviewers were directed to ask to speak to the principal decision-maker for the property (owner or farm manager). Interviewers were instructed to contact each property on their lists at least five times, at different times of the day and across different days, before the property could be classed as a ‘non-contact’.

A total of 407 surveys were completed, 221 (54.3%) from the Cudgegong and 186 (45.7%) from the Bell sub-catchments. The overall refusal rate was 40.9% while the refusal rate for each sub-catchment was 57% (Cudgegong) and 39% (Bell). These rates are reasonable and consistent with current experience. Preliminary analyses of survey responses were undertaken using correlation, analysis of variance (ANOVA), cross-tabulation and reliability analysis (see Glossary) to establish frequencies and scale reliability. The survey and subsequent analyses yielded data on farming activities and practices relating to soil management, perennial pasture management, native vegetation management, weed and stock management in addition to attitudinal data, decision-making practice and sources and influence of information. A full account of the research conducted in Phase one of the PUTTI project is reported in Porter et al (2007).

**Social Network Study**

The research in the Central West included a component focused on investigating the role of social structure and networks on the flow of information between landholders and the adoption of more environmentally sustainable land management practices. This component utilised a technique called Social Network Analysis (SNA) described in Section 3.3.3. The experimental design of the Social Network component commenced late in 2006 in collaboration with the School of Behavioural Science at Melbourne University. The SNA component was conducted throughout the three year term of the PUTTI research.

A snowball sampling approach was used in this exploratory study that commenced with 24 seed cases from the Central West study area. The initial participants were landholders selected from respondents who took part in the behavioural survey in February 2007. To ensure that participants represented a range of land management behaviour, seed cases were selected from the two extremes of the behavioural measure (i.e. those assessed as practicing either more sustainable or less sustainable land management at the time of the 2007 survey). In selecting participants, care was also taken to avoid spatial clustering by ensuring that potential participants were spread across the study area. Data was collected through face to face semi-structured interviews for 23 of the initial 24 seed cases to assess the suitability of question structure and content, while the interview process for subsequent participants was conducted using the telephone.

In accordance with the snowball sampling process, data collection occurred through a series of ‘waves’ where participants in subsequent ‘waves’ were drawn from referrals made during the preceding ‘wave’. To formalise the network boundaries, the first three individuals (referrals) identified as an information source by a participant in the preceding wave and who was involved in agricultural practice was contacted in each of the three waves subsequent to Wave 0 (seed cases). Figure 5 shows a schematic of the sampling technique. The data collection timetable was as follows: Wave 0 ($W_0$) was collected during two field trips (May 2007, June 2008); Wave 1 ($W_1$) over the period November-December 2008; Wave 2 ($W_2$) over the period November-December 2008 and Wave 3 ($W_3$) over the period April-May 2009. The maximum number of cases ($N_{\text{max}}$) under this experimental design was 960.

$$N_{\text{max}} = 24 W_0 + 3(24W_1 + 72W_2 + 216W_3)$$

While the anticipated response rate was 75%, the challenge of collecting network data should not be underestimated. Apart from the obvious problem related to the lack of at least three referrals from each participant, there are other issues caused by difficulties identifying, contacting and recruiting referrals to participate in subsequent waves. In addition, there was no restriction imposed on the occupation of the referrals such that landholders were able to nominate agribusiness professionals as information sources. This is realistic given the nature of rural practice.
where advice is sought from a wide range of sources e.g. agronomists, researchers, stock agents etc in addition to other farmers. Agribusiness professionals though, are less likely to consult farmers for advice. In this study, referrals quickly favoured agribusiness professionals rather than other farmers (Table 2)

A total of 138 landholders or agribusiness professionals were interviewed. Four participants were excluded from the study due to a lack of complete data. Further, referrals included organisations (e.g. NSW Department of Primary Industry), publications (e.g. The Land) and agricultural businesses (e.g. rural equipment suppliers). These referrals were discarded as any referrals for individuals not explicitly involved in agricultural practice or agribusiness i.e. a referral of an agronomist was included while one to an accountant or bank manager was not).

Table 2 Social network participants for each wave of data collection (from Tucker et al, 2009)

<table>
<thead>
<tr>
<th>Wave</th>
<th>Farmers</th>
<th>Agribusiness professionals</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (seed)</td>
<td>24</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>1</td>
<td>19</td>
<td>18</td>
<td>37</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>35</td>
<td>42</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>83</td>
<td>134</td>
</tr>
</tbody>
</table>

As indicated, the research team had data on the land management practices and an associated behavioural score for each of the original seed cases. However, individuals nominated as information sources by the seed cases and all subsequent referrals or nominations may not have participated in the behavioural survey. To overcome the lack of a behavioural score for participants in Waves 1-3, two questionnaires were designed to elicit data enabling the calculation of a land management practice score comparable to that recorded for each of the seed cases. The questionnaires yielded data on current land management practices (for participants who were farmers) or professional opinions about these practices (for participants who were agribusiness professionals). Both questionnaires contained the same items, with differences only in the framing of each question. Tucker et al (2009) provides detail on the questionnaire content for both the network data and the behavioural data.

While a geographic constraint was imposed on the selection of seed cases, (participants were located within the Central West study area), no such constraint existed for participants in waves 1-3. The majority of participants were from NSW (94.8%); however, there was one participant from each of Victoria, Western Australia, South Australia and Queensland, and three from the ACT.

Information topics for the collected data related to soil testing, native vegetation management, perennial pasture management, weed control and stock management as in the major surveys. All information seeking links were identified however in the social influence modelling (described in Section 3.3.3). The dependent variable was the sustainable land management practice score of farmers.
To facilitate analysis all behavioural scores were converted into binary form whereby total scores above a specific level were designated as indicating more desirable land management practice, while those below another specific level were designated as indicating less desirable land management practice. Different thresholds (or cut-off points) were used in each case. Comparisons in the modelling were made between those with scores indicating desirable land management practice and the remainder (that is everyone else in the data set) or those with a score indicating less desirable land management practice and the remainder. The same process was used to divide up respondents for each of the components that make up the overall behavioural score, that is, soil testing, native vegetation management, perennial pasture management, weed control and stock management. As a result of the way scores were converted to binary form, care should be taken to avoid mis-interpreting the results for example, if having few connections means you are more likely to have less desirable land management practices, this does not mean that a respondent with many connections is likely to have more desirable land management practices.

Social influence modelling using a class of statistical modelling called exponential random graph modelling (ERGM) was used in this research component to examine the effect of network structures on behavioural scores (See Robins, Pattison, Kalish & Lusher, 2007, for more information on ERGM models). Network effects that relate to the personal qualities of respondents are also of interest in social influence modelling. The modelling therefore predicted people’s land management behaviours from their social network ties (connections) to others as well as their personal characteristics. Further explanation is provided in Tucker et al. 2009.
3.4.3. Lachlan study areas – Mandagery and Humbug sub-catchments

In phase two, the scoping – survey – modelling cycle was repeated in the Lachlan region. This area, adjacent to the Central West CMA, was proposed as the most appropriate dryland farming region for the conduct of the research during phase 2 by the project coaching committee in mid 2007. The Lachlan CMA agreed to the proposal and identified the Mandagery and Humbug sub-catchments as preferred study areas. Scoping interviews were conducted in October/November 2007 (Mandagery, n = 36; Humbug, n = 25; total n = 61).

Building on previous research, literature review, outcomes of the Lachlan scoping interviews and experience with the behavioural modelling of land management practice in the Central West study area, a refined hypothetical model of the variables thought to influence the practice of sustainable land management practice (the dependent variable) for the Lachlan was developed. The exploratory model consisted of 19 variables, 10 of which were the same or similar to those in the Central West model (indicated by italics in following list): 

- agricultural qualifications;
- farm size;
- age;
- lifestyle;
- trust in science and technology;
- influence of the CMA;
- trust and influence (of respondents in information provided by organisations, businesses and institutions);
- property planning;
- future planning and orientation (emphasis the respondent places on planning for the future, and how much future outcomes influence current activities);
- locus of control (extent that respondents indicate that management of their property is within or outside their control);
- risk and innovation (level of risk respondents are willing to take, extent that respondents report they are innovative);
- egostic environmental values (concern for environment as it relates to self and family);
- biospheric environmental values (concern for environment as it relates to the biosphere);
- perceived environmental condition;
- motivation/optimism (level of confidence respondents have for the future of the community and their property);
- environmental focus (the extent that property management is focussed on environmental benefits);
- social involvement; and
- business focus (extent that property management is focussed on business rather than environmental gains).

Appendix B depicts the hypothesised model for the Lachlan and provides a more detailed description of the model variables.

Drawing on knowledge gained from the scoping interviews and research conducted during Phase one in the Central West, a number of modifications were made to the survey instrument designed specifically to test the hypothetical model. The changes facilitated the more accurate measurement of the dependent variable (land management practice) by including a series of open-ended questions that queried participant’s rationale for undertaking particular practices (Bates et al, 2008). The survey was administered by telephone in February 2007 with a target of 300 respondents. Again participants were recruited from telephone lists, and interviewers were instructed to contact each property on their lists at least five times, at different times of the day and across different days, before the property could be classed as a ‘non-contact’. To achieve this target it was necessary to extend the catchment area for participants beyond the sub-catchment boundaries. However, care was taken to ensure that the environmental conditions within the expanded areas were consistent with those within the Humbug and Mandagery sub-catchments. Following pre-testing, a total of 300 surveys were conducted, with 130 (43.3%) from the Humbug sub-catchment and 170 (56.7%) from the Mandagery sub-catchment. The overall refusal rate was 40.7% while the refusal rate for each sub-catchment was 38.4% (Humbug) and 42.4% (Mandagery). The total refusal rate is comparable to the refusal rate for the Central West survey in Phase one (40.9%).

To improve data interpretation and calculation of the behavioural score (dependent variable) during Phase two, a workshop was held with eight officers from the Lachlan CMA. During the workshop responses to those questions specifically related to land management practice were assessed to determine the extent to which they conformed to practice promoted as desirable, that is, likely to result in positive or negative environmental outcomes and assigned a numeric score. In addition, each land management practice category was weighted to indicate how important the CMA believed the practice area was for sustainable dryland farming.
As in Phase one, preliminary analyses was undertaken to establish frequencies and scale suitability using correlation, analysis of variance (ANOVA), cross-tabulation and reliability analysis. The survey supplemented data obtained during the scoping activity and provided data on attitudes and values related to farming practice, dryland farming in the Lachlan in general; socio-demographics; property planning; decision making; sources of information and trust and influence of that information; the role of social norm in the formation of respondents views; perceptions of environmental condition; the practice of dryland farming specific to soil management, perennial pasture management, native vegetation management, weed and stock management. While the range of data obtained was consistent with that from Phase one, greater depth was afforded by the inclusion of open ended questions asking respondents to indicate the reasons why particular practices were adopted as indicated above. A full account of the research conducted in Phase two is provided in Bates et al, 2008.

3.4.4. Final monitoring and evaluation survey - Central West and Lachlan areas

The third phase of the PUTTI project commenced in 2008 and involved the re-surveying of participants from both the Central West and Lachlan CMA regions. The aims of this phase as stated in Leviston et al., (2009) were to:

- validate and refine the model of land management practice developed for the Lachlan catchment, and assess whether a suitable model can be developed for multiple catchments in NSW.
- investigate differences in land management practice over different sub-catchments.
- identify changes in land management practice that have occurred since the initial phases of the PUTTI research.

Participants in all previous research activities were asked if they were interested in participating in future stages with over 87% indicating their on-going support. Recruitment for the final monitoring and evaluation survey was made by contacting random selections from the list of supportive respondents in the Bell, Cudgegong, Mandagery and Humbug sub-catchments and adjacent areas. The contact protocol adhered to that established for earlier survey phases.

A total of 422 landholders were re-surveyed with the following breakdown of respondents in each sub-catchment: Bell 116 (27.5%); Cudgegong 127 (30.1%); Humbug 91 (21.6%) and Mandagery 88 (20.8%). For the final survey, the overall refusal rate was 20.1% while the refusal rate for each sub-catchment was 12.1% (Bell), 21.6% (Cudgegong), 10.8% (Humbug) and 33.3% (Mandagery). As in previous surveys, participants were asked to report their actual land management practice rather than intended behaviour.

As indicated in Figure 4, analysis and behavioural modelling in phases one and two in conjunction with results of the qualitative research strands facilitated iterative refinement of the predictive model of land management practice. In addition to the contextual factors during the term of the project described in Section 2, the PUTTI research was informed by reports of the factors that influence land management decisions in the scientific literature. This was augmented with findings from the qualitative enquiry performed by the study team, identifying factors found to be important for the adoption of agricultural innovation and conservation practices.

As a pre-cursor to additional model refinement the scientific literature was further reviewed. The review can be found in Leviston et al, 2009 and includes consideration of:

- theoretical frameworks of pro-environmental behaviour (as reviewed by Bamberg & Möser, 2007) including
  - rational choice models based on the principle that people are self-interested and motivated to attain rewards and avoid punishment (e.g. Ajzen, 1991)
norm-activation models where people are morally obligated to behave pro-

sociably as a form of truism (Schwartz, 1977; Schwartz & Howard, 1981; Blamey, 1998)

- locus of control, that is, the extent that an individual feels in control of outcomes. This
  may be either internal where outcomes are contingent on one’s own actions; or external
  where individuals believe that chance, fate or powerful others control outcomes
  (Levenson, 1981; Paulhus & Van Selst, 1990). It was noted that there is some debate on
  whether locus of control is
    - a stable personality trait (Rotter, 1966) or
    - a malleable state that is issue specific (Huebner & Lipsey, 1981; Kinnear, Taylor
      & Ahmed, 1974)

- Learned Helplessness, an associated concept to locus of control. This is a feeling of
  being less in control or even depressed as a consequence of failed attempts to manage
  adverse environmental conditions (Seligman, 1975)

- environmental values and awareness – the extent to which pro-environmental behaviour
  is influenced by the environmental concern an individual demonstrates

- access to financial resources

- attitudes to risk

- property planning (Cary, Barr, Aslin, Webb & Kelson, 2001; Curtis & Byron, 2002; Byron,
  Curtis & MacKay, 2006)

The project provided an opportunity to test those factors influencing environmental behaviour
identified in the literature. In the final iteration of the model of land management practice,
particular attention was focussed on:

- the relationship between property planning and attitudes, particularly to identify those
  factors that prompted landholders to create a formal, written property plan

- the relationship between locus of control and other variables, to investigate the role of
  state – based variables such as physical environment and available resources on locus
  of control.

Assessing Land Management Practice

In its final form, the calculation of land management practice scores was as follows (taken from
Leviston et al. 2009).

Respondents were asked a series of questions about their land management practice in relation
to five key areas in dryland farming: soil management, integrated weed management, perennials
management, native vegetation management and, where applicable, stock management. These
areas of practice were identified as important during qualitative phases of the PUTTI program
(Bates et al., 2008) and through reviews of agricultural research and the CAPs developed by the
CMAs. Respondents were asked to report their actual land management practice rather than
intended behaviour or attitudes towards such practice. Open-ended questions were asked about
each key area of practice, along the following themes:

- What specific practice was undertaken on the farm
- Why the practice was undertaken
- How the practice influenced other things on the farm

The answers provided by respondents to these questions were recorded verbatim by
interviewers. The responses were later assigned a numeric value that reflected whether the
practice and the motivations behind it were likely to result in positive or negative environmental
outcomes. As stated previously, members of the research team worked with representatives from
the Lachlan CMA in early 2008, to ensure the scoring of responses was valid, and to determine
the most appropriate numeric values to assign. Each of the responses given in the survey about
land management practice was examined and quantified according to whether the CMA staff believed it to be a desirable or important practice. More important areas of practice were weighted accordingly. Discussion and deliberation occurred until consensus was reached about the scoring. By quantifying all responses that had been given in the survey, a land management score could be calculated and assigned to all survey respondents. An example of the scores given to responses is provided in Table 3, with desirable responses receiving higher scores.

Table 3 Calculation of Land Management Practice score - scoring example final monitoring and evaluation survey

<table>
<thead>
<tr>
<th>Area</th>
<th>Example Item</th>
<th>Example Response and score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock Management</td>
<td>What have you done to reduce the impact of your stock?</td>
<td>“Fenced of waterways” = 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“Move the troughs around” = 1</td>
</tr>
<tr>
<td>Soil Management</td>
<td>How do soil tests influence what you do on your property?</td>
<td>“They don’t” = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“To counter-act acidity” = 2</td>
</tr>
<tr>
<td>Native Vegetation Management</td>
<td>Why do you have native vegetation?</td>
<td>“ Haven’t got rid of it yet” = -1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“ Improve water flow quality” = 2</td>
</tr>
</tbody>
</table>

In Phase three, the model emerging from the Lachlan research (Phase two) was used as the base exploratory model for Phase 3 and was tested using responses of the 422 re-surveyed participants from the Bell, Cudgegong, Mandagery and Humbug sub-catchments. Appendix D provides details of the confirmatory modelling along with the model fit indices. The confirmatory modelling suggested the removal of egoistic values, biospheric values and property planning. The paired down model predicted 33% of the variance in land management scores (see Appendix D).

It should be noted that the initial survey in the Central West was preliminary and used a slightly different measure of land management practice. During Phase three, respondents from the Central West were assigned two scores. The first was consistent with the process described above. The other utilised the data for items that were common with the 2007 survey. This allowed comparisons to be made across time for Central West respondents.

3.4.5. Practice change program – Landscapes and Livelihoods workshops

Previous research indicates that attempts to introduce scientific and technological advances and/or technically based farming innovations to landholders without established credibility and high levels of trust in the information itself and its source is unlikely to achieve sustained change in farming practice (Carolan, 2006; Marshall, 2002, 2004a, 2004b, 2005; Pannell et al 2006; Vanclay 2004). Furthermore, change processes in agricultural practice take place within complex institutional settings. Throughout the PUTTI project repeated interaction occurred between the research team and members of the two catchment communities within the study area. This was achieved by involving a diverse range of community members including individual landholders, agribusiness professionals, Landcare groups and CMA staff in research activities like shed meetings, workshops, individual and group interviews and surveys. In some cases landholders took part in five or six separate activities.

As an outcome of Phase two it was proposed that an approach based on social and cooperative learning where both processes and outcomes are collective was adopted for the development of a change process with the catchment community (Blackmore, 2007; Ison, Rolling and Watson, 2007). The Landscapes and Livelihoods component built on this proposition and was based on the premise that having a deeper appreciation of the interest in and capacity for change among individuals and groups within the community, and giving greater consideration to what is involved in change processes was an essential step to enable progress in the development of a change program. This approach ensures that both solitary and collective space is provided for individuals.
and communities to identify what is important to them, to design what might be done in the future and reflectively think about what has been done in the past. The behavioural modelling provides an indication of the important factors (attitudes, attributes and values) that affect the adoption of land management practice. The process of understanding change in situ across different catchment communities helps to reveal the connection between actions and ideas and the relationship between knowledge, behaviour and values (Keen, Brown and Dyball, 2005).

The project team made a decision to align workshop activities aimed at exploring change issues with groups that were either already in operation or were in the process of being established to maximise the relevance and applicability of the outcomes. Across the study areas there are several well established Landcare groups. Two Landcare groups were identified as ideal for inclusion because of their current stage. The Little River group was about to embark on a major education activity and the Watershed group were in the process of reviewing previous activities and assessing future needs and actions. In addition, the CMAs were in the process of implementing a program of salinity awareness activities with targeted groups of landholders in an effort to encourage them to include knowledge of salinisation processes into their decisions about land management practice and to assist salinity mitigation within the targeted landscapes. These programs were known as Footprints in the Central West and the Lachlan Salinity Action Plan (LSAP) in the Lachlan. The groups identified for inclusion in the Landscapes and Livelihoods activities provided a spectrum of individuals and groups at different stages of involvement in NRM and with varying levels of learning and understanding about land management practice, the effect on catchment health and experience with change processes. It was decided to also include two workshops with CMA staff members from the Central West and Lachlan region.

Participants for the workshops were recruited by telephone from lists of landholders in the target areas provided by key contacts within each of the included groups. Nine workshops were held between July 2008 and June 2009, with a total of 69 participants as shown in Table 4.

Table 4. Attendance details for landscapes and livelihood workshops

<table>
<thead>
<tr>
<th>Workshop Group</th>
<th>Workshop Location</th>
<th>No. of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footprints project group (CWCMA)</td>
<td>Goolma</td>
<td>11</td>
</tr>
<tr>
<td>Little River Landcare (CWCMA)</td>
<td>Wambangalang (between Dubbo &amp; Yeoval)</td>
<td>5</td>
</tr>
<tr>
<td>Watershed (CWCMA)</td>
<td>Mudgee</td>
<td>10</td>
</tr>
<tr>
<td>Humbug (LCMA)</td>
<td>West Wyalong</td>
<td>7</td>
</tr>
<tr>
<td>Gumble Creek, LSAP program (LCMA)</td>
<td>Cudal</td>
<td>4</td>
</tr>
<tr>
<td>Walli Area, LSAP program (LCMA)</td>
<td>Cowra</td>
<td>5</td>
</tr>
<tr>
<td>Lachlan CMA Staff</td>
<td>Cowra</td>
<td>11</td>
</tr>
<tr>
<td>Central West CMA Staff</td>
<td>Wellington</td>
<td>9</td>
</tr>
<tr>
<td>Lachlan Research Forum (3 CMA staff &amp; 4 scientists)</td>
<td>Forbes</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>69</td>
</tr>
</tbody>
</table>

The workshops are more accurately described as focus groups with interview questions posed to the group in a naturalistic method to generate discussion among participants (Wilkinson, 2008). The aims of the workshops, as indicated in Green et al. (2009) were to:

- Provide community members with an opportunity to express their thoughts, experiences and stories of rural agricultural life
- Examine the contradictory messages that are implicit in material presented to farmers. These messages may be inferred, unconscious or not discussed openly.
- Probe beneath the obvious explanations for unsustainable land management and understand the causes of issues.
- Identify the deeper social meanings farming communities have about sustainable practices.
The anticipated outcomes from the workshop activities included:

- Enhanced researcher and participant understanding of barriers and issues associated with sustainable land management.
- Identification of potential changes / strategies that are consistent with the worldviews people have about their present and future practices.
- Identification of messages to be communicated that potentially mitigate some of the inconsistencies and contradictions associated with land management.

Questions for use during the focus groups took account of the outcomes of phases one and two and were based on De Simone (2004) and Inayatullah (2004).

Causal Layered Analysis (CLA), a qualitative methodology described in Section 3.3.4, was used to analyse and interpret the data arising from the workshops. Transcripts of the data were coded according to the most appropriate causal layer (see Table 1) to facilitate interpretation. After analysis was completed for each causal layer, the interpretations were brought together to provide an overall understanding of how workshop participants viewed sustainability in their community.

Summaries of each focus group including key messages and interpretations were sent to participants who were invited to review and respond with any feedback to the research team. No major changes were required to be made to the summaries as a result of this verification procedure (Appendix B in Green et al. 2009, contains all workshop summaries).

4. RESULTS

4.1. Key Findings

4.1.1. Factors influencing the adoption of improved agricultural practices

Behavioural modelling undertaken during the course of the project facilitated the identification of the relative significance of observed and latent variables on desirable land management practice of landholders.

The land management model for the Lachlan area demonstrated a significant refinement over that for the Central West accounting for 35% of the variance as opposed to only 14% for the Central West.

The Lachlan behavioural model was used as the base exploratory model for Phase 3. The confirmatory modelling suggested the removal of egoistic values, biospheric values and property planning. The paired down model predicted 33% of the variance in land management scores.

While the paired down model suggested that the factors identified during the Lachlan research phase continued to be relevant for the wider study area, an additional exploratory model was constructed in an effort to develop a model of broader relevance. The further exploratory model was enhanced with additional variables allowing a greater focus on property planning and locus of control as described in Section 3.4.3. (See Appendix E for enhanced exploratory model along with variable names).

The simplified version of the final behavioural model with non-significant variables removed is shown in Figure 6. The strength of the relationships between variables is shown on the arrows in the diagram. These coefficients may range from -1 (indicating a strong negative relationship) to +1 indicating a strong positive relationship. The model accounted for 38% of the variance in land conditions underpinning the voluntary adoption of sustainable land management practice.
management practice (quite robust in the behavioural science domain) and goodness of fit indices demonstrated that the model accurately explained the data (see Appendix E).

Interpretation of the refined and final behavioural model indicates those conditions leading to an increased likelihood that dryland farmers will undertake desirable land management practice. The conditions are:

- **Having an internal locus of control** - which can be defined as having a sense of being able to determine one's own actions and outcomes;
  - An internal locus of control is influenced by perceived access to resources to undertake land management activities.
  - There is a reciprocal relationship between having a property plan and possessing an internal locus of control; and higher levels of risk and innovation and possessing an internal locus of control, and

- **Perceiving oneself as having social influence**, which can be defined as being sought after by other farmers for advice and being influential in this capacity;
  - This is in turn influenced by the extent to which people are willing to try innovative methods and take risks on their farms

- **The extent of risk and innovation** that people demonstrated in regards to their production methods was only indirectly related to their land-management practices. As such, the relationship between land management practices and risk and innovation was mediated, or explained by, people’s perceived levels of social influence. Risk and

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![Figure 6 Simplified model of land management practice for the Central West and Lachlan study areas.](image)
innovation was directly influenced by perceived access to resources to undertake land management activities.

- Possessing strong **biospheric environmental values**, which can be thought of as having a value system that conveys concern for naturally occurring features of the environment such as native animals, birds and plants; and
- Demonstrating high levels of **trust** in key sources of **agronomy advice** (i.e. agronomists, agribusinesses and the Department of Primary Industries) and stating that such sources influence land management practices.

(As stated in Leviston et al. 2009)

Data from the behavioural surveys contributed a substantial amount of data on socio-demographics, agricultural practice and attitudes of dryland farmers in the Bell and Cudgegong sub-catchments of the Central West and the Mandagery and Humbug sub-catchments of the Lachlan regions (see Bates et al. 2008; Leviston et al., 2009; Porter et al., 2007).

### 4.1.2. The role of information networks in sustainable land management practice

Data from the social network component reveal that information sources were primarily either the government, other farmers or from the agribusiness sector and aged between 35 and 65. While there was a broad range of topics, the most frequently sourced information related to stock or crop management and everyday farm management. For farmers, family played an important role in discussions about what to do on their property (41.8% of respondents) followed by other farmers (16.5%) and business, financial or legal advisors (15.4%). In the case of agribusiness professionals, government departments (30.4%) and other agribusiness professionals (22.4%) were important. More than half of the respondents involved another family member or relatives in the final decision (see Tucker et al., 2009). While this might be expected it confirms the significant role of family in the decision making processes of farmers.

Analysis from the exploratory social influence modelling showed that behavioural scores could be explained in part by social structures (relationships) present in the data. Sociograms (network diagrams) provide a pictorial depiction of these relationships while the statistical results of the social influence models provide model estimates and goodness of fit statistics.

The sociogram for the information network showing the connections of those farmers likely to have more desirable land management practice is shown in Figure 7. Modelling showed that those with **more desirable land management practice** had connections with **owners of multiple properties**, however it is clear that the number of properties does not directly impact the land management score. Note also that the arrows between nodes (respondents) are non-directed, that is indicate a connection only not the direction of the contact. Modelling also showed that farmers are **more likely to demonstrate less desirable land management behaviour** if they are **not connected to others** (either other farmers or agri-business people). That is, farmers with less sustainable behaviours are not ”networking” and not engaged in information gathering/exchange (see Figure 8). Appendix F shows the parameter estimates and goodness of fit estimates for both these models.

The models for each of the five sub-components (soil testing, native vegetation, weed management, perennial pastures and stock management) revealed some additional effects. These are detailed below (from Tucker et al. 2009). No significant effects were identified for perennial pasture management in this exploratory modelling process. Appendix F shows the sociograms of the social influence models for each of the land management components along with parameter estimates.

**Soil Management**

Participants who owned multiple properties and those who were connected to others with multiple properties were more likely to engage in desirable land management practice. Additionally,
participants with connections to agribusinesses identified as promoting desirable land management practice also performed better on soil testing measures. Those with fewer properties were more likely to engage in poor soil testing practices.

**Native Vegetation Management**

Participants were more likely to engage in sustainable native vegetation management if they were connected to other farmers. However, participants who were connected more generally within the network (not specifically to farmers) were likely to engage in poor native vegetation management. Further farmers with poor native vegetation management are unlikely to select the same person for advice.

**Figure 7 Information network of farmers (circles) and agribusiness professionals (squares) (n=134).**
*More sustainable overall behaviours are in red. Larger nodes represent farmers with more properties.*
Figure 8 Information network (n=134) of Farmers (circles) and Agri-Business people. Less sustainable overall behaviours are in red. Larger nodes represent older farmers.

**Weed Management**

Connections to others in the *same geographical region* were important for sustainable weed management. Sustainable management was more likely by those connected to other sustainable managers in the same area. That is, being connected to a sustainable manager only significantly increased the chances of 'better' weed management if participants were located close together. Conversely, those with ties to others who were geographically removed from them were more likely to receive poor scores on weed management measures.

Connections to others in the network were important to sustainable weed management with active people more likely to score well, and inactive people more likely to score poorly. However, there appears to be a point at which people can have too many connections, with participants who were very active in the network less likely to engage in sustainable weed management.

**Stock Management**

The modelling indicates that those with sustainable stock management behaviour were not generally active in the network apart from those with connections to males and to agribusiness professionals. A farmer connected to a female or someone who was not a government agribusiness professional was likely to demonstrate less sustainable stock management behaviour.

4.1.3. **Spatial and temporal differences between study areas**

The initial behavioural survey was conducted in the Central West while the second was in the Lachlan region. The final survey in 2009 however, provides the best opportunity to compare areas and sub-catchments as it is the most current. Note the comparisons relate to the differences observed during the survey of dryland farmers and as such conclusions should not be drawn about the wider catchment areas and farmers in general. Correlation analysis, one-way and two-way analysis of variance (ANOVA) cross tabulation, paired sample tests and reliability
analysis was used to compare results and effects were considered significant at p < 0.01 (see glossary for explanation of terms). A review of the differences between different sub-catchments provides signals for where some interventional activities could be pursued.

Farm profiles

While generally across all study areas cattle and sheep for wool or breeding were the main farming activities, cattle predominated in the Central West with broad acre cropping or cereals in the Lachlan. When considering the main focus of farming activities, the majority of respondents in all study areas indicated that they were “just hanging in there” reflecting the seriousness of the drought and its impact on dryland farming families. The impact was more pronounced in the Humbug, the most western and most drought affected area studied.

Section 3.4.4 described differences between people who had an *internal* rather than *external* locus of control (that is they believed they had a measure of control over outcomes as opposed to outcomes being determined by powerful others or fate). Further the predictive model showed that locus of control played the most substantive role on land management practice. Differences were found in the main focus of farming activities between internal and external locus of control respondents. For example, those with an internal locus of control were more likely to be focussed on increasing the size of their enterprise (20.7%). However, care should be taken in interpreting these results as a percentage of those categorised as externals were found to be focussed on diversifying their enterprises indicating a desire to ‘manage’ their situation. A larger percentage of externals overall stated that they were “just hanging in there” (64.4%) and over 8% of them stated that they were trying to find a way to get out of farming (see Leviston et al., 2009, 28).

When asked about motivations for farming, ensuring financial security was a major factor across all areas but was more important in the Lachlan area particularly in the Humbug. Again there was a difference between internal and external locus of control where respondents classified as more internal being more motivated to ensure financial security and improving the environmental health of the property.

Land management practice

There were differences between study areas in the land management practice score with the Bell scoring statistically significantly higher scores (p<0.01) than the Humbug. In general scores were higher in the Central West.

Overall respondents scored better on perennial and native vegetation management than they did on soil, stock or weed management. In general, The Humbug out performed other areas in soil management; the Bell in the management of stock, perennial and native vegetation and the Mandagery in weed management (Full details are provided in Leviston et al. 2009).

The Bell and Humbug respondents recorded significantly higher mean levels of perceived responsibility for soil health, water quality and erosion than the Cudgegong and Mandagery sub-catchments.

There was a statistically significant decrease in land management practice scores between surveys in the Central West particularly in the Bell sub-catchment (see Leviston et al., 2009 for detail). In the Lachlan, while there was no statistically significant difference in land management

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3 Respondents from the final survey with a locus of control score 1 standard deviation above the sample mean were categorised as ‘internals’; those with scores 1 standard deviation below the mean were categorised as ‘ externals’.
practice score between surveys for the study area as a whole, a significant increase in scores occurred in the Mandagery.

**Resources to undertake land management**

Respondents from the Humbug region recorded significantly lower levels of perceived financial resources to undertake land management activities than other sub-catchments. A difference between areas in locus of control was also evident with respondents in the Humbug demonstrating more external locus of control. Those with an internal locus of control demonstrated significantly higher levels of perceived resources available to carry out land management activities. Respondents with formal agricultural qualifications recorded higher levels of land management practice scores than those without.

**Gender effects**

Female respondents were significantly less likely to have formal agricultural qualifications. Male respondents recorded higher levels of locus of control (that is more internal) than female respondents in all areas other than the Bell. Male respondents also recorded higher levels of perceived resources to undertake land management activities than female respondents in all except the Bell sub-catchment. Male respondents recorded higher scores for land management practice than female respondents in all except the Bell sub-catchment.

Respondents were classified as high, mid or low in perceived resources on the basis of a tertile split (i.e. the highest, middle and lowest third of scores). The interaction between gender and resource groups was non-significant; however, the mean land management score obtained by women in the low resource group (M=38.92) was significantly lower than the men in the low resource group (M=47.92). This represents a large effect size (r=.24). There were no significant differences between men and women in the high resource group.

**Community resilience**

Respondents from the Bell and Mandagery sub-catchments felt that opportunities for interaction had on average decreased in the last three years while those from the Cudgegong and Humbug felt that they had remained the same. In terms of their level of confidence in their communities’ future in ten years time, the mean rating for Humbug respondents was lower and they were also more pessimistic about the future of their individual properties.

**Differences in the factors influencing decision making**

Some similarity to the findings of the social network analysis was shown with results from the survey. The most trusted sources of information were agronomists followed by other farmers, field days and the DPI. Other farmers, agronomists and field days were also attributed with having the most influence over the management of farms. The CMA did not feature prominently as a source of information (see Leviston et al. 2009, 40-43).

Though agronomists were trusted and influential sources of information, the majority of respondents across the study areas did not hire them with the exception of the Humbug where just over 50% of respondents consulted agronomists. The levels of trust and influence in both the Central West and Lachlan areas remained stable between surveys.

Formal property planning continued to be an area that respondents did not invest in with 73% stating that they did not have a written property plan. The Bell had the highest incidence of landholders who did have a formal plan and 18.1% of the 30.2% with a plan enlisted aid from a professional during its creation. The number of landholders with a property plan in the Central West has stayed relatively constant since the 2007 survey, while in the Lachlan it has decreased slightly since 2008. This may reflect a sense of futility in planning due to the on-going drought.

Overall, the majority of quantitative items common to both surveys for both areas showed no differences in responses over time. However, there was a decrease in the level of concern landholders felt about the consequences of environmental degradation for birds; their family; their
lifestyle; all people and for their children over time (the above material is drawn from Leviston et al. 2009, which contains full details of results).

4.1.4. Processes and pre-cursors of behavioural change for sustainability

One of the most prominent issues evident in discussions with landholders was change both in the farming lifestyle and community level. Importantly it emerged that changes in farming practice could not be considered in isolation from other aspects of landholders lives and was related to deeply believed notions of a farmers identity.

There is evidence that the project created greater awareness among participants of alternative land management practices (84.6% of respondents in the final survey thought that projects like PUTTI were worthwhile). It is apparent that from the perspective of the landholder, there is considerable uncertainty about the advantages of modifying practices particularly in a period of protracted drought when it is difficult to justify the potential financial and productivity risks involved.

Perhaps one of the most revealing outcomes of the Landscapes and Livelihoods workshops was the different conceptualisations of sustainability held by landholders and CMA staff alike. This was not aimed at side-stepping the issue but rather expanding sustainability beyond the environmental to include social and cultural domains. However there was an even more fundamental perception by some that we should be striving to go beyond what is simply sustainable (seen as maintaining the status quo) to focus on regenerative processes that were more positive and contributed to community health and well being. The espoused aim of CMA’s is to motivate landholders to adopt NRM practices that are more sustainable is predicated on shared knowledge of what constitutes sustainability, not only between CMA staff but also between advocates of sound NRM practice and landholders. Many CMA participants recognised the diversity of perceptions of sustainability. Incorporation of this awareness into sustainability messages and promoted NRM actions is likely to be a positive approach to achieving change.

As described by Green et al. (2009), the workshops also elicited a range of factors participants felt were drivers or barriers to change (see Table 5). Some issues perceived as barriers to change were also perceived as drivers of change. This reinforces the need to ensure shared understanding of meaning between CMA staff and in community discussions about changes in land management practice.
Table 5 Barriers and drivers of change expressed by workshop participants (from Green et al., 2009)

<table>
<thead>
<tr>
<th>Barriers of change</th>
<th>Drivers of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (old are conservative)</td>
<td>Age (young farmers = new knowledge)</td>
</tr>
<tr>
<td>Money (lack of)</td>
<td>Money (access to)</td>
</tr>
<tr>
<td>Knowledge barriers</td>
<td>Education/knowledge/courses</td>
</tr>
<tr>
<td>Conflicting information</td>
<td>Innovations/technology</td>
</tr>
<tr>
<td>Lack of support</td>
<td>Local support (young farmers network)</td>
</tr>
<tr>
<td>CMA having a narrow focus</td>
<td>Local agronomists</td>
</tr>
<tr>
<td>Short term timeframes</td>
<td>Climate change/drought</td>
</tr>
<tr>
<td>Bad experiences in the past</td>
<td>Passion for farming</td>
</tr>
<tr>
<td>Climate/weather</td>
<td>Social diversity</td>
</tr>
<tr>
<td>Personality</td>
<td>Positive success stories</td>
</tr>
<tr>
<td>Depression/reduced farmer confidence</td>
<td>Early adopters setting benchmarks</td>
</tr>
<tr>
<td>Avoidance of the issue</td>
<td>Stewardship programs</td>
</tr>
<tr>
<td>Need for profits in short and long term</td>
<td>Strong ties with researchers</td>
</tr>
<tr>
<td>Declining farm profit</td>
<td>Other organisations with a NRM agenda</td>
</tr>
<tr>
<td>Declining rural population</td>
<td>Increased land prices</td>
</tr>
<tr>
<td>Technology becoming too advanced</td>
<td></td>
</tr>
<tr>
<td>Too much enterprise mix</td>
<td></td>
</tr>
<tr>
<td>Remoteness</td>
<td></td>
</tr>
<tr>
<td>Landscape variability</td>
<td></td>
</tr>
<tr>
<td>Increasing urbanisation/subdivision</td>
<td></td>
</tr>
<tr>
<td>Farmers needing to be marketers as well as producers</td>
<td></td>
</tr>
</tbody>
</table>

4.1.5. Indicators of behavioural change at landholder and community levels

Regardless of the role of a stakeholder, capacity for change or adaptation has personal or individual dimensions as well as contextual constraints related to the financial, bio-physical, environmental, cultural and institutional setting. The PUTTI research demonstrates the importance of ensuring members of the catchment community possess a shared understanding of sustainability concepts.

Among the issues and concepts to consider in the development of indicators for sustainability drawn from the PUTTI research (with adaptations from Berkes, 2009; Leeuwis, 2004; Renn & Schweizer, 2009) are:

- Development of a common understanding of sustainability
- Understanding of the most appropriate scale to manage sustainability
- Development of views of landscapes and what constitutes ecological soundness
- Recognising local and regional expressions of broader sustainability issues like environmental degradation and socio-cultural decline
• Shared understanding of cause and effect e.g. cause of dryland salinity, impact on the landscape (at farm and landscape scale), mitigation strategies, temporal lags in expression
• Identifying thresholds (signs that a change has occurred)
• Identifying intervention opportunities
• Identifying what the intervention entails from the point of view of different stakeholders
• Identifying the institutional requirements (e.g. finance, support, term of involvement)
• Identifying cost of recovery when thresholds are crossed or exceeded
• Understanding of the risks involved in ignoring impacts or ‘doing nothing’
• Fostering opportunities for reciprocal sharing of knowledge (experiential, systematic, formal, informal and practical)
• Ensuring powerful individuals or groups do not dominate interactions and decision making
• Providing opportunities for real and transparent involvement in decision making
• Providing for flexibility in resourcing arrangements
• Developing mechanisms to support equal access to information
• Investigate risk sharing opportunities
• Ensuring that goals and roles of different stakeholders are clearly and openly stated
• Allowing space for experimentation and reflection
• Ensuring local involvement in the development of indicators that represent easily recognisable signs and signals
• Developing mechanisms for upward and downward accountability
• Developing and documenting co-knowledge produced through interaction, discussion and observation between landholders, experts and scientists
• Acknowledging and validating contributions from all
• Valuing time in planning engagement activities (transaction costs)
• Providing for continuity in activities and interactions to foster and sustain trust
• Developing strategies for resolving conflict
• Supporting and expanding networks (social and professional)
• Building self efficacy including perceived
  o ability to mobilise resources
  o availability of skills and competence
  o validity of interpretation, knowledge and planned practice
  o ability to accommodate risks
• Foster and support gender equity and involvement

5. DISCUSSION
The primary objective of the PUTTI project was to identify the social and psychological barriers to the adoption of improved dryland agricultural practices and identify measures to overcome these barriers. This was achieved through the behavioural modelling in conjunction with the qualitative investigations embodied in scoping interviews, the Landscapes and Livelihood workshops and the Causal Layered Analysis.
The Social Network Analysis was primarily an exploratory exercise to assess the relative importance of characteristics of the information networks of landholders on the adoption of environmentally sustainable land management practices. Analysis shows that networks may not be operating as anticipated with some interesting results on the connections between landholders and others with multiple properties. While the number of properties does not directly impact overall land management score, people who were connected to owners of multiple properties tended to score higher. Ownership of multiple properties also featured in the adoption of positive approaches to soil management, and to weed management with some limitations.

The project was conceived as a partnership program between researchers, the catchment community and decision makers. In reality however, it is difficult to operationalise this concept given the pressures of managing a dryland farming enterprise or catchment in times of drought and underlying confusion about the role of community engagement in NRM. Regardless, the transaction costs involved are significant and CMA staff, landholders, agricultural professionals have many commitments. The project does demonstrate however, that expending resources in engagement at multiple levels has significant payoffs in terms of building platforms for common understanding, trust and future collaborative activities.

The research suggests that the baseline for awareness among landholders of conservation measures commonly used in the scientific or land management literature is relatively low compared with expectations. The issue is not whether there is sufficient information available about the relative advantage of implementing basic soil testing protocols or conservation farming techniques. Rather the issues are more practical or fundamental and relate to individual psycho-social traits like perceived self-efficacy, recognition of the need to change behaviour, readiness and long term security. Many landholders are uncertain about their future and that of their community and perceive sustainability in broader terms where their love of farming as a lifestyle is inextricably linked with aspects of the rural community in which they are situated.

The PUTTI research shows that even discussions about changing practices may be preliminary as some landholders may not be ready to hear or see the benefits of change or the need to modify practices. As described in Green et al (2009) in any group of landholders or geographic location, landholders are likely to be at different stages of preparedness for change. It is essential that this is recognised when developing any proposal advocating changes in land management practice. Furthermore, a level of complexity is added by the different backgrounds, experience levels, physical properties of farms, life stages and the range of improved land management practices advocated. For example, a landholder may have taken part in an on property workshop on soil testing that increased his awareness of soil variability and variation with depth and area. He may have learnt the value of regular soil testing that makes him or her more aware of the benefits to be gained from using the knowledge gained from regular soil tests to modify cropping practice and the variety of crops sown. Other landholders in the same area who have not participated in the workshop may not have the same level of awareness, and are therefore not at the same stage.

In examining perceptions of and readiness for change, the Landscapes and Livelihoods component looked at alternative frameworks for considering the change process. The Stages of Change model (Prochaska, DiClemente & Norcross, 1992) and Community Readiness theoretical model (Edwards, Jumper-Thurman, Plement, Oetting & Swanson, 2000) provide guidance on group and individual stages of change. The Queensland Department of Natural Resources and Water (2007) adapted the Edwards et al. model for use in a natural resource management setting. Green et al. provide examples of stages of change drawn from the Landscapes and Livelihood workshop participants (see Table 6).
### Table 6 Stages of change relevant to farming practices (from Green et al., 2009)

<table>
<thead>
<tr>
<th>Stage of Change</th>
<th>Workshop Participants Description of Change Process in Farming Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre – contemplating change</td>
<td>No or limited active engagement in broader farming or community activities.</td>
</tr>
<tr>
<td></td>
<td>Begin to participate in field days or farming events at varying degrees of commitment as a means of scoping opportunities, contacts and information about farming practices generally.</td>
</tr>
<tr>
<td>Contemplating change</td>
<td>Notice land or stock management issues on their property.</td>
</tr>
<tr>
<td></td>
<td>Begin a discussion with other farmers who may/may not have experienced similar issues.</td>
</tr>
<tr>
<td></td>
<td>Begin “looking over neighbours fence” and at other properties in their catchment to learn from other farmers activities.</td>
</tr>
<tr>
<td></td>
<td>Monitor the relative success or failure of others efforts at change as a means of considering their personal propensity to change.</td>
</tr>
<tr>
<td>Preparing to change</td>
<td>Contemplation of financial capacity to engage in change – consideration of markets, weather and other external uncontrollable factors that may impact on their overall farm viability and their degree of willingness to risk participating in a changed behaviour.</td>
</tr>
<tr>
<td></td>
<td>Information seeking from professionals, other farmers, experts, books, journals and the internet.</td>
</tr>
<tr>
<td></td>
<td>Initiate small trials on own property based on learnings.</td>
</tr>
<tr>
<td>Action</td>
<td>Continued practice at trial scale or expansions of activities based on appraised success at trial scale.</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Continued activity with the opportunity to expand.</td>
</tr>
</tbody>
</table>

It is important to note that the recognition of different stages of readiness applies not only to landholders but also to the CMA and their staff. CMAs exhibit differences in modes of operating, maturity in regional delivery, choice of mechanisms employed to facilitate resource management and experience levels of staff. This will impact on their ability to engage in collaborative decision making and willingness to commit to the idea of power sharing and operational transparency, concepts essential to an adaptive co-management approach to catchment management aimed at voluntary cooperation and adoption achieved through effective engagement with the catchment community.

The PUTTI research demonstrates the influence of internal locus of control (which can be interpreted as perceived self-efficacy) on the capacity and willingness of landholders to adopt improved land management practice. Furthermore to understand how landholders and others involved in NRM view issues of sustainability including best management practices, it is essential to appreciate how their worldview influences conceptualisations of the issues and interpretation of proposed solutions including the potential impact on their livelihood and community.

The most promising approach encountered throughout the research was to start with modest engagement strategies with landholders at the farm scale located in areas of significance for dryland salinity management.

The LSAP and Footprint activities provided opportunities for repeated interaction and co-production of knowledge, the development of trust and support for self-efficacy, opportunities for partnership activities and recognition of potential mitigation or management strategies. Because the scale of interaction was appropriate, landholders recognised the value of information available and understood how it applied to their property. This translated into greater trust in the CMA and
validation of the role they play in the community as well as in catchment management. This was reflected in the reactions and observations made by participants in the Landscapes and Livelihood workshops who came from the areas targeted by LSAP and Footprints. Building on these activities, the CMA and members of the catchment community are in a better position to discuss issues and elaborate learnings and draw in other landholders in the future. The importance of continuity in these situations can not be underestimated.

The PUTTI research has demonstrated the utility of adopting mixed methods to investigate the factors that influence the adoption of improved land management practice by dryland farmers. As depicted in Figure 4 the research design facilitated reciprocity between qualitative and quantitative methods ensuring the relevance and applicability of the research questions and validity of interpretations arising from the quantitative analysis. The Landscapes and Livelihoods workshops and Causal Layered Analysis was effective in identifying the significance of worldview and finding the deep links between farming and the land. The social network component while modest, shows promise as a method to quantitatively examine the extent and importance of social and professional networks in rural communities.

PUTTI utilised a mix of methods resulting in a set of findings that indicate where effort might be focussed to modify land management practice. Further the research provides substantive evidence for a change in the fundamental approach to managing natural resources at the regional level, including a shift away from pre-determined solutions towards collaborative framing of issues and the iterative development of solutions and strategies for implementing them.

6. RECOMMENDATIONS

The findings of the PUTTI research and the conduct of the study itself has highlighted the intrinsic connection between knowledge of the catchment from different perspectives (individual property to region) and process (social and cultural as well as biophysical) in achieving positive outcomes in community, cultural and environmental sustainability. The research identifies a number of fundamental issues for catchment management across different scales.

Efforts should be made to address the lack of confidence evident across the catchment, from the landholder to individual actors at the institutional level as it severely limits individual and collective ability to adapt to changing conditions and has an ongoing impact on sustainability. This creates a downward cycle of dependency particularly during times of drought. Breaking out of this cycle requires courage and leadership to foster a changed approach towards environmental management where shared learning is the priority.

The effectiveness of catchment management would benefit from the inclusion of indicators related to process, transformative learning and problem solving. This would offer significant value particularly to track change in attitudes, development of consensus and accommodation of different perspectives when seeking solutions or developing management strategies. The current paradigm in regional natural resource management supports a command and control approach where pre-determined actions and solutions are promoted as the way to manage environmental issues. There is little, if any space for discussion, exploration of different perspectives, listening and adjustment or modification of strategies outside of the confines of the management agency. Furthermore educational and knowledge sharing opportunities are restricted as extension is no longer regarded as a legitimate role for regional resource agencies leading to a greater dependence on fewer consultants and commercially sponsored agricultural professionals. Natural resource managers are constantly pushed to do more and demonstrate achievements through quantitative indicators in annual time frames that are not focussed on modifying or influencing behaviour, but rather show infrastructure related changes like an increase in kilometres of fencing. This could be interpreted as assuming that the
change in infrastructure will automatically result in a change in farming behaviour, although clearly this is not what is intended.

*Any development of behavioural change indicators must address the conceptual disparity between the worldviews of scientists, catchment managers and landholders of sustainability.* It became clear in the conduct of the PUTTI research that the issues need to be addressed by local stakeholders as different worldviews are underpinned by associated assumptions, values and attitudes that shape the perspectives and perceptions of individuals. Indicators represent a simplification of complex concepts. There are different views not only about what is important but also on the appropriate scale and standard of measurement. Concepts need to be worked through to ensure agreement and consistency in the mental models of different members of the catchment community. The process offers opportunities to develop relationships based on trust and equity: two fundamental elements of adaptive co-management. In addition, opportunities for sharing perceptions and knowledge about bio-physical, production and socio-cultural processes between scientists, extension workers, consultants, agro-professionals and landholders are essential to support the re-framing of issues, the identification of potential actions and the determination and monitoring of indicators. While the range and complexity of the issues may be daunting and there are substantial gaps and shortfalls in capacity in the catchment community, CMAs are in an ideal position to undertake this task. Due consideration and reflection by the CMA, on how the imposition of changes in practice might be interpreted and implemented, and an increased awareness of the self efficacy levels of landholders is essential for the success of such initiatives. For example, encouraging no-till, stubble retention or the use of native grasses may challenge a landholders’ self identity where for some, a tidy farm or freshly-ploughed field ready for sowing reflects their ability and expertise as a farmer. In addition, if there is a need to employ the services of a contractor because they do not own the appropriate machinery, it may undermine self confidence and feelings of control. Results of the qualitative research indicate that a one size fits all approach is not appropriate and that greater flexibility is required in encouraging modified practices particularly if there is a reliance on incentives which many landholders regard as poorly designed and inaccessible. Furthermore, “by prescribing management practices and designating specific areas for agri-environmental work, such schemes fail to allow farmers to develop or demonstrate skilled role performance” (Burton, Kuczera & Schwarz, 2008, 16). The stages of change approach discussed in brief above (see Green et al. 2009 for more detail), offers one perspective on understanding why members of the catchment community are at different stages of readiness for interventions.

The CMAs have an opportunity to develop trust and the self-efficacy of landholders and other members of the catchment community by engaging in tailored social learning opportunities like the LSAP and Footprint activities. At the catchment community level, CMAs are in an ideal position to develop social learning opportunities and processes that facilitate the co-production of knowledge, seen as more important for the adoption of sustainable practices than the traditional knowledge transfer approach (Hagmann, Chuma, Murwira, Connolly & Ficarelli. 2002; Roling & Wagemakers, 2000; Eshuis & Stuiver, 2005; Jiggins et al., 2007; Tabara & Pahl-Wostl, 2007). However, there are a broad range of areas in which learning needs to occur and this requires “space and time for a new meaning to emerge” (Snowden, 2002, 5).

The PUTTI project demonstrated the utility of this approach where the benefits of increased trust, shared learning, reflection and willingness to continue engagement through the adoption of ground-level activities aimed at modifying land management practice were evident in the Footprint and LSAP activities. In these programs, knowledgeable and respected experts worked with individual landholders to explain Hydrogeological Landscape maps and interpret them at the local property level so that landholders could understand the interaction between their management practices, local conditions and the expression of salinity in their landscape. Additional activities aimed at improving understanding of soil testing, conservation farming techniques for example were also offered. Extending this model to a larger number of activities addressing different environmental issues provides greater opportunities for shared learning. It is
important to start small and gradually enlarge the scale of activity ensuring an integral inclusion of repetitive cycles of reflective learning and discussion facilitating a gradual increase in ability to undertake more complex problems as depicted in Figure 9. A focus on double loop learning facilitates reflective practices that allow individuals to review the purpose of actions and the underlying assumptions, rules, values and attitudes, identifying weaknesses and limitations and formulating better responses to problems (Tabara & Pahl Wostl, 2007; Blackmore, 2007).

Community engagement cuts across all areas within the jurisdiction of CMA s and should be regarded as integral to their effective operation. As a basic starting point there needs to be agreement on what constitutes sustainability and sustainable land management practice including the multiple dimensions encapsulated within the worldviews of members of the catchment community from landholders to agency staff. Land management practices proposed by CMAs require examination and discussion at the ground level to ensure there is a shared understanding of what is involved, what the benefits might be as well as the constraints on implementation.

Figure 9 The observation-planning-action-outcome cycle of learning through participation in co-management (from Berkes, 2009, 1697)

Transformational change needs to occur among landholders, scientists and natural resource agency staff to accommodate co-management in anticipation of an adaptive co-management approach to catchment management. NRM across regional – local - property scales is very complex and there are multiple interacting processes. Transformative change involves surrendering control, taking risks and accepting alternative viewpoints to solve problems and mobilise the resources necessary for implementing solutions. While these are challenging pathways, there are likely to be long-lasting and positive impacts on the adaptive capacity of catchment communities as a result of adopting transformative processes. (See Appendix G for an adaptation of Maton’s, 2000, framework identifying environmental dimensions and goals to guide transformational processes).

CMAs have the potential to act as “bridging organisations” to create links with other organisations operating at the same or higher governance levels. This would create opportunities for sharing knowledge and representing alternative views about the equity and implications of federal and state government policy for rural communities. Although the regional model of natural resource management assumes a substantive element of inclusive governance, this is relatively unsupported by institutional arrangements. To address this issue and effectively work within the broader context of macroeconomic and policy processes beyond their control, catchment communities need to be part of a system where they have links to organisations operating at higher levels. This vertical and horizontal collaboration may assist integration and help to address the institutional complexity amplified by the operation of the regional NRM model described by Lane and Robertson (2009). The many roles of bridging organisations are depicted in Figure 10 though it is not expected that one organisation is able to fulfil all these functions.
The importance of social networks in the communication of information and adoption of land management practices leading to both positive and negative environmental outcomes needs to be understood and utilised. It appears that the land management behaviours of landholders who have connections with owners of multiple properties result in actions that are more environmentally sustainable. This has implications for the development and support of mentoring type arrangements between enterprises that consist of single properties and those that typically consist of multiple properties. The utility of local area networks operating between landholders in the same geographic region needs to be investigated for the promotion of good weed management as connections to a sustainable weed manager was found to be important if the properties of landholders were close together.

Programs aimed at supporting the ability of landholders resident in areas that have been affected disproportionately by the drought such as the Humbug and women more generally, are likely to result in more positive land management practices and improved self-efficacy. Landholders in the Humbug catchment demonstrate more external locus of control and had lower levels of perceived financial resources. Women were less likely to have formal agricultural qualifications and were also implicated in less sustainable stock management practices among those connected to them. Equitable management of the catchment suggests that resources should be directed towards these groups. Efforts that identify specific practices of relevance and that emulate the LSAP and Footprint projects in approach are likely to be most appropriate.

In summary, CMAs are well placed to embrace the opportunity to take leadership in regional NRM and transform themselves into bridging organisations whereby they can

- explicitly describe and explain their role to the catchment community as an agency focussed on facilitating social learning
- begin a program of incremental change by working with landholder groups on a small number of well defined ‘sustainability’ projects that provide space to move through the observation-planning-action-outcome cycle and enhance the perceived self-efficacy of participants
- develop vertical and horizontal connections with relevant agencies to form an information sharing network which enables the downward filtering of information to the catchment community and upwards to the policy level
- influence NRM policy by demonstrating and promoting the advantages of reflective adaptive management and arguing for the inclusion of targets that attest its value.
APPENDIX A

Including the following:

- Hypothesised model of land management practice for the Central West
- Description of model components in the hypothesised model
- Non-significant variables removed from the hypothesised Central West model (from Porter et al. 2007)
- Final land management practice model for the Central West (from Porter et al. 2007)

Hypothesised model of land management practice for the Central West


Figure 11 Hypothesised model of land management practice for the Central West

Description of model components in the hypothesised model

**Land Management Practices**

The Land Management Practices variable is comprised of responses to a number of different land management questions, pertaining to the following areas of practice: weed control; native vegetation management; perennial pasture management; stock management (where applicable); and soil management and testing. An overall land management score was calculated.

**Farm Size**

The Farm Size component of the model is the number of hectares of land that each respondent farms.

**Farm Experience**

The Farm Experience component of the model refers to the number of years respondents have spent as dryland farmers.
**Age**
The Age component of the model is the respondent’s age in years.

**Lifestyle**
The Lifestyle component of the model refers to the extent to which respondents indicate that they are farming for the lifestyle as opposed to a business venture. Higher scores in this variable indicate that a respondent is farming more for the lifestyle it affords than for business purposes.

**Agricultural Qualifications**
The Agricultural Qualifications component of the model refers to any formal qualifications that respondents have that are relevant to land management and farming.

**Community Engagement**
The Community Engagement component of the model refers to respondents’ engagement with the community, including non farm related community groups such as sporting clubs.

**Farm Plan**
The Farm Plan component of the model refers to whether or not respondents have a formal written farm plan.

**Environmental Values**
The Environmental Values component of the model refers to the respondents’ general views of the environment and the interaction humans have with it.

**Succession Planning**
This component measures whether the respondent intends to pass the farming property down to the next generation in the family.

**Science and Technology**
The Science and Technology component of the model refers to respondents’ beliefs that science and technology can aid in finding useful solutions to land management issues.

**Perceived Barriers to Change**
The Perceived Barriers to Change component of the model refers to the extent that cost, time and government regulations are perceived to be barriers to undertaking desirable land management practices.

**Perceived Environmental Condition**
The Perceived Environmental Condition component of the model refers to respondents’ perception of the condition of their property and the region as a whole. It covers perceptions of water quality, soil health, weed presence and erosion.

**Trust in and Influence of Information Sources**
The Trust in and Influence of Information Sources component of the model indicates how much trust respondents have in information provided by various organisations, businesses and institutions, and how much these various sources of information influence what they do on the farm.

**Social Norm**
The Social Norm component of the model measures the extent to which the views of other farmers in the area influence respondents’ behaviours

**Perceived Effectiveness of Behaviour**

The Perceived Effectiveness of Behaviour component of the model refers to the extent to which respondents believed that the stated land management practices are effective components of overall good land management.

**Innovator**

The Innovator component of the model measures the extent to which respondents report they enjoy trying new things, and being innovative in the way they manage their farm.
Non-significant variables removed from the hypothesised Central West model (from Porter et al. 2007)

- Community Engagement
- Age
- Succession Planning
- Social Norm

Two further components of the model contained no significant pathways with the remaining model components. These were Perceived Environmental Degradation and Perceived Barriers to Change. These components were split into sub-components as follows:

- Perceived Environmental Condition
  - Perceived Environmental Condition of Individual Property,
  - Perceived Environmental Condition of the Area.

Both of these had significant pathways within the model and were retained for further analysis.

- Perceived Barriers to Change
  - Perceived Cost Barriers,
  - Perceived Time Barriers
  - Perceived Government Regulation Barriers.

Only Perceived Cost Barriers had significant relationships within the model. Perceived Time Barriers and Perceived Government Regulation Barriers were dropped from the model.
Final land management practice model for the Central West (taken from Porter et al. 2007)

Figure 12 Model for Land Management Practice in the Central West with 14% variance explained

Figure 12 shows that four latent variables had significant direct relationships with Land Management Practices – Innovator, Farm Plan, Perceived Effectiveness and Perceived Cost Barriers. Although the other latent variables did not have a significant direct effect on Land Management Practices, they all imparted a mediated influence through their direct relationship with other variables.

The relationships between the variables in the model can be summarised as follows.

- **Land Management Practices**
  
  The following conditions lead directly to an increased likelihood of undertaking desirable Land Management Practices:
  - a reduced perception that cost is a barrier to undertaking desirable land management practices;
  - a greater belief that particular practices are an effective means of good land management;
  - having a written farm plan; and
  - a reported emphasis on innovative practices.

- **Farm Size**
  
  Larger farm size leads directly to:
  - increased perception that cost is a barrier to undertaking desirable land management practices.

- **Science and Technology**
Greater belief in the relevance of science and technology leads directly to:
- greater levels of trust in, and influence taken from sources of information regarding land management practices.

- **Lifestyle**
  Seeing farming as more of a lifestyle than a business leads directly to:
  - a decreased likelihood of having a written farm plan; and
  - an increase in environmental values.

- **Agricultural Qualifications**
  The possession of agricultural qualifications leads directly to:
  - an increased likelihood of having a written farm plan.

- **Trust in and Influence of Sources of Information**
  Greater trust in and influence of sources of land management information lead directly to:
  - a greater belief that particular land management practices are an effective means of good land management.

- **Environmental Values**
  Greater environmental values lead directly to:
  - increased perceptions of environmental degradation of the area as a whole.
  - **Perceived Environmental Condition – Area**
    Perceptions of degraded environmental condition of the area lead directly to:
    - a greater belief that particular land management practices are an effective means of good land management.

- **Perceived Environmental Condition – Property**
  Perceptions of good environmental condition of property lead directly to:
  - a greater belief that particular land management practices are an effective means of good land management.
APPENDIX B
Including the following:

- Hypothesised model of land management practice for the Lachlan
- Description of model components in the hypothesised model
- Non-significant variables removed from the hypothesised Lachlan model (from Bates et al. 2008)
- Final land management practice model for the Lachlan (from Bates et al. 2008)

Hypothesised model of land management practice for the Lachlan

![Diagram of hypothesised model](image)

**Figure 13 Hypothesised model of land management practice for the Lachlan**

*Note:*
Colours in the figure are used to illustrate the differentiation between preliminary variables (green), moderating or secondary variables (yellow), and dependent variables (orange).

Description of model components in the hypothesised model
The abbreviated model component variable names as they appear in the estimated model for the Lachlan are provided in italics in the sections below (e.g. BEHAVFIN).

**Land Management Practice**

The land management practice variable is the outcome construct of interest in the PUTTI project. In this model it is comprised of participant responses to a number of land management items, and focuses on the following areas of interest: weed control; stock management (where applicable); native vegetation management; perennial pasture management; and soil management and testing. For each participant, an overall land management score was calculated using responses to questions relating to each of these areas (*BEHAVFIN*). Members of the Lachlan CMA were instrumental in helping to understand how the responses to each of these land management measures could be evaluated and quantified validly. Collaboration with the CMA is explained in more detail later in the report.

**Agricultural Qualifications**

The agricultural qualifications component of the model refers to any formal qualifications that respondents have that are relevant to land management and farming.

**Farm Size**

The farm size component of the model refers to the size of the respondents’ farm in hectares.

**Age**

The age component of the model refers to respondents’ age in years.

**Lifestyle**

The lifestyle component of the model refers to the extent to which respondents indicate that they are farming for the lifestyle as opposed to a business venture. Consequently, higher scores in this variable indicate that a respondent is farming more for the lifestyle it represents than for business purposes.

**Trust in Science and Technology**

The science and technology component of the model refers to respondents’ beliefs that science and technology can provide effective solutions to land management issues.

**Influence: CMA**

This component refers to the perception of CMA influence over on-farm activities and the amount of contact respondents have with the CMA.

**Trust and Influence Scale**

The trust and influence component of the model indicates how much trust respondents have in information provided by various organisations, businesses and institutions, and how much these various sources of information influence what they do on their farm (*TINF3, TINF4, TINF8 & TINF10*).

**Property Planning**

Refers to whether respondents have a written property plan, and whether this plan was created with the aid of a professional (*FarmPlan*).
**Future Planning and Orientation**

The future planning and orientation component refers to how much emphasis the respondent places on planning for the future, and how much considerations of future outcomes influence their current activities.

**Locus of Control**

The locus of control component refers to the extent to which respondents indicate that the management of their farm is either within their control, or outside of their control and impinged upon by external factors (Att23r, Att21r & Att24).

**Risk and Innovation**

The risk and innovation component of the model refers to the level of risk people are willing to take in the management of their property. The innovator component of the model measures the extent to which respondents report they enjoy trying new things and being innovative in the way they manage their farm.

**Egoistic Environmental Values**

This refers to concern for the environment as it relates to self and family (ENVAL9, ENVAL6 & ENVAL12).

**Biospheric Environmental Values**

Respondents’ value of the environment as it relates to concern for the biosphere (ENVAL3, ENVAL1 & ENVAL2).

**Perceived Environmental Condition**

The perceived environmental condition component of the model refers to respondents’ perception of the condition of their property and the region as a whole. It covers perceptions of water quality, soil health, weed presence and erosion.

**Motivation/Optimism**

The motivation/optimism component of the model refers to the level of confidence held by respondents regarding the future of the community and the future of their property.

**Environmental Focus**

Environmental focus refers to the extent to which the management of property is focused on environmental benefits.

**Social Involvement**

The social involvement component identifies the extent to which respondents have interaction with others in their community.

**Business Focus**

The extent to which management of property is focused on business gains over environmental.
Non-significant variables removed from the Lachlan model (from Bates et al. 2008)

- Agricultural qualifications
- Farm size
- Age
- Lifestyle
- Trust in science and technology
- Influence of the CMA
- Future planning and orientation
- Risk and innovation
- Motivation/Optimism
- Environmental focus
- Social involvement
- Business focus
- Perceived environmental degradation
The model for the Lachlan shows that the following conditions lead to an increased likelihood of undertaking desirable land management practice:

- Increased trust in and influence of outside sources such as other farmers, scientists, field days and the Department of Primary Industries;
- Having an internal locus of control – the sense of being able to determine one’s own actions;
- Having a formal property plan, created with the assistance of a professional;
- High biospheric environmental values - a value system that conveys concern for the physical and naturally occurring environment (such as native animals, birds and plants); and
- Low egoistic environmental values - a value system that conveys secondary or reduced concern about the impacts of environmental problems on family and self.
APPENDIX C

Assessment of scale reliability for the final survey of land management practice (taken from Section 3.3, Leviston et al. 2009).

Attitudinal statements was presented to respondents which later grouped together to form the scales (measurements of a concept) that were used in this study. Forty-six attitudinal statements were developed through analysis of the qualitative research in the Lachlan and the Central West as well as a comprehensive literature review in the areas of assessing environmental values.

Table 8 lists the scales used to measure each key concept measured in the survey, the items included in each scale and the associated Cronbach’s alpha. After recoding of reverse-worded items, a single score was calculated for each respondent on each variable by averaging the respondent’s scores across the items comprising the scale. The Cronbach’s alpha provides a measure of the reliability of the scales; scores can range from 0 to 1 with scores closer to 1 indicating higher reliability. All the scales had satisfactory to high levels of reliability.
Table 7 Summary description of scales used to measure attitudes and values in final survey (including reliability)

<table>
<thead>
<tr>
<th>Concept</th>
<th>Item</th>
<th>Reliability - Cronbach a</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Locus of control</strong></td>
<td>The fate of farming is in the hands of the people in power and there's not much that individual farmers can do about it</td>
<td>.718</td>
</tr>
<tr>
<td></td>
<td>The success of the farm is mostly determined by factors outside of my control</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The weather and commodity prices can knock you around in the short term, but in the long run there is still a lot you can do to stay ahead of the game</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Many times I feel that I have little influence over the things that happen to me</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No matter what things I try on the farm, the drought prevents them from working</td>
<td></td>
</tr>
</tbody>
</table>

**Scale details:** Measured on a 5 point scale ranging from 1 (strongly disagree) to 5 (strongly agree). High scores indicate greater sense of control over events that affect one's life.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Item</th>
<th>Reliability - Cronbach a</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceived social influence</strong></td>
<td>How often do people come to you for agricultural advice?</td>
<td>.747</td>
</tr>
<tr>
<td></td>
<td>How much influence do you think you have on other farmers when it comes to agricultural practices?</td>
<td></td>
</tr>
</tbody>
</table>

**Scale details:** Measured on two separate 5 point scales ranging from: 1 (never) to 5 (all the time); 1 (no influence) to 5 (significant influence). High scores indicate higher levels of perceived social influence.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Item</th>
<th>Reliability - Cronbach a</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk and innovation</strong></td>
<td>I am always one of the first producers in my area to adopt new technology</td>
<td>.678</td>
</tr>
<tr>
<td></td>
<td>I am happy to try new farming methods that aren't used a lot</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I am willing to take higher than average risks in order to get higher financial returns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I am willing to take more risks than other farmers in the area with respect to my production methods</td>
<td></td>
</tr>
</tbody>
</table>

**Scale details:** Measured on a 5 point scale ranging from 1 (strongly disagree) to 5 (strongly agree). High scores indicate higher levels of farm innovation and willingness to take risks.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Item</th>
<th>Reliability - Cronbach a</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceived resources</strong></td>
<td>There are many resources such as time, money and knowledge, that impact on what one can do on their property. Sometimes there is a gap between the current situation and what we would like the situation to be. If 10 represents the very best situation that you can think of for yourself and 1 represents the worst, can you rate your current situation with regards to your resources to carry out land management activities?</td>
<td>.642</td>
</tr>
<tr>
<td></td>
<td>How satisfied are you with the difference between your current situation and your ideal situation with regards to resources?</td>
<td></td>
</tr>
</tbody>
</table>

**Scale details:** Measured on two separate scales ranging from: 1 (worst situation) to 10 (very best situation); and 1 (not at all satisfied) to 5 (extremely satisfied). High scores indicate higher levels of perceived resources.
Table 8 (Cont.) Summary description of scales used to measure attitudes and values in final survey (including reliability)

<table>
<thead>
<tr>
<th>Concept</th>
<th>Item</th>
<th>Reliability - Cronbach a</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Property planning</strong></td>
<td>Do you have a written property plan?</td>
<td></td>
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<tr>
<td></td>
<td>Was your property plan created with the aid of a professional consultant?</td>
<td></td>
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<tr>
<td></td>
<td>Do you hire an agronomist to help you with any of your farming activities?</td>
<td></td>
</tr>
<tr>
<td><strong>Scale details:</strong> Measured as a dichotomous variable: Yes or No</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Change intentions</strong></td>
<td>How likely is it that you will make changes in your land management practices over the next 3 years?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Do you want to change your land management practices over the next 3 years?</td>
<td></td>
</tr>
<tr>
<td><strong>Scale details:</strong> Measured on a 5 point scale ranging from 1 (highly unlikely) to 5 (highly likely); and as a dichotomous variable: Yes or No</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Egoistic/ Social concerns</strong></td>
<td>How concerned are you about environmental problems because of the potential consequences for the following:</td>
<td>.964</td>
</tr>
<tr>
<td></td>
<td>Stock</td>
<td></td>
</tr>
<tr>
<td></td>
<td>You</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Your future</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Your family</td>
<td></td>
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<tr>
<td></td>
<td>Your lifestyle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Your health</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All people</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Children</td>
<td></td>
</tr>
<tr>
<td></td>
<td>People in your community</td>
<td></td>
</tr>
<tr>
<td><strong>Biospheric concerns</strong></td>
<td>How concerned are you about environmental problems because of the potential consequences for the following:</td>
<td>.917</td>
</tr>
<tr>
<td></td>
<td>Native animals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Native plants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Native birds</td>
<td></td>
</tr>
<tr>
<td><strong>Scale details:</strong> Measured on a 5 point scale ranging from 1 (not at all concerned) to 5 (extremely concerned). High scores indicate high levels of concern about consequences of environmental problems on aspects of the biosphere</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Confirmatory modelling of land management practice for the final model (phase 3). (from Leviston et al. 2009)

Figure 15 Confirmatory Land Management Practice structural equation model

The model was able to predict 33% of the variance in land management practice scores. Fit indices are presented in Table 9 and a simplified version of the model is presented in Figure 16.

Table 8 Model fit indices* for the paired down confirmatory structural equation model

<table>
<thead>
<tr>
<th>Fit Statistics</th>
<th>Obtained Value</th>
<th>Recommended Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square (df)</td>
<td>33.84 (22), p=.051</td>
<td>p &gt; .05</td>
</tr>
<tr>
<td>CFI</td>
<td>0.98</td>
<td>≥ .90</td>
</tr>
<tr>
<td>GFI</td>
<td>0.98</td>
<td>≥ .90</td>
</tr>
<tr>
<td>RMSEA</td>
<td>0.036</td>
<td>≤ .08</td>
</tr>
</tbody>
</table>

*Model fit indices are explained in the Glossary
While these results suggest that factors identified in phase two of the PUTTI project remain relevant to the wider catchments, it was felt that exploratory modelling would service both interpretation of previous modelling and result in a model of broader relevance.
APPENDIX E

Enhanced exploratory model for land management practice across all study areas (from Leviston et al. 2009)

Figure 17 shows the relationships between the latent variables (shown in the model as ellipses) and their respective indicators (shown in the model as rectangles). The model schematic reveals how well the indicators measure the latent variables. For example, \textit{ATT24R} is one of three attitudinal statements intended to measure locus of control. The value of the coefficient on the path indicates how well the statement (\textit{ATT24R}) actually measures the concept of locus of control. Coefficients on these paths can range from -1.0 (i.e. a strong negative relationship between the latent variable and the indicator) to +1.0 (i.e. a strong positive relationship between the latent variable and the indicator). Each of the indicators included in the model were sufficiently reliable measures of the latent construct they were designed to represent (as demonstrated by the Cronbach’s alpha scores of the scales presented in Appendix C).

![Figure 17. Exploratory model predicting land management practice in the Lachlan and Central West study areas](image)

Table 10 shows the variable names as they appear in the Estimated Model (Figure 17) and the corresponding model component names.

---

4 Variable labels in the Estimated Structural Equation Model (Figure 17) are as they appear in Lisrel 8.72, and differ from the descriptive labels in the simplified model.
Table 9 Variable names and descriptive labels for the estimated Structural Equation Model (Figure 17)

<table>
<thead>
<tr>
<th>Estimated Structural Equation Variable Name</th>
<th>Model Component Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVTHRT</td>
<td>Perceived level of environmental threat faced by the region</td>
</tr>
<tr>
<td>PRESOURC</td>
<td>Perceived resources - the level of satisfaction with the resources (time, money &amp; knowledge) that people feel they have available to undertake land management activities.</td>
</tr>
<tr>
<td>TINF</td>
<td>Trust and influence – trust in and influence of a range of agricultural information providers</td>
</tr>
<tr>
<td>BIOS</td>
<td>Biospheric environmental values – concern for environment as it effects native plants and animals</td>
</tr>
<tr>
<td>PROPLN</td>
<td>Property planning</td>
</tr>
<tr>
<td>RISKINNO</td>
<td>Risk and innovation - the extent to which people are willing to try innovative methods/ technologies and take risks on their farms</td>
</tr>
<tr>
<td>LOC</td>
<td>Locus of control—sense of being in control over decisions</td>
</tr>
<tr>
<td>SOCINF</td>
<td>Social influence and connectedness - the extent to which people have social influence in their agricultural community</td>
</tr>
<tr>
<td>BEHAV</td>
<td>Land management practice</td>
</tr>
</tbody>
</table>

Goodness of fit indices for the final behavioural model

Table 10 Model fit indices for the final land management model

<table>
<thead>
<tr>
<th>Fit Statistics</th>
<th>Obtained Value</th>
<th>Recommended Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square (df)</td>
<td>284.17 (256), p=.109</td>
<td>p &gt; .05</td>
</tr>
<tr>
<td>CFI</td>
<td>1.00</td>
<td>≥ .90</td>
</tr>
<tr>
<td>GFI</td>
<td>0.94</td>
<td>≥ .90</td>
</tr>
<tr>
<td>RMSEA</td>
<td>0.42</td>
<td>≤ .08</td>
</tr>
</tbody>
</table>
APPENDIX F

Parameter estimates and sociograms for social influence models

Overall land management behaviour – more desirable practices

Table 11 Parameter estimates for those demonstrating more desirable land management practice

<table>
<thead>
<tr>
<th>Structural parameters in model</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute density</td>
<td>-3.847090</td>
<td>2.69760</td>
</tr>
<tr>
<td>Activity</td>
<td>1.326912</td>
<td>1.26346</td>
</tr>
<tr>
<td>Star 2</td>
<td>-0.925829</td>
<td>0.66200</td>
</tr>
<tr>
<td>Contagion</td>
<td>0.083076</td>
<td>0.86312</td>
</tr>
</tbody>
</table>

Actor-relation parameters

| Geographic homophily           | -0.014247           | 0.03614        |
| Number of properties           | 0.633828            | 0.34124        |
| Connection to people with      | 0.953302            | 0.41041*       |
| multiple properties            |                     |                |

* indicates a significant relationship

Overall land management behaviour – less desirable practices

Table 12 Parameter estimates for those demonstrating less desirable land management practice

<table>
<thead>
<tr>
<th>Structural parameters in model</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute density</td>
<td>-0.355837</td>
<td>2.89899</td>
</tr>
<tr>
<td>Activity</td>
<td>-7.148464</td>
<td>2.50153*</td>
</tr>
<tr>
<td>Contagion</td>
<td>-5.682289</td>
<td>3.87794</td>
</tr>
</tbody>
</table>

Actor-relation parameters

| Geographic homophily           | -0.101038           | 0.05512        |
| Age                           | 1.660736            | 0.55593*       |
| Connection to age             | 1.291188            | 0.45283*       |

* indicates a significant relationship
Soil Management – sustainable practices

Figure 18 Information network (n=134) of Farmers (circles) and Agri-Business people. Desirable soil testing behaviours are in red. Larger nodes represent more properties.

Table 13 Parameter estimates for network model of sustainable soil management

<table>
<thead>
<tr>
<th>Structural parameters in model</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute density</td>
<td>8.569773</td>
<td>3.11263 *</td>
</tr>
<tr>
<td>Activity</td>
<td>-1.453861</td>
<td>1.07152</td>
</tr>
<tr>
<td>Contagion</td>
<td>1.671053</td>
<td>1.21449</td>
</tr>
</tbody>
</table>

**Actor-relation parameters**

| Geographic homophily                    | 0.025699            | 0.03991        |
| Number of properties                    | 1.618804            | 0.56778 *      |
| Connection to people with multiple properties | 1.861772            | 0.82716 *      |
| Connection to sustainable agribusiness  | 0.486936            | 0.21651 *      |

* indicates a significant relationship
Soil Management – less sustainable practices

![Information network for farmers demonstrating less sustainable soil testing practices (in red). Larger nodes represent more properties.](image)

**Figure 19** Information network for farmers demonstrating less sustainable soil testing practices (in red). Larger nodes represent more properties.

**Table 14** Parameter estimates for network model of less sustainable soil management

<table>
<thead>
<tr>
<th>Structural parameters in model</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute density</td>
<td>3.16535</td>
<td>2.58389</td>
</tr>
<tr>
<td>Activity</td>
<td>-0.57972</td>
<td>0.82539</td>
</tr>
<tr>
<td>Contagion</td>
<td>0.14273</td>
<td>0.75403</td>
</tr>
<tr>
<td>Star 2</td>
<td>-0.09644</td>
<td>0.41383</td>
</tr>
</tbody>
</table>

**Actor-relation parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic homophily</td>
<td>-0.00427</td>
<td>0.02458</td>
</tr>
<tr>
<td>Number of properties</td>
<td>-0.84392</td>
<td>0.42043 *</td>
</tr>
<tr>
<td>Connection to people with multiple properties</td>
<td>-0.16339</td>
<td>0.26828</td>
</tr>
</tbody>
</table>

* indicates a significant relationship
Native vegetation – more sustainable management

Figure 20 Information network of Farmers with desirable native vegetation management (in red)

Table 15 Parameter estimates for network model of sustainable native vegetation management

<table>
<thead>
<tr>
<th>Structural parameters in model</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute density</td>
<td>-1.852819</td>
<td>2.25118</td>
</tr>
<tr>
<td>Contagion</td>
<td>-0.900818</td>
<td>0.68763</td>
</tr>
<tr>
<td>Star 2</td>
<td>-0.706193</td>
<td>0.38376</td>
</tr>
</tbody>
</table>

**Actor-relation parameters**

<table>
<thead>
<tr>
<th></th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic homophily</td>
<td>-0.011667</td>
<td>0.02655</td>
</tr>
<tr>
<td>Connection to other farmers</td>
<td>1.811060</td>
<td>0.88139 *</td>
</tr>
<tr>
<td>Connection to Agribusiness</td>
<td>1.359207</td>
<td>0.84153</td>
</tr>
</tbody>
</table>

* indicates a significant relationship
Figure 21 Information network of Farmers with less desirable native vegetation management (in red).

Table 16 Parameter estimates for network model of less sustainable native vegetation management

<table>
<thead>
<tr>
<th>Structural parameters in model</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute density</td>
<td>0.239009</td>
<td>2.79013</td>
</tr>
<tr>
<td>Contagion</td>
<td>-1.642278</td>
<td>0.82386</td>
</tr>
<tr>
<td>Activity</td>
<td>-1.275375</td>
<td>0.88083</td>
</tr>
<tr>
<td>Star 2</td>
<td>0.888270</td>
<td>0.41189 *</td>
</tr>
</tbody>
</table>

Actor-relation parameters

| Geographic homophily          | 0.030769            | 0.02246       |
| 2 path equivalence            | -1.596615           | 0.60119 *     |

* indicates a significant relationship
Weed management - sustainable practice

Figure 22 Information network of Farmers with sustainable weed management practices (red circles)

Table 17 Parameter estimates for network model of more sustainable weed management

<table>
<thead>
<tr>
<th>Structural parameters in model</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute density</td>
<td>-3.463832</td>
<td>2.07504</td>
</tr>
<tr>
<td>Contagion</td>
<td>0.680052</td>
<td>0.61712</td>
</tr>
<tr>
<td>Activity</td>
<td>1.651471</td>
<td>0.66265 *</td>
</tr>
<tr>
<td>Star 2</td>
<td>-0.603808</td>
<td>0.27482 *</td>
</tr>
</tbody>
</table>

Actor-relation parameters

| Geographic homophily           | 0.015929            | 0.01467        |
| Contagion among partners       | -0.516719           | 0.22842 *      |

* indicates a significant relationship
Weed management – less sustainable practice

Figure 23 Parameter estimates for information network model for farmers with less sustainable weed management

<table>
<thead>
<tr>
<th>Structural parameters in model</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute density</td>
<td>3.479834</td>
<td>2.54582</td>
</tr>
<tr>
<td>Activity</td>
<td>-2.163198</td>
<td>0.80251 *</td>
</tr>
<tr>
<td>Star 2</td>
<td>0.373391</td>
<td>0.37690</td>
</tr>
</tbody>
</table>

* Actor-relation parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic homophily</td>
<td>-0.027701</td>
<td>0.03188</td>
</tr>
<tr>
<td>Remoteness to partners</td>
<td>0.322692</td>
<td>0.12358 *</td>
</tr>
</tbody>
</table>

* indicates a significant relationship
Figure 24 Information network for farmers with sustainable stock management behaviours (in red).

Table 18 Parameter estimates for information network model for farmers with sustainable stock management

<table>
<thead>
<tr>
<th>Structural parameters in mode</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute density</td>
<td>-0.417841</td>
<td>2.91687</td>
</tr>
<tr>
<td>Contagion</td>
<td>0.287929</td>
<td>0.56139</td>
</tr>
<tr>
<td>Activity</td>
<td>-1.047971</td>
<td>0.55721</td>
</tr>
<tr>
<td>Geographic homophily</td>
<td>-0.008074</td>
<td>0.02548</td>
</tr>
<tr>
<td>Gender (male)</td>
<td>1.014932</td>
<td>0.83190</td>
</tr>
<tr>
<td>Connection to Gender (male)</td>
<td>1.378919</td>
<td>0.66532 *</td>
</tr>
<tr>
<td>Connection to Agribusiness</td>
<td>2.980730</td>
<td>1.47346 *</td>
</tr>
</tbody>
</table>

* indicates a significant relationship
Figure 25 Information network for farmers with less sustainable stock management behaviours (in red).

Table 19 Parameter estimates for information network model for farmers with less sustainable stock management

<table>
<thead>
<tr>
<th>Structural parameters in model</th>
<th>Parameter estimates</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute density</td>
<td>4.849394</td>
<td>2.92936</td>
</tr>
<tr>
<td>Activity</td>
<td>0.583168</td>
<td>0.78142</td>
</tr>
<tr>
<td>Contagion</td>
<td>-0.290112</td>
<td>0.74416</td>
</tr>
<tr>
<td>Geographic homophily</td>
<td>-0.042396</td>
<td>0.03101</td>
</tr>
<tr>
<td>Remoteness to partners</td>
<td>0.256413</td>
<td>0.12830</td>
</tr>
<tr>
<td>Connection to gender (female)</td>
<td>-1.686186</td>
<td>0.73708 *</td>
</tr>
<tr>
<td>Connection to Agribusiness (non gov)</td>
<td>-2.720358</td>
<td>1.32222 *</td>
</tr>
</tbody>
</table>

* indicates a significant relationship
## APPENDIX G

Maton’s Transformative change framework applicable to catchment management.

### Table 20 Dimensions, levels and goals of transformational processes (adapted from Maton, 2000)

<table>
<thead>
<tr>
<th>Environmental dimensions</th>
<th>Instrumental</th>
<th>Structural</th>
<th>Relational</th>
<th>Cultural</th>
</tr>
</thead>
</table>
| Attributes               | Processes & methods to achieve goals  
Problem-solving capacity  
Leadership                | Opportunity structure  
Distribution of resources & power | Connectedness  
Inclusiveness  
Shared mission  
Support  
Belonging | Belief systems  
Values  
Social norms  
Traditions  
Practices |
| Transformational goals   | Capacity-building  
Group empowerment | Relational  
community-building | Culture challenge | |
| Setting & level of analysis | Organisational effectiveness  
Empowering community | Supporting & significant settings | Alternative | |
| Community type           | Competent  
Empowering | Caring  
Questioning | | |
| Societal focus           | Problem-solving  
Justice  
Inclusiveness | Balance | |

In this framework, the instrumental dimension refers to the type of activities undertaken to achieve fundamental goals of the organisation or group; the structural dimension refers to the operating environment of the group with goals of enhancing access to resources and empowerment; the relational dimension refers to the intergroup and personal relationships with goals of inclusiveness, support for individuals and groups, trust and cooperation; and the cultural dimension refers to the inherent belief systems, values and norms of the societal setting of the group (Maton, 2000).
**Glossary**

**ANOVA – Analysis of variance** – a statistical procedure used when you have two or more groups and you wish to compare their mean scores on a continuous variable. A two-way ANOVA allows you to test the impact of two independent variables on one dependent variable.

**Correlation** – The linear relationship between two variables. A correlation coefficient’s value ranges between -1 and +1, with the sign indicating the direction of the relationship and the numerical value the strength of the relationship.

**Cronbach’s alpha** – a measure of the extent to which a set of questionnaire items are consistent. It is a correlation value and the closer it is to 1.0 the better, or more internally consistent, the items are considered.

**Latent variable** – a variable that is not directly measured but is assessed indirectly through two or more measured (observed) variables.

**Model fit indices** – **Chi-square** is a test of differences in frequencies which can be used to estimate the statistical significance (or validity) of conclusions about the differences between groups. It also can be used as a measure of the goodness of fit (the extent to which a derived modelling solution can reproduce the original data). As a measure of goodness of fit, a non-significant or smaller chi-square indicates a good fit, while a large value indicates a poor fit. **CFI** (Comparative Fit Index), **GFI** (Goodness of Fit Index) and **RMSEA** (Root Mean Square of the Errors of Approximation) are further statistics associated with goodness of fit. Goodness of fit indices are measures of the extent to which the derived model approximates the original data. A good fit is one that explains the data well. These indices need to be within a certain limit to indicate a good fit. More detailed information can be found in Structural Equation Modelling references such as Diamantopoulos and Siguaw (2000).

**Paired-samples t-test** – a statistical procedure used when you have only one group of people and data from two different occasions, or under two different conditions.

**Principal Components Analysis (PCA)** – A mathematical technique to reduce a high-dimensional space to just a few orthogonal axes called principal components, which are defined in terms of weighted combinations of variables that maximize the variance of the data along those axes. PCA is typically used for clustering data and making its visualization easier.

**Reliability analysis** – a statistical technique used to assess the internal consistency of a scale, that is, the degree to which the items that make up the scale are all measuring the same underlying construct.

**Structural Equation Modelling** – a set of statistical techniques that allow a set of relationships between one or more independent variables (either continuous or discrete) and one or more dependent variables to be examined. The independent or dependent variables can be either measured or latent.
REFERENCES


