

Adaptation to Climate change in Farming Communities: Observations from two Research Projects in South Australia

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Received for publication February 5, 2018.

Abstract

Findings are presented from two major research projects investigating impacts of climate change in rural South Australia. One focuses specifically on farmers' responses to periods of pronounced heat and drought on both Eyre and Yorke Peninsulas. The second looks more broadly at how rural communities across the State respond to spells of extremely high temperatures. In both cases, the primary data source is semi-structured interviews with key informants who provided information on their personal responses to changing weather patterns. Small focus groups were an additional information source, enabling participants to share their experiences, and especially for farmers and their advisors, to discuss what sources of information they use regarding climate change and the risks it poses. Attachment to place is revealed as playing an important role in how rural inhabitants respond to heat and drought. This is especially true for farmers who are frequently members of communities of practice in which information about risks from various sources, including climate change, is shared. Farmers respond to these risks, not only based on their own knowledge of land management on their farm, but also through advice generated within a community of practice. This is distinct from information supplied by formal institutions such as State Government departments. Farmers' responses to risk are essentially short-term and directed at specific farm-based practices. Implications for the nature and source of information for farmers and rural communities are discussed with a simple model of information flows (or knowledge transfer) presented that incorporates both communities of practice and formal institutions. It is argued that greater scope should be given to valuing local knowledge, through more two-way flows of ideas and information involving farmers, their advisors, rural communities, and State and Federal government agencies.

Key words

Climate change, Adaptation, Farmers, Rural, Communities of practice, Formal institutions, South Australia.

This paper is based on findings from two major research projects conducted in South Australia¹. One was focused specifically on adaptation to climate change, investigating farmer decision making in the State's Eyre and Yorke Peninsulas (Fig. 1). The second considered how the broader community across rural South Australia was adapting to the health challenges of climate change and primarily to increasing temperatures and more extended periods of very hot weather. The projects used qualitative methods, including focus groups and semi-structured interviews to elicit information on both attitudes and responses to climate change. These generated rural narratives from geographically and climatically diverse areas across the State to explore the impacts of extreme heat, drought, and broader climate change, and how different aspects of place may shape experiences, perceptions and responses. The research examined how experiences, perceptions, and responses to extreme heat and drought are influenced by physical, social, and psychological aspects of place. The aim was to provide a broader understanding of the impacts, challenges, and responses to extreme heat and drought by farmers and rural communities and the implications for adaptation.

Adaptation to climate change

The broader context for the research is the clear evidence for South Australia in recent decades of both increased warming and unreliable rainfall accompanied by spells of more pronounced extreme weather events (e.g. heat-waves, droughts, and storms) (Climate Commission, 2012; DEWNR, 2012; BOM and CSIRO, 2016). In the future, this may mean shorter or more unreliable growing periods for species of native plants and animals, also affecting crop and livestock production on farms (Eyre Peninsula NRM Board, 2009). Adaptation by farmers might involve changing the range of crop types and introducing different enterprise mixes (Doudle et al., 2009). There is also a need for improved ability to recognize and analyze impacts on farm enterprise costs, benefits, and risks. Investment in improving relevant information flows to farmers may be required in addition

¹NRM Alliance/Department of Water, Land & Biodiversity Conservation SA, 'Regional communities adapting to climate change,' Lead Researcher: G.M. Robinson; Australian Research Council Discovery Grant (DP1200101983), 'Adaptive capabilities in the elderly during extreme heat events in South Australia,' Lead Researcher: Peng Bi Interviews were conducted by Sue Williams, Karen Cosgrove, and Christopher M Raymond. Ethics approval was provided by the University of South Australia and the University of Adelaide.

to increased research and development on low-rainfall agriculture and crop varieties more tolerant of drought and high temperature extremes (Anwar et al., 2013).

The paper aims to build on studies analyzing the basis for adaptations to climate change (Tompkins et al., 2010; Adger et al., 2013; Wise et al., 2014). These have shown adaptation largely occurs in response to published research findings, awareness raising (often by lobby groups and networks), training programs related to promotion of sustainable development, and the implementation of strategic development plans and legislation. Adaptation to climate change is taken to mean 'adjustments in natural or human systems in response to actual or expected climate stimuli and their effects, which moderates harm or exploits beneficial opportunities' (IPCC, 2007). Various types of adaptation can be distinguished, including anticipatory, autonomous, and planned adaptation. Anticipatory or pro-active adaptation takes place before impacts of climate change are observed. Autonomous or spontaneous adaptation does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Planned adaptation is the result of a deliberate policy decision, which is based on an awareness that conditions have changed or may change so that action is required to return to, maintain, or achieve a desired state.

Adaptation is frequently incremental, where short-term and small-scale actions reduce losses to a system or enhance the benefits of variations in climate. Alternatively, it can also be transformational when actions are adopted at a much larger scale or intensity than current actions. Transformational adaptation may be actions that are new to a region and may involve technological innovation, institutional reforms, behavioral shifts, and cultural changes (Kates et al., 2012; O'Brien, 2012). It is the incremental adaptation that to date has proven most common in many parts of the world, whilst more far-reaching adaptations will require greater understanding of the factors which encourage or discourage the implementation of adaptation measures across multiple groups and scales of management, especially for specific localities, regions, and by sector (Arnell, 2010). Individual barriers and drivers of climate change adaptation are now relatively well understood, but less is known about how adaptation occurs across multiple levels in society, affecting not only individuals, but also groups and institutions (Biesbroek et al., 2013; Eisenack et al., 2014). Hence, this paper not only addresses adaptation as taken by individuals, but also in the case of farmers as part of shared group thinking and with distinctive institutional inputs.

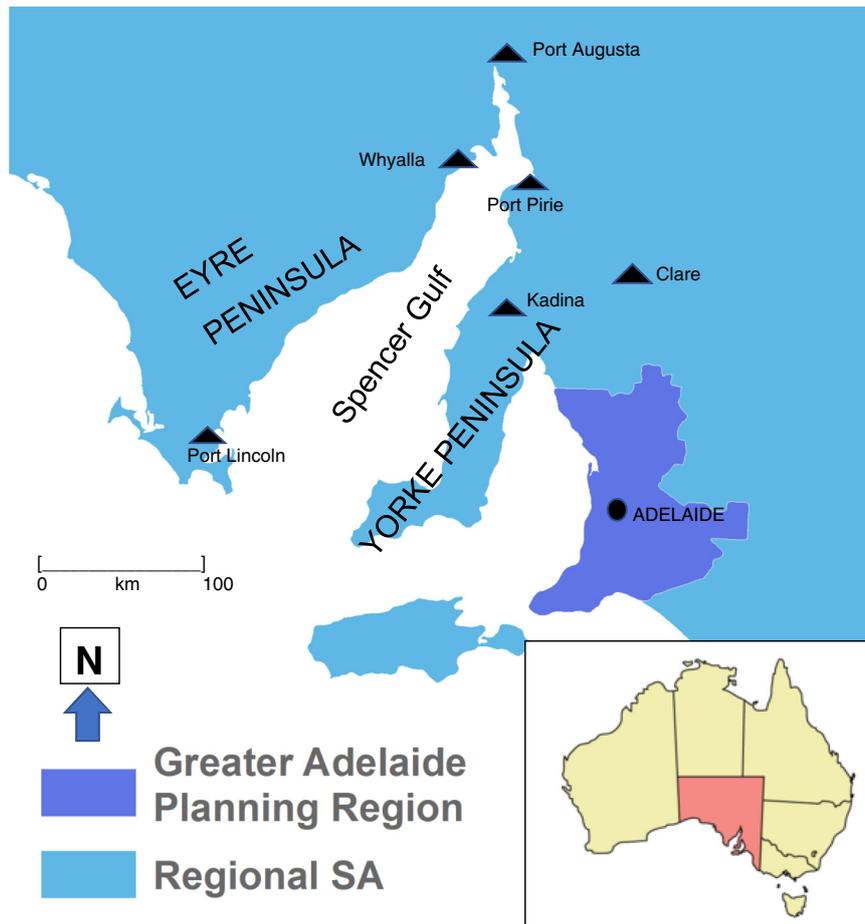


Figure 1: Location Map. Source: SA Planning Portal. Available at: https://saplanningportal.sa.gov.au/_data/assets/image/0006/283128/LGAs_Region_Graphic_legend2.png.

An additional context for this research is the relationship between climate change and public health issues. Effective public health responses to extreme heat and/or drought require an understanding of the impact on health and well-being, and the risk factors or protective factors within communities (Akompab et al., 2013; Williams et al., 2013). Hence, it is desirable to improve public health planning for heat emergencies in South Australia, as accentuated by the prolonged heat event in 2009 that resulted in significant mortality and morbidity (Hansen et al., 2015; Zhang et al., 2017). It is suggested that individuals with strong attachments to place may have a particular resilience to severe weather based on how this attachment interacts with other individual and rural community characteristics.

Methods

The research comprised two strands. First, a focus on farmers and their advisors used a sample of 30

interviews (15 in the Eyre Peninsula and 15 in the Yorke Peninsula) using a semi-structured interview guide. Participants were selected based on nominations from the general managers of local Natural Resource Management (NRM) Boards. The number of interviews was determined with reference to the concept of data saturation (Charmaz, 2006; Fusch and Ness, 2015), whereby a point is reached in the sampling when no new themes or new thematic information are attained or add to the overall experiences described by the interviewees. This was reached around $n = 15$ in each area. In addition, some focus groups were conducted, involving in total 50 farm advisors and representatives from government and conservation organizations. The latter included members of NRM Boards, employees in State Government departments and primary industry organizations, and representatives from key financial organizations who advise farmers, including Rabo Bank, Elders, and Landmark. Many of the farmers and their advisors, including agronomists, were members of farm systems

groups, such as the South Australian Farmers Federation (SAFF), the Australian Bureau of Agriculture (ABA), and the South Australian No-Till Farmers Association (SANTFA).

Most of these interviews took place just after a serious drought had affected the Eyre and Yorke Peninsulas. So, respondents and participants were largely commenting on adaptations that had occurred in the very recent past and which were often still in progress as part of an ongoing response. The interviews as well as the focus groups took place on farms in the two areas, generally to coincide with field trials. Some interviews with representatives from government took place in Adelaide or in offices in the two case study areas.

The farmers interviewed were primarily specialist grain (wheat and barley) or sheep producers. The former generally also grew canola (oilseed rape) and a few pulses as break crops. Some holdings were mixed livestock and grain enterprises. The Yorke Peninsula has had the label 'barley capital of the world' applied to it since the late 19th Century, but it also has producers of prime beef and lamb. In recent years, lentils have become a more popular crop there, and it currently produces half of the national lentil crop, but mainly reflecting favorable prices rather than a response to climate change.

Second, there was investigation involving the broader rural public. This included 28 in-depth interviews across the state, including nine farmers, people working in the health-care sector, and employees in both the private and public sectors, which covered a cross-section of different ages, educational backgrounds, and employment characteristics. Interviewees were selected using a convenience, snowballing sampling approach, with invitations to participate distributed via various rural organizations which included information about the research project on their websites, e-mail mailing lists, and newsletters. Individuals expressing interest in participating were contacted initially via e-mail and then by telephone after which individual interviews or focus groups membership was agreed (Williams et al., 2017). Again, the concept of data saturation determined the sample size of $n = 28$. Interviews with these community members were spread over two years during which there were several 'heat spikes'.

Each interview across both strands lasted from 40 to 90min and was conducted either at the residence of the respondent and/or at their place of work. The interviews with farmers and the related focus group sessions concentrated on five issues:

1. respondents' understanding of climate change and how this encouraged or discouraged adaptation to climate change;

2. the availability of information on adaptation to climate change and how this addressed the needs of farmers;
3. effectiveness of methods used by formal institutions (such as State Government departments) and communities of practice (such as farm system groups) to communicate knowledge about climate change adaptation to farmers;
4. improvements required (if any) in the types of information on climate change and adaptation to climate change available to farmers; and
5. networks and relationships developed with formal institutions and/or communities of practice across the country to provide up-to-date information on adaptation to climate change.

For the group drawn from the wider community, questions dealt with:

1. how long they had resided in the area;
2. how they would describe extreme heat in their region;
3. their views about how extreme heat affects themselves and others in their community;
4. how people respond to and cope with excessive heat;
5. the factors that might facilitate, or act as barriers to, coping with extreme heat within their region and community;
6. how extreme heat affected their work or other activities; and
7. the potential impacts of increasing extreme heat in their community.

The research utilized grounded theory analysis (Strauss and Corbin, 1990) to identify, analyze, and report themes produced by the interview data. It is an approach seeking to discover or generate theory from the data collected as opposed to basing inquiry on pre-established theoretical foundations. In broad terms, this reflects the scope for developing theory on which factors encourage or discourage adaptation to climate change, especially within the agricultural sector.

The analysis searched for important themes emerging from the interviews and focus groups rather than quantifying relationships between variables or considering all possible variations of a concept. Once interviews were transcribed, they were coded for analysis by:

1. close reading of the transcript and recording initial ideas;
2. generating initial categories of factors encouraging or discouraging adaptation to climate change;

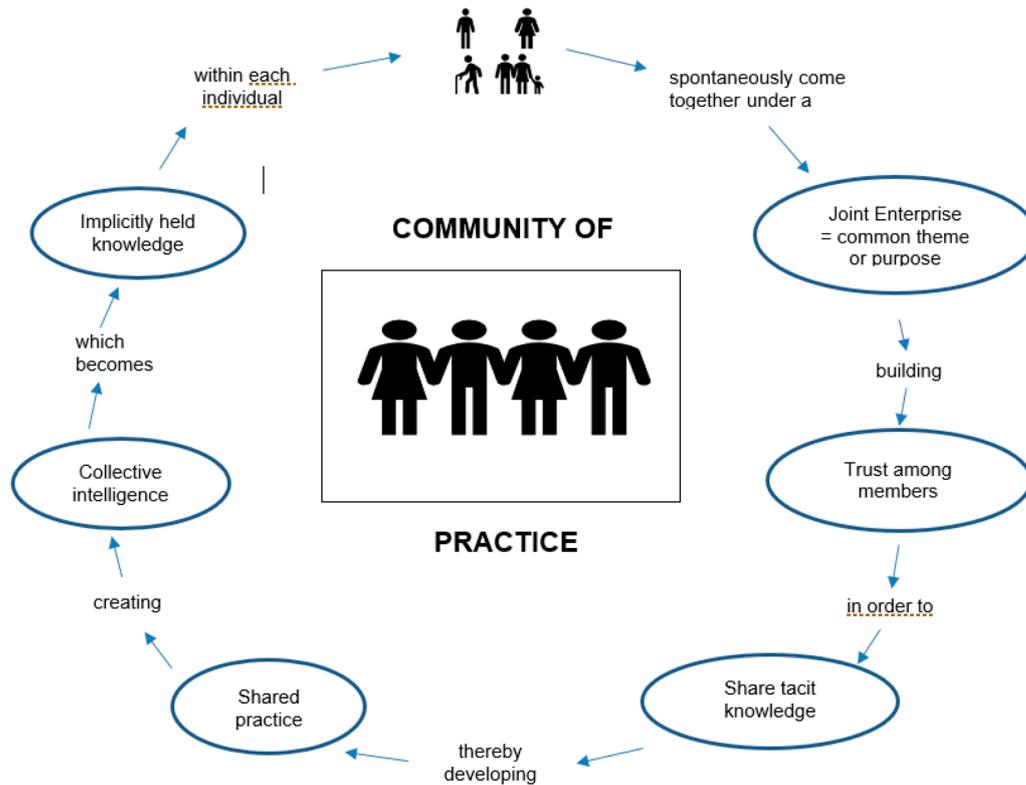


Figure 2: Communities of practice. Based on Pennington (2011).

3. searching for themes and assigning particular text to the categories; and
4. confirming that the themes related to the categories generated across the entire dataset.

Farmers' adaptations to climate change

The various interviews and focus groups revealed the importance of two sources of influence on farmers' behavior with respect to taking actions to deal with climate change. First, there were formal institutions, which are groups which follow rules and procedures created, communicated, and enforced through channels widely accepted as official, such as courts, legislatures, and bureaucracies. The government agencies responsible for regulating natural resource management, NRM Boards, are examples of formal institutions in this context. However, more important was a second source, communities of practice, which are informal structures brought together through the social construction of knowledge. In these communities, members share a similar set of interests, expertise, roles and goals; opportunities exist for members to interact with one another through both formal

and informal spaces; and groups share a common practice or set of practices, e.g., farm systems groups (Fig. 2).

The research revealed that farmers are capable of autonomously adjusting to risks encountered in their business. However, they are more likely to respond to short-term risks because these have direct impact on their farm operations, rather than longer-term risks related to climate change. The communities of practice, and especially farm systems groups, tailored their trial programs and communication techniques to address short-term risks to the farming system. As part of a community of practice, knowledge and information relating to climate change adaptation is targeted at trusted individual advisors, such as agronomists hired by farmers, who then present it to the farmers. Members of farm system groups tended to regard information about climate change from formal institutions as being highly complex and focused on the long-term. This information does not necessarily consider direct and immediate risk, is often quite general and unspecific to a particular locality, and so was often regarded by farmers as being of limited value.

There were different views about the existence of human-induced climate change. The majority of the

farmers stated they did not believe in this, though younger farmers were more likely to accept that observed changes to weather patterns across several years reflected human influence. However, the majority tended to talk about 'natural' variability of weather and it was this that they responded to in terms of adapting their farming systems (Raymond and Robinson, 2013). Representatives from both formal institutions and communities of practice stated that the divergence of opinion on the existence of climate change was an important constraint on the communication of scientific information about adaptation to climate change. This meant that when advice about adaptation was delivered to the farmers, for example by close advisors, generally it was not couched in terms of climate change. Instead, advisors might refer to the need to adopt methods to improve soil moisture:

We've just run a series of workshops [...] just on soil moisture, and talking to our members about, if you have a full profile of soil moisture right now, because of summer rain or last season's carry-over of moisture, you can grow longer season varieties on oil seeds and that sort of stuff with a lower risk, but if you have no soil moisture and you're going to be growing that crop only on the in-season rainfall, what are you going to do and how are you going to manage in-season nitrogen applications if the surface of the soil is wet, but knowing you don't have deep moisture, and how nitrogen moves with wetting fronts and all that sort of stuff (farm systems group advisor)?

Farmers were in receipt of numerous reports on climate change, often produced by formal institutions, including CSIRO, the South Australian Research and Development Institute (SARDI), and South Australian Government-commissioned reports (e.g. Rebbeck et al., 2007). In general, farmers tended to refer to many such reports as being highly complex, reporting different projections from multiple models, and based on assumptions that were often hard to understand. One grain producer on Eyre Peninsula stated explicitly:

Most of them [government reports] do not encourage us [farmers] to think more deeply about climate change. In fact, with me, they have the opposite effect of making me more sceptical.

Some farmers and their advisors referred to how they regarded the findings presented by climate change science as 'too complex' and even 'conflicting,' regarding this as a major barrier to encouraging adaptation to climate change. Many of the farmers did

not know how to react to the various reports, so they sought advice from their trusted advisors, including neighbors, agronomists, and individual farm consultants, to understand the implications for their own enterprise.

A typical criticism of scientific reports on different adaptation options for rural landholders was that they did not fully reflect local realities of the impacts of climate variability or climate change. For example, several interviewees mentioned that some reports failed to consider how rainfall varied across their region in accordance with local topography. For some farmers, though, a distinction was made between material prepared at federal or state level and that coming from regional and local sources, notably the government agency responsible for regulating natural resource management: regional NRM Boards. For example, in the Eyre Peninsula, widespread consultations between the Board and farmers were contributing to on-farm adaptation measures such as introducing different pasture species and planting salt-tolerant perennial species (Crawford et al., 2010). Eyre Peninsula Natural Resources Management Board, 2017. Many grain producers were planting fast-maturing wheat varieties to combat shorter growing seasons and also adopting no-till farming to conserve moisture and increase carbon in the soil. These adaptations have been championed in the region by a Regional Climate Change Adaptation Plan, produced through wide community consultation (Siebentritt et al., 2014).

Information from local research centers was also valued, e.g., the Minnipa Agricultural Research Centre on Eyre Peninsula, which celebrated its centenary in 2015, was a source of advice and material relating to climate change. Information from the Centre was often conveyed through the communities of practice and trusted farm advisors, including dissemination at field-day events held at the Research Centre. These had particular themes, e.g., farming on sandy soils. Information from state government (e.g., SARDI) and national organizations (e.g. Grains Research and Development Corporation) could also be conveyed through these events. PIRSA's key delivery agent for major programs and projects across South Australia is Rural Solutions SA, which has regional offices, helping to break down the 'distance barrier' with farmers.

In addition to the disjuncture between scientific reports and some farmers' views, there was also an important temporal dimension associated with farmers' actions. Many farmers would not enter into long-term binding commitments to manage natural resources, e.g., by committing to 15-year management plans proposed by the Eyre Peninsula NRM Board (Williams

et al., 2009). They preferred to seek assistance from government agencies to address immediate impacts of climate variability, e.g., adopting new crop varieties capable of withstanding lower soil-water moisture availability. Farm systems groups were meeting this need by creating field sites for testing the effectiveness of new crop varieties on different soil types. This focus on short-term risk was viewed negatively by some institutional respondents who wanted greater engagement from farmers toward strategies enabling longer-term adaptation to climate change. For example:

There is a need for some strategic planning, looking at the long-term basis for farming, because most farmers are focused on the day-to-day issues. There are already signs that the long-term changes are now adversely affecting some districts, so for example, [...] I know of at least three farms which are no longer farmed, where the landholders have basically just walked off or have gone to the mines or something, just left them. [...] There are also more adaptive measures such as changing to less intensive cropping systems, changing to a more live-stock focus, which do need to happen. Farmers are generally not focusing on those issues adequately at this stage (government-employed advisor).

However, farmers often justified their shorter-term focus:

Things that are relevant to farmers are what we can do in the short-term to sort of make the best use of what we've got (sheep farmer, Eyre Peninsula).

A longer-term approach to adaptation was also hindered by the presence of other considerations affecting farmers' decisions. These included the state of international markets, which helped determine the price for commodities. Price signals were a more immediate factor affecting decisions than more nebulous long-term climate signals. Moreover, the move from independent farm co-operatives to large multinational corporations had brought uncertainty to grain marketing, adding to difficulties faced by farmers when deciding what to grow to produce an economic return.

Yet, despite reluctance to focus on long-term adaptation to changing climate, there was plenty of evidence that farmers were responding to perceived short-term risk:

Farmers are interested in what's going to make them money in the short term [...] So, that's more relevant, I think, than sort of talking about what's

going to happen in twenty or thirty years, because none of us really know what other changes there's going to be in that time anyway. So, things that are relevant to farmers are what we can do in the short-term to sort of make the best use of what we've got (grain producer, Yorke Peninsula).

Information from communities of practice was disseminated on a regular basis, for example, at monthly meetings of farm system groups and other local community networks. Partnerships created via regional development boards (RDAs) were also acknowledged as being important, though these rarely involved state-level formal institutions. Communicating relatively simple scientific information through these meetings was regarded as having significant impact, especially through 'learning by doing' approaches:

So, what they need to do or the only way really to get to them is to involve them in something where they can do something specific, such as trialling new crop varieties (farm systems group advisor).

As a result, several adaptations to heat and drought were being introduced. One example is dry sowing, that is sowing a crop irrespective of the occurrence of 'normal' rainfall, and sowing grain earlier than the local norm to take advantage of rain in March and April but using slow-maturing varieties. Heat stress was identified as a yield limiting factor, with one response being sowing at different times so that crops mature outside the highest risk periods. Another adaptation was inclusion of two-year break phases in low-rainfall crop sequences as a reliable management tool for increasing the yields of subsequent wheat crops. This might involve a fallow period or alternatively rotating cereals and pasture or perhaps growing a break crop. The latter include canola, lupins, peas, and lentils.

It is through farm-based demonstrations and exchanges of information that farmers are encouraged to make adaptations to the changing climate. In this way, many farmers are autonomously adapting to risk, not just to changing weather patterns but to a wide range of risks they face each day, including changing economic and market signals. This 'autonomous adjustment' is occurring independently of direct government assistance, through strategies involving increases to farm size or adopting new technologies, or augmenting farm incomes by taking off-farm work, intensifying/extensifying current enterprises or entering into partnership, cooperative or share farming enterprises. They were mainly reactionary and not anticipatory adjustments but were producing some

widespread changes to farm businesses across the two regions, e.g., moving from long-season wheat varieties to short-season varieties, from pure Merino (which provide wool only) to Delaine Merino (which provide both meat and wool), sowing crops in April rather than May, retaining stubble to minimize soil moisture loss, and switching wholesale from cropping to livestock. So, even if respondents do not accept human-induced climate change per se, they are adjusting anyway. For example:

I can recall from 30-40 years ago that we would often get heat waves come, with hot north winds coming much too early, like in late August/ September which affect the crops. You know, it might hit them at flowering time, affect the yield, knock them about; it means we need more rain. If you have a kind spring then they can cope with less rain, etc. So, we need more varieties bred that are drought tolerant/heat tolerant (grain producer, Eyre Peninsula).

It was also recognized, though, that adaptive actions against climate change were not always possible:

One day in 2004 in October we had a very, very high [...] the temperature went up to about 43 or 44, really high for one day, but it happened when crops were just towards the end of their ripening cycle [...] it just finished it. One really hot day would have taken hundreds of thousands [of dollars] off the value of those cereal crops through the mid-North (grain producer, Mid-North, South Australia).

The focus groups and interviews with respondents from communities of practice emphasized the significance of farmers' individual trusted advisors in promoting adoption of technologies or different methods to mitigate farm risks. These individuals might be a leader of a farm systems group, a farm neighbor or an independent farm consultant such as agronomists employed by farm goods and services companies (e.g. Landmark and Elders), or independent farm consultants unaligned with any one company. These advisors had largely replaced the role of the government extension service worker as this assistance had been phased out. However, direct links between city-based formal institutions and trusted individual advisors seemed to be relatively limited, especially in terms of engagement in planning for adaptation to climate change. Farmers tended to ascribe this to the 'tyranny of distance', with most institutional headquarters based in Adelaide (200-600km away).

The main aim of farm systems groups was to enhance farm businesses, with use of face-to-face communications at on-farm workshops attended by members, mainly farmers, and their advisors. This meant that information could be effectively disseminated amongst the membership and it was often well-tailored to the farmers' needs. This contrasted with the information presented by formal institutions, which was more likely to be prepared by scientists and urban-based policy makers, often in the implementation of specific programs, such as Caring for our Country, aimed at environmental protection and sustainable farming practice across Australia (Government of Australia, 2013). This information was often generalized material on climate change policy and climate change, whereas communities of practice provide site-specific information. Farm systems groups provide farm-specific or regionally-specific information on topics such as plant-available water, new crop varieties, new fertilizer types and new sowing techniques to manage farm risks. In contrast, institutions provide opportunities for rural landholders to comment on climate change policy in regional natural resource management plans. All interviewees acknowledged that more specific information on climate variability or change would assist adaptation, especially if it referred to seasonal differences rather than longer-term trends.

The importance of place

It was apparent across both sets of interviews and the focus groups that one of the factors affecting how farmers and the wider rural community responded to risks associated with climate change was the relationship individuals had with place. Farmers distinguish themselves based on their occupation, and an inherent connection with land and weather that is part of farming. There is a sense of continuity of the concept of themselves as farmers that extends across time and different situations, which may be desirable for reinforcing their identity. This is the principle of referent continuity, which relates to the continuity of behaviors within place, continuity in relation to historical connections with physical features, or social connections with long-term family and friends (Twigger-Ross and Uzzell, 1996; Downey et al., 2017; Philip and MacLeod, 2018). People's pasts are linked to specific places, such as generational family farms, thus perpetuating a sense of continuity of the self. Places such as family farms are reference points for past selves and actions. Hence, we can acknowledge the significance of subjective aspects of place, like perceptions, experiences, and place relationships, when

considering how people, in this case farmers and rural residents, respond and adapt to climate-related challenges. Yet, there is scant understanding of how affective connections with place may influence how people respond or adapt to increasing exposure to heat and/or drought.

The importance of referent continuity underpinning the actions of farmers and members of the wider rural community appeared in various guises in the interviews and focus groups, giving support to findings of other research conducted in South Australia. For example, Raymond et al. (2010a), whose study included landholders in the Yorke Peninsula, demonstrated that attachment to place combined aspects of social bonding (to a local community), nature bonding (to a particular environment) and personal context (including a 'rootedness' in place through which identity and place dependence are constructed). However, the nature of this attachment did not contribute significantly to pursuit of measures to maintain or improve planting of native vegetation on farms (Raymond et al., 2011). This may reflect farmers' main concern to survive economically, and hence measures to adapt to heat and drought must be geared toward production. This is illustrated in this study by farmers using clay spreading and delving on drought-susceptible sandy soils. Several farmers using this to counteract drought, indicated a high level of continuity with practices adopted by their predecessors by explicitly referring to 'similar measures to those taken by my parents/grandparents'.

Place identity can be described as 'those dimensions of self that define an individual's personal identity in relation to the physical environment by means of a complex pattern of conscious and unconscious ideas, beliefs, preferences, feelings, values, goals and behavioural tendencies' (Proshansky, 1978, p. 148). The people interviewed in this study have a distinctive rural identity, with climate and place integral to this identity relationship. Their experiences and resilience in the heat and drought may make a positive contribution toward maintaining and reinforcing their place identity. Strong place relationships may contribute to community resilience and adaptive capacity, which is a feature of Australian rural communities coping with other challenges, such as economic downturns, and natural disasters, especially drought and excessive heat (Buikstra et al., 2010; Nelson et al., 2010).

With respect to responses to climate change, farmers repeatedly referred to their actions in the context of a temporal continuum. Comments such as, 'Basically I'm following the example of my father's responses to the major drought in the 1980s' and "I remember how my grandfather dealt with a 'big dry' in the 1960s" reflect a desire to maintain a continuity

of decision making on the farm. This contributes to a widespread view amongst the farmers that recent experiences of heat and drought are simply 'normal' and are on a continuum of extreme weather that previous generations of the farm family have encountered. As they largely regard recent climatic variability as the norm, they do not attribute it to any human impacts. However, this does not mean that they do not respond to this variability, but rather it places their response in a particular context, which may have a significant impact on the nature of that response. It emphasizes actions that can be related to past experiences of family and neighbors and therefore reinforces the importance of communities of practice as these are regarded as being part of a 'circle of trust'. In contrast, formal institutions sit outside this circle, so that the nature of the information they provide has a double negative: it is from 'outside the circle' and it is presented in a style, language, and general content that is often unappealing to farmers.

The narratives of the farmers and other rural residents display the construction of a farm, rural or remote place identity, with climate being an integral part of place within this relationship. For example, rural people with a long connection with place tend to feel they are better able to understand and cope with the challenges of extreme heat. Indeed, for some, especially the farmers, heat adaptive behaviors can be described as traditions. They largely practice what can be described as self-efficacy, coping with extreme weather without making many changes to the general pattern of their lives. This may restrict transformative adaptations, though some of the changes being promoted by farm systems groups may be approximating this type. The adaptations tend to reinforce a sense of continuity, but also self-esteem, self-efficacy and possibly also distinctiveness.

Research involving the wider community

Interviewees described how the extended duration of heat and/or drought, a lack of overnight relief, arid landscape or lack of natural shade could make the experience of heat more challenging. They expressed special anxiety over increased fire-risk. Other important considerations were restrictions to water supplies, leading to a loss of amenity, especially for those residents who are self-reliant for water; and concern about their gardens, local parks, trees, and wildlife; highlighting the importance of the natural environment to these rural residents. A sense of loss was expressed when natural features had succumbed to the heat and dry conditions.

Extended spells of very hot weather were associated with inconvenience and discomfort, as described by most participants, and in some cases potentially serious health effects. The farmers generally did not consider small-scale events of extreme heat and/or drought to be a major threat to their livelihood as they could point to measures they had taken within their farm management to adapt. These included greater reliance on crops and livestock bred to suit harsher conditions. However, they referred to longer periods of heat in combination with reduced rainfall as potentially a serious threat. For example, there was reference to crops being 'wiped out' by unseasonal heat combined with very dry conditions.

In terms of individual well-being, respondents spoke about excessive heat curtailing activity, and some incidence of heat stress-related illness and fatigue. In terms of longer lasting effects, for example on work and livelihoods, extreme heat was not regarded as a major threat to livelihood. Farmers described their stock as being very heat-tolerant, providing water and shade were adequate. There was more reference to the effects of extreme heat on trees and wildlife, highlighting the importance of the natural environment, and its importance in contributing to the character of place. Several interviewees mentioned failing generators on rural properties and lack of air-conditioned public space for 'refuge' in small towns on very hot days. Interviewees from non-farm backgrounds were well-aware of agricultural losses due to excess heat and drought as well as damage to infrastructure.

It was widely felt that strong support networks in rural communities were beneficial in coping with prolonged spells of very hot weather. Hence it was regarded as common practice for neighbors to 'keep an eye out for each other'. Nevertheless, there was recognition of the potential for extreme heat to compound disadvantage and adversity, and this resonated across different rural locations. Low-level discomfort associated with the heat was widely accepted:

I think you'll find that it's just not so much of an issue for country people. They just don't have the expectation of being comfortable all the time, and there are more important things, so comfort is so far down the scale compared to drought and fire and damage to crops. There is this preoccupation and at the risk of generalising in urban Australia there is an expectation that we should all be comfortable all of the time (rural resident, Riverland, South Australia).

There was an underlying concern expressed by the majority of respondents that increasing severity of the climate could contribute in various ways to people leaving rural areas. Several referred to negative impacts on farmers' livelihoods and the notion that farmers could be 'driven off the land'. On a similar theme, there was reference to youngsters not wishing to return to rural life once they had been to the city to study, because life was 'harsher' in rural areas, especially for poorer residents. The latter might not be able to afford air conditioning, which would perhaps also be true for some city dwellers but there shopping malls and public buildings could provide air-conditioned space, which was not always available in country areas. In remote areas, running generators or buying in water added to the cost of living:

Any increase in temperature that affects the economic strength of the community will impact on people, you know losing people because there's less things available. I mean that happens during drought times here as well but if we see an increase in that, that will add pressure on those who need to leave or those that are staying but trying to cope with the smaller population. There will be those kinds of things that you don't think of as being immediate impacts (farmer, Eyre Peninsula).

This builds into a concern that climate change might contribute to out-migration and therefore ultimately be detrimental to the social well-being and long-term viability of the entire community. In contrast, several interviewees cited cases of elderly residents on remote farms who refused to leave their properties in a severe heat-wave despite the possibility that the heat was contributing to recurrent bouts of illness.

Discussion and conclusion

The two research projects discussed in this paper have helped elucidate some of the key factors affecting decision making by farmers with respect to climate change adaptation. They have revealed that farmers are autonomous adapters who respond to risk on a regular basis. Changing weather patterns, and especially periods of excessive heat and drought, are just one of the risks they address, but they use information provided by trusted advisors and neighbors to make significant changes to their farming systems in response to recognition of identified risks. In terms of adapting to climate change, it is the communities of practice as opposed to formal institutions that tend to be more influential. Farm systems groups play a spe-

cial role as they provide a significant conduit for information about adaptations. The latter generally take the form of alterations to farm practices, e.g., involving water management, and can be transformative in nature, e.g., adoption of drought-resistant crops, new breeds of livestock, and even wholesale changes to the type of farming.

Trusted advisors from within communities of practice often utilize demonstration days and field trials to provide practical details of how adaptations can be adopted at the farm level. In this manner farmers can gain direct experience of potential changes to apply on their farms, in stark contrast to the more academic and often more generalized information emanating from some formal institutions. That the latter is frequently provided by government contributes to a lesser acceptance by farmers because of their often uneasy relationship with government in Adelaide.

This negative view of formal institutions that was often presented by farmers and their advisors ignores the area where these institutions play an important overarching role with respect to adaptation to climate change, namely with respect to planned adaptation. Whereas the farmers are making autonomous adaptations, government establishes the parameters and details of planned adaptation. It does so in the form of establishing regulatory controls on water usage and via development of strategies for climate change and energy use. Whilst these did not feature prominently in the dialogue with farmers and their advisors, planned adaptations affect certain aspects of farming activity. For example, the Water Plan for the Southern Basins and Musgrave Wells Prescribed Areas on Eyre Peninsula, established in June 2016, sets out rules for extraction of groundwater, with a new licensing scheme. (Eyre Peninsula Natural Resources Management Board 2016). Given the importance of groundwater supplies, careful management and restrictions on usage are vital to maintain supply in the face of climate change. This is recognized in the state's climate change strategy, released in November 2015 (Government of South Australia, 2015). Whilst much of the strategy focuses on urban and energy issues, it highlights a climate adaptation champion from an Eyre Peninsula farm and acknowledges the work of the Northern and Yorke Peninsula NRM Board and RDA Yorke and mid North. For example, the latter has promoted retention of broadacre vegetation on farms, increased revegetation, and plantation forestry. There has also been preparation of regional adaptation plans, which should provide a framework within which adaptation actions will nest, including initiatives on management of biodiversity and water, community services, and infrastructure.

These planned adaptation initiatives may alter the relationship between formal institutions and farmers, especially as there are regionally targeted schemes being introduced. For example, the Eyre Peninsula NRM Board has launched its Adapt NRM Grant Program, 'to support local government, regional bodies and industry associations undertake projects that promote the sustainable management of natural resources and progress priority adaptation options outlined in the Regional Climate Change Adaptation Plan for the Eyre Peninsula' (Government of South Australia, 2015, p. 50). Amongst the initial projects are ones on reclaimed water irrigation, soil management and biodiversity. So, there will be direct engagement with farmers thereby presenting opportunities for new types of interaction specifically involving innovative mitigation actions.

In terms of building upon what this research reveals about farmers' responses to climate variability, there appears to be a need to reconsider how information about climate change is provided to farmers. This would entail creation of different relationships between formal institutions and communities of practice. This change is symbolized in Figures 3 and 4. Figure 3 emphasizes the current role of trusted individual advisors who channel information about climate change adaptation to farmers. The latter do not readily assimilate information emanating from formal institutions. Nor is there much opportunity for farmers, their advisors or others in the rural community to inform or shape policy on adaptation. Figure 4 makes allowance for the growing role of planned adaptation in suggesting how new relationships between the major players might be developed in future. It stresses a greater role for local knowledge, developed in part through formal institutions (especially NRM Boards) working more closely with communities of practice. Further creation of suitable forums is proposed that enable farmers, individual trusted advisors, and communities of practice to engage with government and to inform policy on climate change adaptation.

This recommendation acknowledges that a greater role for local knowledge in various circumstances has been strongly supported in many quarters in the past decade (see Girard, 2015). Such arguments recognize that knowledge can come in many forms, and from different sources, with government and science not having a monopoly on information that can be utilized in farm management. However, power relations can restrict locally-held knowledge from being valued or utilized by decision-makers in government, especially knowledge possessed by farmers, which 'represents various degrees of localised, expert, tacit, and implicit knowledge which may have been derived through

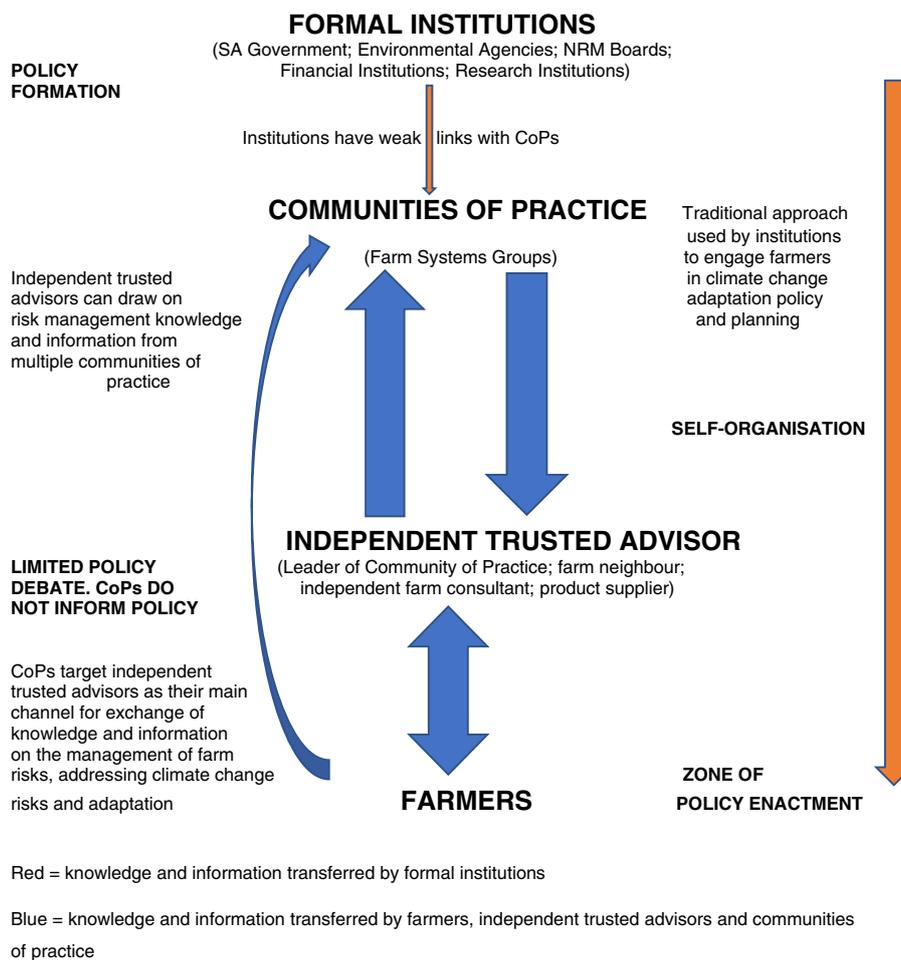


Figure 3: Current transfers of knowledge and information on adaptations to climate change. NB. The width of the arrow reflects the extent of transfer of climate change adaptation knowledge and information between the respective parties.

formalised or informal processes' (Raymond et al., 2010a, p. 1767). Experiential and local knowledge is often not generated through formalized processes, in contrast to that produced by government. Yet, 'hybrid' knowledge obtained from various sources can be produced through social learning processes that combine scientific knowledge with that developed through personal experience, interpretation and interaction (Stringer et al., 2017). This hybrid can then be explicitly applied in agricultural development programs, as in the case of Mexico's Yaqui Valley (McCullough and Matson, 2016), agroforestry in India, (Singh and Dhayani, 2014) and European viticulture (Krzywoszynska, 2016). However, in developing such programs there are epistemological challenges to overcome relating to fundamental differences in the way people perceive the nature of knowledge or how they come to know something. Moreover, 'any knowledge integration process needs to be sufficiently flexible to take

into account changes in perceptions emerging during the project and to deal with new information arising after application' (Raymond et al., 2010b, p. 1770).

There are, though, increasing numbers of good examples where integration between scientific and local, top-down and bottom-up, knowledge has successfully occurred (e.g. Girard et al., 2015; Moschitz et al., 2015), including projects to facilitate adaptation to climate change (e.g. Xu and Grumbine, 2014; Bocco and Napoletano, 2017). Cross and Ampt (2017) report on successful adoption of a rotational grazing system in south-east Australia using few purchased inputs to develop a more sustainable agroecological farming system. They describe the adoption of the grazing system as occurring through the work of a community of practice centered on farmers and their knowledge, but with some input of scientific knowledge and principles. They acknowledge, though, that there is often limited support from formal institutions

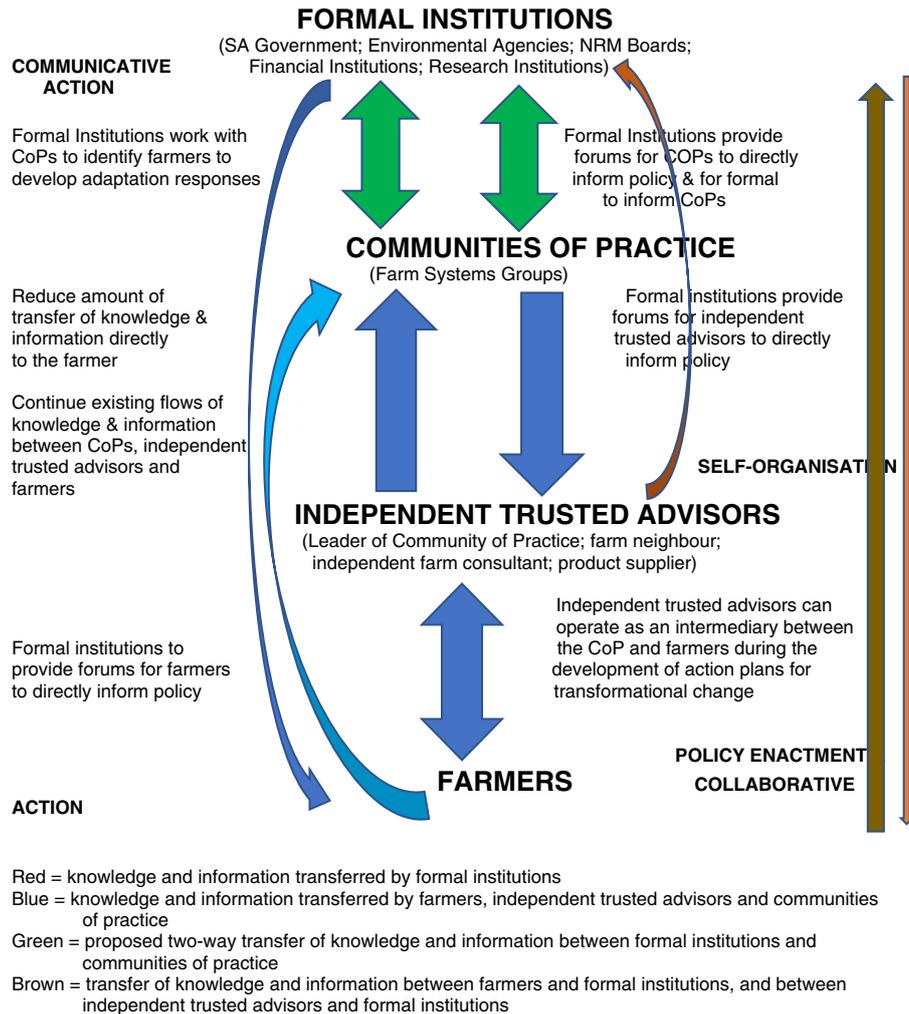


Figure 4: Proposed co-management model to support transfer of knowledge and information on adaptations to climate change. NB. The width of the arrow reflects the extent of desired transfer of climate change adaptation knowledge and information between the respective parties.

for integration of different types of knowledge or a bottom-up farmer-centered approach.

To help realize the arrangement indicated in Figure 4 a three-step approach is suggested in promoting greater adaptation to climate change by farmers and the wider rural community:

1. encourage groups of actors to reach a shared understanding of issues and identify their vision for the future;
2. translate the vision of each group into action plans; and
3. support multiple cycles of joint and collaborative action.

This follows Bjerkes' (2010) argument that effective management of resources requires devolution

of rights over resources and property to local user-groups and organizations, not solely decentralization from one government agency to another. Shared understandings are extremely important in the context of climate change, given the diversity of views about causes and likely consequences (Raymond and Spoehr, 2013). If longer-term adaptive strategies are to be implemented, it is vital for government to develop more effective dialogue with communities of practice and individual farmers.

Action plans are now forming part of the Government of South Australia's strategy to tackle climate change, but more opportunities are needed to enable farmers and people in rural communities to mould plans, introducing vital local knowledge about land management and rural living to address the full ramifications of climate change. This will require

representatives from formal institutions to be receptive to the experiential knowledge generated within communities of practice, and to work together to develop transformative change. For the various parties to work together in joint or collaborative action will probably require new networks and relationships to be developed. Such changes may involve new approaches being taken. For example, the communities of practice tend to frame climate change adaptation through the lens of management of short-term on-farm risks rather than a response to long-term climate change. This tends not only to eschew transformative adaptation but also contrasts with the approach of formal institutions. In recognizing the value of addressing longer-term changes, the communities of practice would have to change the way they conceptualize risk, whilst formal institutions would need to engage more with the notion of a broader spectrum of risk that includes both the short- and long-term.

The starting point for this proposed new approach is a willingness of formal institutions to work more closely with communities of practice, trusted advisors and farmers in collaborative adaptation research, policy development and program implementation. This will require the various groups to share their knowledge of adaptation to climate change and to learn from each other. As illustrated in Figure 4, this emphasizes the need for two-way communications between formal institutions, communities of practice and farmers.

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