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Adapting to Climate Change: Lessons from Farmers and Peri-Urban Fringe Residents in South Australia

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Abstract: This paper reports on results from two major research projects conducted in South Australia. The first investigates adaptation to climate change in two of the state's major grain and sheep farming regions, using semi-structured interviews and focus groups. The second uses a postal questionnaire and an internet-based survey of residents in the peri-urban fringes of Adelaide, the state capital, to examine knowledge of and attitudes to climate change and resulting adaptations, especially in the context of increasing risk of wildfires. The research on adaptation to climate change in agriculture focused on formal institutions (e.g., government agencies) and communities of practice (e.g., farm systems groups). Both groups noted that farmers autonomously adapt to various risks, including those induced by climate variability. The types and levels of adaptation varied among individuals partly because of barriers to adaptation, which included limited communication and engagement processes established between formal institutions and communities of practice. The paper discusses possibilities for more effective transfers of knowledge and information on climate change among formal institutions, communities of practice, trusted individual advisors and farmers. Research in the peri-urban fringe revealed that actions taken by individuals to mitigate and/or adapt to climate change were linked to the nature of environmental values held (or ecological worldview) and place attachment. Individuals with a strong place attachment to the study area (the Adelaide Hills) who possessed knowledge of and/or beliefs in climate change were most likely to take mitigating actions. This was also linked to previous experience of major risk from wildfires. The paper concludes by discussing prospects for developing co-management for reducing the impact of climate change across multiple groups in rural and peri-urban areas.

Keywords: climate change; adaptation; mitigation; wildfires; risk; farmers; peri-urban; South Australia

1. Introduction

This paper reports on results from two major research projects conducted in South Australia: one on 'Regional communities adapting to climate change' and the other on 'Bushfires and biodiversity: Optimising conservation outcomes in peri-urban areas at risk.' The latter used a postal questionnaire

and an internet-based survey of residents in the peri-urban fringes of Adelaide, the state capital, to examine knowledge of and attitudes to climate change and resulting mitigation/adaptation, especially in the context of increasing risk of wildfires (termed locally as bushfires). The first project focused on adaptation to climate change in two of the state's major grain and sheep farming regions, using semi-structured interviews and focus groups.

The paper first addresses current understandings about barriers that may restrict adaptations to climate change. Consideration of these barriers is then reported with respect to the two different scenarios represented by the research projects. One relates specifically to decisions taken by farmers with respect to their farm operations whilst the second reports on attitudes and actions of householders in the peri-urban fringe. In both cases emphasis is placed on responses to available information and what might constitute improved communication strategies to overcome barriers to adaptation.

The background to this research is a climatic record in which there has been a pronounced warming trend for South Australia in the last one hundred years, featuring a series of positive anomalies since 1980 compared with the one hundred-year mean annual temperature from 1915 to 2015 [1]. In addition, there have been a series of notable recent dry spells, with widespread rain deficiencies for prolonged periods, such as that occurring in spring and summer 2012/13 [2]. This trend towards hotter and drier weather is forecast to continue through the 21st century, with mean annual temperatures across the state possibly rising by more than 2 °C by 2100 [3]. This combination of greater heat and drought is likely to promote increased risk of wildfires [4] as well as more incidences of weather-related illness [5–7] and general inconvenience [8]. The extent of the projected changes is likely to have far-reaching consequences for agricultural activity [9,10], including the possibility of decreases in median grain yield across the state from between 13.5 to 32% under the most likely climate change scenarios [11,12].

2. Barriers to Climate Change Adaptation

The paper focuses on adaptations to climate change, defining adaptation as "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities" [13,14]. Adaptations may be incremental, involving short-term and small-scale actions to reduce losses or enhance the benefits of variations in climate. Alternatively, they may be transformational, where actions are adopted at a much larger scale or intensity than current actions, and/or comprise those that are new to a region. Transformations may be based upon technological innovation, institutional reforms, behavioural shifts and cultural changes [15]. Climate change mitigation addresses the reduction of the causes of global warming: increased atmospheric carbon dioxide (CO_2), methane and other gasses resulting from a range of human activities such as burning fossil fuels, land use change and deforestation. Adaptation recognizes that currently higher than 'normal' levels of greenhouse gases already exist and even if they levelled off today they would produce significant changes to the climate. Hence, we need to adapt to these changes. "Many adaptations to climate change will be spontaneous actions to perceived and actual risks in the environment" [16]. Households use risk management strategies that are either ex-ante (risk prevention, reduction and mitigation), such as emissions reduction, actions to reduce household exposure to given risks and taking out insurance cover or ex-post (coping) actions, which are often ad hoc [17].

People's engagement with climate change adaptation and mitigation may be limited by "objective constraints that intervene between individuals' desire to become engaged (affective engagement) and their ability to take relevant actions" [18]. Further investigation of this with respect to adaptive actions for Australia's Great Barrier Reef revealed constraints reflecting individuals' lack of knowledge about actions they could take, lack of time and possessing different priorities, all of which were influenced by individuals' age, gender, education level, income and place of residence. In general, these constraints and barriers "arise from uncertainties of future climate and socio-economic conditions, as well as financial, technologic, institutional, social capital and individual cognitive limits" [19]. Moreover, climate change may well be frequently regarded as being 'somebody else's problem' and not something

an individual, a household or even a community can tackle. There is also a tendency for individuals to assess risks arising from climate change as being minimal [20].

In further elaboration on 'barriers,' Gibson et al. identify issues pertaining to both consumption and sustainability within households [21]. There is a complex set of relationships between everyday household practices, cultural processes and climate change but strong environmental beliefs are not necessarily correlated with mitigating actions [22–24]. Grothmann and Patt argue that two key psychological factors, namely risk perception and perceived adaptive capacity, are major restrictions on individuals taking adaptive action. Social barriers are generally malleable and can be overcome but only with greater understanding of how they operate [25].

Previous research on household decision making, especially amongst farm families, suggests that practical initiatives representing adaptations to risk often do not consider climate as a separate risk but rather combine it with other environmental and social stresses [26,27]. This means that adaptations are integrated into actions linked to sustainable development, resource management and disaster preparedness [28]. However, much of this work on adaptation refers to farm families where risks from climate change may be a direct threat to their livelihood [29–31]. Less work has been concentrated on adaptation and, more particularly, mitigation by households in urban and suburban locations involving specific actions by householders as opposed to supporting higher taxes for energy and fuel. Yet it is acknowledged that actions taken by individuals and households to mitigate climate change, when considered as an aggregate, are significant. Hence mobilizing individuals to act is complementary to any national climate change strategy [32], with suggestions for greater government encouragement of altered adoption and use of available technologies in homes and for non-business travel [33].

In examining barriers to climate change adaptation, the investigations reported in this paper used grounded theory, in which the research seeks to generate theory from a systematic approach, rather than basing it on a specific pre-determined theory [34]. This acknowledges the need to develop theory about factors which discourage or encourage adaptation to climate change. Theory generation is based primarily on recognizing important themes that emerge from interviews, observations and focus groups. However, there is also the opportunity to build on the previous work referred to above.

3. Farmers Adapting to Climate Change in the Eyre and Yorke Peninsulas, South Australia

3.1. Study Areas

Research into farm-based adaptation to climate change took place in two areas in South Australia: the Eyre Peninsula and the Yorke Peninsula. The Eyre Peninsula in the west of the state covers an area of over 80,000 km^2 with a population of approximately 55,000 people. The economy is dominated by agriculture (broadacre cropping and sheep), mining, mineral processing, tourism, aquaculture and fishing. Around 45% of native vegetation cover remains. Climate change may produce shorter, hotter, drier and/or more unreliable growing periods [35]. Research has shown the desirability of developing farming systems more responsive to increased seasonal variability, including modifications to the range of crop types, enterprise mixes, input types and levels of water use [36].

The Northern and Yorke region (see Figure 1) covers an area of 34,500 km^2 and includes the Yorke Peninsula, the Northern Mount Lofty Ranges and the Southern Flinders Ranges. The region has a population of 89,000 people. Dryland farming (mixed crops and livestock) is the dominant land-use. Only 26% of remnant native vegetation remains in the agricultural areas but the proportion is 94% in the pastoral zone in the north of the area [37,38].

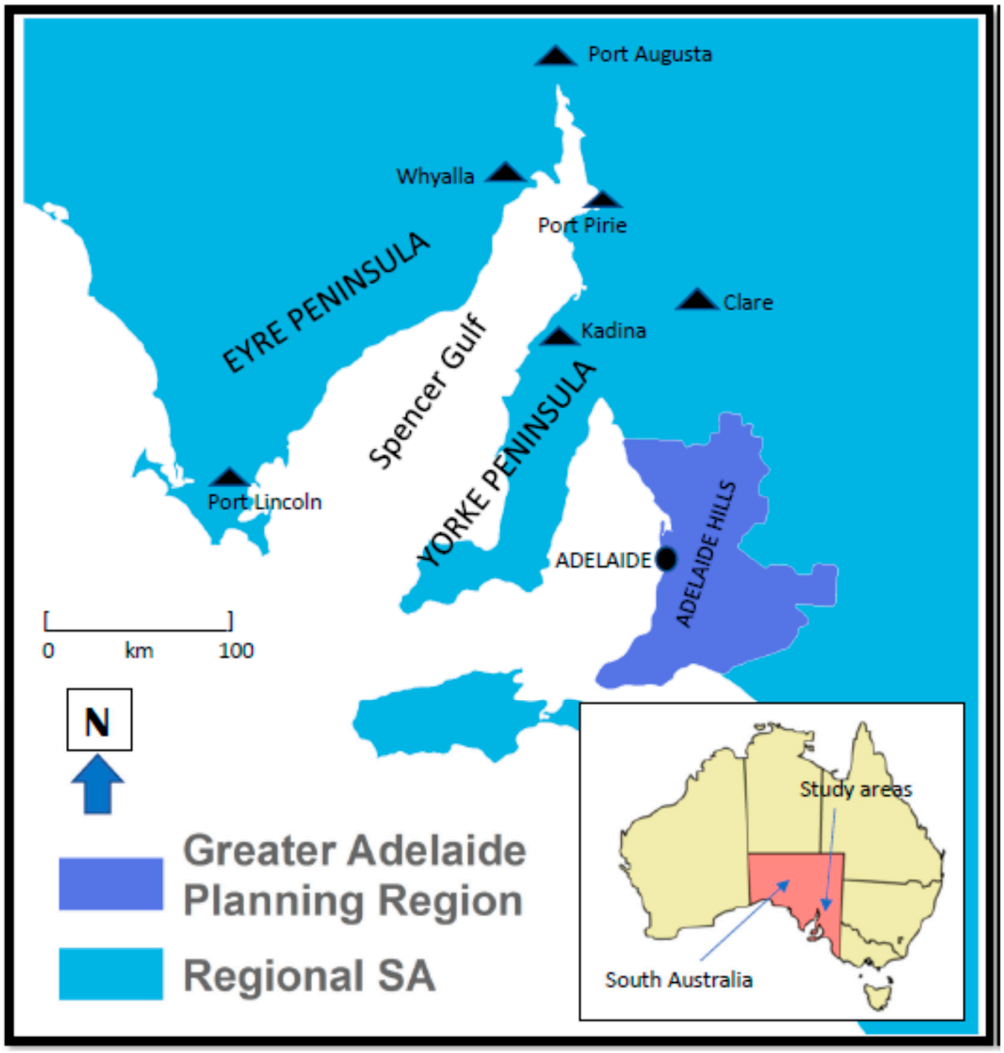

Figure 1. Location map (source of base map [39]).

3.2. Methods

Interviews were conducted with a sample of 30 farmers: 15 in the Eyre Peninsula and 15 in the Yorke Peninsula (Figure 1), using a semi-structured interview guide. Participants were selected by using nominations received 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 [40,41], in which a point is reached in the sampling when no new themes or thematic information are attained or add to the overall experiences described by the interviewees. This occurred around $n = 15$ in each area. In addition, focus groups were held involving in total 50 farm advisors, members of primary industry organisations (including employees in State Government departments), members of NRM Boards, representatives of conservation organisations, members of farm systems groups (including the South Australian Farmers Federation, the Australian Bureau of Agriculture and the South Australian No-Till Farmers Association) and employees of financial organisations providing advice to farmers (e.g., Rabobank, Elders, Landmark). So, in total 80 individuals participated in the interviews and focus groups.

The interviews and focus group proceedings were transcribed, after which open coding was applied. This comprised becoming familiar with the content through close reading of the transcript and noting down initial ideas, before generating categories of those factors which encourage or discourage adaptation to climate change [42]. The next step was searching for themes by selecting text from the

interview transcripts and assigning it to the categories. As core themes became apparent, a second level of coding, selective coding, was employed, which involved defining and refining the specifics of each theme. This generated clear information for each theme based on the overall dataset. The final stage involved theoretical coding; namely, identifying relationships between responses from two key groups to the different themes and relating them to the literature.

3.3. Results

In terms of providing farmers with information about climate change, it was possible to differentiate between two sets of organisations, namely formal institutions and communities of practice [30]. The former are groups which follow rules and procedures that are created, communicated and enforced through channels widely accepted as official, such as courts, legislatures and bureaucracies. One example of a formal institution in this context is the government agency responsible for regulating natural resource management: NRM Boards, one for each of the two regions studied. Another is the Department of Primary Industries and Regions South Australia (PIRSA), a key economic development agency in the Government of South Australia, with responsibility for the prosperity of the state's primary industries and regions. Communities of practice are informal structures or groups brought together through the social construction of knowledge, in which 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. Farm systems groups are exemplars of communities of practice.

Interview responses from farmers indicated they are capable of autonomously adjusting to on-farm risks associated both with short-term variability in physical conditions and also variations in the market for their produce. However, they are more likely to respond to short-term risks which have a direct impact on their farm operations rather than longer-term risks such as those related to climate change. There was a strongly expressed view from farmers that the communities of practice, notably the farm systems groups, generally tailored their trial programmes and communication techniques to address short-term risks to the farming system. Knowledge and information about adaptation to climate change is gathered and absorbed by the farmers' trusted individual advisors in the communities of practice who then pass it on to the farmers.

In contrast, the information provided by the formal institutions tends to be regarded by farmers as quite complex and focused more on long-term climate change rather than considering direct and immediate risk. Farmers do not regard statements such as 'a prediction of 3 to 4 °C warming this century' as presenting information of practical value. They deal in much shorter-term risk and so require warnings of an impending heat wave or of a serious rainstorm in the next week. Much information from government sources may not be location specific whereas farmers desire something that pertains to their own farm and immediate locality.

An added complication may be the fact that two-thirds of the farmers interviewed and 40% of farm advisors in the focus groups did not believe in human-induced climate change and so they are quite sceptical about information being presented on the stated topic of climate change. This may be a significant barrier to making climate change-related adaptations as strength of belief in climate change has been found to be a key factor in explaining differences in adaptation actions. For example, this was the case in work by Wheeler et al. [43] with respect to irrigators in Australia's Murray-Darling Basin and among Swedish forest owners by Blennow et al. [44]. In the Murray-Darling farmers convinced that climate change is occurring were more likely to plan accommodating, but not expansive, adaptation strategies.

Farmers generally (75%) did not consider extreme heat or drought to be a major threat to their livelihood because they were able to take measures to adapt to these extreme weather events. For example, they referred to the fact that their crops and livestock were bred to suit the conditions.

> *"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)

Nevertheless, they acknowledged that spells of extreme (or 'exceptional') heat in combination with reduced rainfall could be problematic. They supported this view by providing accounts of crops being 'wiped out' by unseasonal heat combined with dry conditions.

> *"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, Yorke Peninsula)

Overwhelmingly (>80%), farmers referred to adopting moisture conservation practices that addressed excessive heat and/or drought. They tended to adopt measures similar to those employed by their predecessors on the farm (usually parents or grandparents) to cope with 'exceptional' circumstances. A variety of measures was involved, for example, clay spreading and delving on sandy soils, raising the pH of acidic soils through liming, containing saline seepage by planting salt tolerant perennial species such as alkali grass (*Puccinellia*), tall wheatgrass (*Thinopyrum ponticum)* and saltbush (*Atriplex* species). Adopting different pasture species [45] and planting of shorter season wheat varieties to combat shorter growing seasons were other common strategies. In addition, there were instances of some long-term adaptations, such as large-scale changes to the farming type, e.g., moving from cropping to sheep [46], though economic motives might also be involved, such as responding to low grain prices [47].

Information gained from the interviews and focus groups suggests that the nature of the communications between government and farmers needs to be changed to enable a stronger two-way flow of information and knowledge. At present, there is often a marked top-down approach from government/formal institutions, which largely fails to acknowledge the key role played by communities of practice. Based on the data assembled in this research, this current situation is portrayed in Table 1. It is one that produces relatively little policy debate, with the communities of practice in the two study areas having relatively few opportunities to inform government decision making. The was summarized by one farm advisor in a focus group discussion:

> *"Farmers tend to feel that policy makers do not stray far from Adelaide. The farmers have a view that they are 'out of sight, out of mind' in respect to policy making."* (farm advisor, Eyre Peninsula)

In one of the interviews with farmers, this sentiment was reiterated:

> *"We don't have much contact with the people who provide information on climate change. They are in Adelaide and we are a long way away! They don't seem very interested in what we might know about weather patterns and how to deal with it all."* (grain producer, Eyre Peninsula)

Table 1. Characteristics of key linkages between formal institutions, communities of practice, independent trusted advisors and rural farmers with respect to current transfer of knowledge about adaptation to climate change.

Actors	***Formal Institutions (FIs)***	***Communities of Practice (CoPs)***	***Independent Trusted Advisors (ITAs)***	***Farmers***
Formal Institutions (FIs)	Set policy with traditional top-down approach	Relatively weak links. Little opportunity for CoPs to influence policy	Relatively weak links	Policy enacted 'on the ground' but policy debate missing.
Communities of Practice (CoPs)	FIs are increasingly recognizing importance of the need to engage CoPs	Hugely important in provision of information in rural communities	ITAs are often part of CoPs	Risk management knowledge and other information from multiple CoPs inform farmers
Independent Trusted Advisors (ITAs)	May have some informal links to FIs but little influence on policy	Often embedded in CoPs; sometimes a leader of a CoP	Often have agronomy or financial background	ITAs are main vehicle or channel for exchange of knowledge and information on the management of risks, which in turn addresses risks from climate change and climate change adaptation
Farmers	Complain that FIs do not consult. One-way, top-down flow of information about climate change	High value placed on on-farm meetings, e.g., trialling new techniques, equipment, best practice	ITAs have partly replaced traditional extension service workers	Autonomous adjusters to risk

Table 2. Characteristics of key linkages between formal institutions, communities of practice, independent trusted advisors and rural farmers with respect to current transfer of knowledge about adaptation to climate change.

Actors	***Formal Institutions (FIs)***	***Communities of Practice (CoPs)***	***Independent Trusted Advisors (ITAs)***	***Farmers***
Formal Institutions (FIs)	Set policy with traditional top-down approach	Relatively weak links. Little opportunity for CoPs to influence policy	Relatively weak links	Policy enacted 'on the ground' but policy debate missing.
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In general, government seems to under-utilize the knowledge and expertise of the farmers. A stronger two-way flow of information would require greater interaction not only between government agencies and communities of practice but also more directly with individual farmers as illustrated in Table 2. This might help overcome some of the farmers' antipathy to messages being promulgated by government. More so if the short-term consideration of risk by farmers was given more acknowledgement by government and vice-versa a recognition by farmers that a longer-term horizon for consideration of climate change requires some immediate on-farm actions.

4. Peri-Urban Residents Adapting to Climate Change in the Adelaide Hills, South Australia

4.1. Study Area

The Mount Lofty Ranges are located immediately to the east of South Australia's state capital, Adelaide. Rising to a height of 936 m, they extend north-south for around 300 km, with the area closest to Adelaide generally known as the Adelaide Hills, which is also an administrative district. It was one of the first areas of South Australia to be settled by European settlers and now has a population of around 60,000 in a mixture of farming communities, rural hamlets and townships, larger service centres and suburban commuter developments. It has a Mediterranean-type climate, with moderate rainfall (mostly < 800 mm pa) brought by south-westerly winds, hot summers (mean daily January maxima = 27.8 °C) and cool winters (mean daily July maxima = 14.9 °C) [48]. This supports apple, pear and cherry orchards as well as a major high quality, cool-climate wine region.

As described above for the Eyre and Yorke Peninsulas, drier and hotter conditions are predicted in addition to more extreme weather events, which will increase the likelihood of wildfires (termed locally 'bushfires') [49]. The last wildfire in the region to cause loss of human life occurred in 1983 when 160,000 ha burnt and 28 deaths were recorded (though immediately to the north, a fire in November 2015 burnt over 85,000 ha and caused two deaths). More recently, in 2015 across the northern part of the Hills over 20,000 ha burnt, destroying 26 homes but with no human fatalities. So, many residents should be aware of the risk of wildfires in the area, though the link between increased risk and climate change may be less widely recognised.

4.2. Methods

A postal questionnaire comprising 55 questions was distributed to 2650 households in the Adelaide Hills (see Figure 2). This yielded 797 responses or a 30.1% rate of return and was supplemented with information obtained from an internet-based survey (n = 308) conducted by Underwood [50] representing a subset of questionnaire respondents who volunteered to provide additional data. This survey elicited a 44.1% response rate and contained 23 questions largely focusing on climate change, using a combination of Likert scale [51], multiple fixed-choice answers and open-ended questions, allowing participants to express their beliefs and perceptions. It also used a series of attitude-based statements towards the environment to determine whether residents hold pro-, mid-, or anti-ecological views. Respondents were asked whether they believed that a changing climate is altering the risk of wildfire on their property. If the response was yes, they were asked if they had made any conscious changes in terms of their Bushfire Survival Plans (BSP) as a result (each household is encouraged to prepare such a plan).

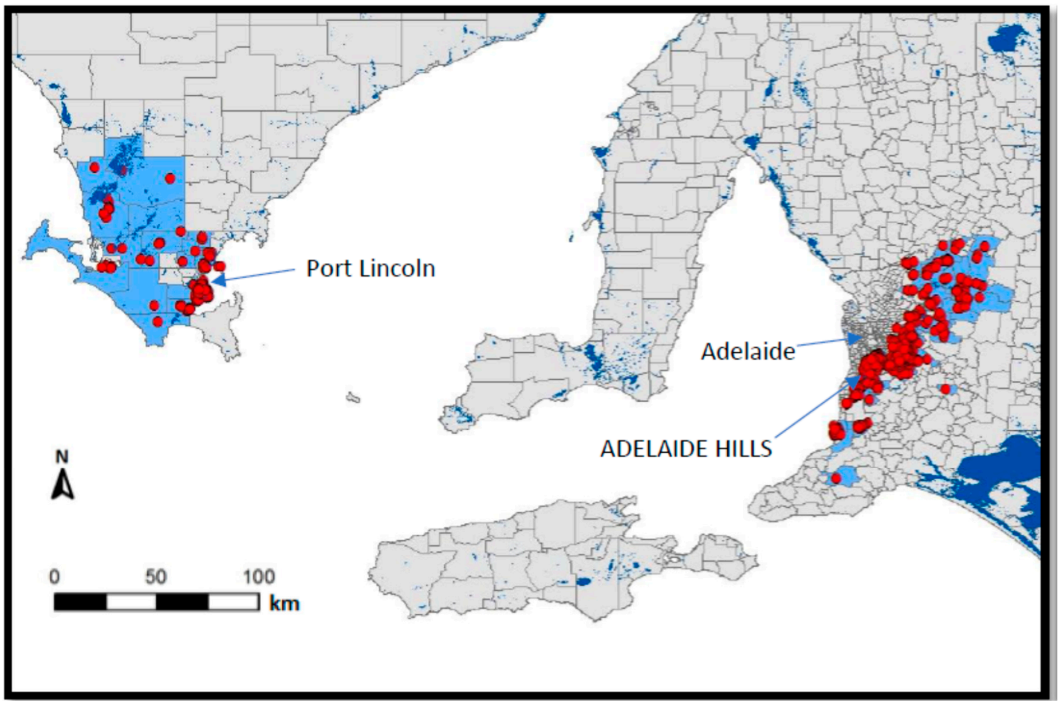

Figure 2. Areas where questionnaire survey distributed (medium blue) and residential location of participants (red dots). NB. This paper only focuses on responses from the Adelaide Hills.

4.3. Results

Our recent review of climate change interactions with wildfire management in peri-urban South Australia [52] showed that two-thirds of respondents to the postal questionnaire agreed with the statement that climate change was a general risk to the region. A similar proportion agreed that climate change was altering wildfire risk on their properties. From the internet-based survey, it was apparent that actions taken by individuals to adapt to climate change in the peri-urban fringe were closely linked to the nature of the environmental values they hold (or their ecological worldview) and to place attachment. Individuals with a strong place attachment to the Adelaide Hills who possessed knowledge of and/or beliefs in climate change were most likely to take action. The respondents who recognized that climate change is increasing the risk of wildfires ranked natural values highly and were supportive of ecological conservation goals.

Another important factor was previous experience of major risk from wildfires (defined as living in a property damaged or threatened by a wildfire event), which also prompted a greater likelihood of actions to lessen the effects from a wildfire. The latter varied from removal of major trees, bushes and undergrowth within the vicinity of the house to installing irrigation systems to keeping gutters free from leaves and debris. Tree removal close to buildings has been encouraged by recent relaxations to the state's Native Vegetation Act and in 2012, amendments were made to the Development Act 2003 to allow landowners to clear vegetation within 20 m surrounding their home without having to undergo approval from the Native Vegetation Council. Further changes were also made to the process involved in gaining permission to clear beyond 20 m (again relaxing the approval process), with the purpose of such changes being to facilitate so-called 'fire-smart communities' [53].

Householders' actions were primarily a response to reducing wildfire risk and some of these actions could be problematic in terms of reducing local biodiversity, e.g., removing trees near houses. But there were also increases in 'green' lifestyles e.g., installing solar panels, increasing the use of recycling, practising 'eat local' (i.e., consumption of food with short as opposed to long food-miles) where possible and consciously adopting more sustainable travel practices. Clearing leaves, twigs and long grass immediately adjacent to the house was practised by 89% of respondents to the postal survey,

whilst 85% cleared gutters of leaves. Three-quarters watered their gardens frequently during the wildfire season (officially from 1 December to 30 April) and a similar proportion cleared undergrowth at least to 20 m from the house. Two-thirds claimed they had a BSP (as recommended by the Country Fire Service), though this did not always refer to a formal written plan, merely an informal intention of what to do in the event of a major fire. In such an emergency, 62% had obtained and prepared equipment such as ladders, buckets and mops to put out spot fires and 61% stated they would move combustible materials such as firewood and wooden garden furniture away from the house. One-third of residents had removed large trees from within 20 m of their house and 15% up to 40 m from the house.

In terms of self-assessed knowledge about climate change, the respondents to the larger survey divided equally between high, medium and low knowledge whilst two-thirds felt that changing climate was altering the risk of wildfire on their property [52]. Yet, there was no significant relationship between recognition of risks posed by climate change and the perceived likelihood of wildfire within the next five years. Just under 90% felt that climate change was occurring both in the region and globally, primarily supported by observable changes to the seasons and more severe weather events. For example, in the words of different residents:

> *'The seasons now are different to what they were 20 years ago';*
> *'I believe the scientists and weather observation records show that the climate is changing';*
> *'Changes in climatic conditions in the 30+ years we have lived in our current house have affected the plant and animal biodiversity around us.'*

However, some respondents thought this was a natural phenomenon:

> *'Climate change occurred before Man and will continue regardless of our efforts';*
> *'I strongly believe we are in a warming cycle but don't think the science is settled enough to say it's a one off irreversible Man-induced change.'*

Of the respondents to the online survey, 44% believed they could take no or hardly any personal actions that could help mitigate climate change whilst just 14.2% believed there was a lot they could do [50]. This contrasts with the finding from a state-wide survey in which 65% of respondents reported that they 'agreed' or 'strongly agreed' with the proposition that risks associated with a changing climate could be 'reduced by their own actions' [54]. Our online survey suggests there are major constraints to individual engagement with climate change, reflecting the presence of various psychological barriers [55], referred to by Gifford [56] as 'the dragons of inaction.' These barriers are related to "a muddle over causes, consequences and appropriate policy measures for mitigation" [57]. At the centre of this is a widespread view that the consequences of possible behavioural shifts arising from the need to implement mitigation measures are daunting and hence the creation of socio-psychological denial mechanisms. Consequently, the public is largely ignoring actions promoted by government to mitigate climate change, such as using less household energy. Indeed, where individuals are using less energy it is often primarily as a money saving measure rather than to mitigate climate change [58,59]. Nevertheless, 16.5% of sample respondents stated that some of their everyday behaviour was influenced by concern about climate change and only 24% had made no or little attempt to change their behaviour in response to climate change. However, when identifying specific behaviours, recycling (17.5% of all responses) was the most popular single behaviour and 'reducing waste and pollution' accounted for a further 9.9%. More direct actions, such as reducing energy use and using renewable energy (principally domestic solar power) accounted for 11.1% (Table 3).

There was no correlation between self-assessed climate change knowledge and climate change beliefs. However, a Kruskal-Wallis test between knowledge of climate change and climate change behaviours was significant at the 0.05 level ($H_6 = 13.27$, $p < 0.05$). The same test run on climate change behaviours and climate change beliefs (globally) showed no significant relationship ($H_6 = 7.68$, $p > 0.05$) but for climate change beliefs with respect to South Australia, a significant relationship was found at the 0.05 level ($H_6 = 13.52$, $p < 0.05$).

Table 3. Actions taken out of concern for climate change.

Actions Taken	Frequency of Response (*n*)
Recycle	44
Reduce energy usage around the home	32
Reduce car usage/use public transport more	32
Use renewable energy sources	28
Reducing waste and pollution	25
Conserve natural resources	20
Sourcing local/sustainable products	20
Planting more vegetation	18
Consuming less meat/sustainable resources	14
General support/volunteering/communication about climate change	14
Use rain water instead of mains supply	5
* **Total**	252

* The total equals more than the $n = 136$ who responded to the internet survey as respondents could identify more than one action. Source: Underwood [50].

Based on the relationships between respondents' perceptions of climate change and wildfire risk, key differences emerged between three distinct groups, as reported in the detailed analysis by Bardsley et al. [52]. The first of these comprised 38.4% of respondents who recognise an increased wildfire risk in response to climate change and have changed their BSPs in response. These respondents tend to live on rural blocks of land which possess native or wildlife gardens; they are typically aged in their 40s and 50s; are more likely to have experienced wildfire damage; possess strong ties to place; are more actively preparing for the emerging risk; and have a pro-environment outlook. This group also indicated they possessed the capacity to activate their BSPs and they showed greater place attachment than other respondents. They were more likely than other respondents to thin vegetation and to prune large trees but less likely to remove large trees from within 40 m around their house. Indeed, they placed greater value overall on maintaining the wooded environment and biodiversity of the Hills despite the wildfire risk.

The second group comprised 26.5% who recognised an increased wildfire risk due to climate change but were neither altering their household plans and actions, nor supportive of collective action to mitigate wildfire risk. These are largely aged between 18 and 44; with a graduate education; and live on residential-size blocks. Members of this group typify the gap between perceptions (of risk) and taking actions (to mitigate that risk) because whilst they recognize a growing risk, they are not planning for the likely changes that will arise. It is possible that members of this group prefer to let others take actions that will reduce risks. Alternatively, they may value their 'pleasant green environment' above other considerations and do not wish to see it changed to reduce risk of wildfire.

In the third group (35.1% of all respondents) many did not recognise that climate change alters wildfire risk. This group was typified by older male residents who may not believe in climate change; work in non-professional employment; and have a low educational attainment. However, they are similarly supportive of risk mitigation actions as the first group. This implies that climate change is only one of several factors that can influence individuals to act or to support collective actions. Group three appears more supportive of prescribed burning and vegetation clearance to mitigate risk and they themselves are exploiting the opportunity of a weakening of the SA Native Vegetation Act to clear trees in their gardens.

5. Discussion and Conclusions

A common thread that links the two studies reported above is the various responses made by farmers in the Eyre and Yorke Peninsulas and householders in the Adelaide Hills to changes in climate. They respond in different ways: from some householders making little attempt to adapt to greater heat and/or drought to some farmers making substantial modifications to their farming systems in attempts to withstand drier and hotter conditions. For farmers and householders alike, there was a spectrum of adaptive decision-making, with the research on householders revealing different groups

based on perceptions of climate change and wildfire risk. Differentiation of the survey respondents into three groups raises important questions about whether different messages need to be delivered to them to overcome barriers that might prevent some residents from taking desirable adaptive or mitigation actions. Similarly, with the farmers, focus groups and interviews highlighted how different communication and engagement strategies can be at the heart of transmitting important information about climate change and on-farm adaptation.

Irrespective of whether the farmers regarded human-created climate change as the main factor in episodes of greater heat and drought, they adjusted their farming systems in response to the changing conditions. In this respect, they can be regarded as autonomous adapters, treating climate change as one of several risk factors that they experience. This supports the findings of work by Head et al. [29] whose assessment for farmers facing drought in eastern Australia is apposite: "These farmers are not adapting to future conditions but are in continuous interplay among multiple temporalities, including memories of the past . . . Capacities to deal with risk and uncertainty vary with a range of social and locational factors, tending to coalesce into patterns of vulnerability and resilience that offer strong predictors as to which households are most likely to be sustainable in the longer term." They took measures to drought-proof their operations as much as possible but their adaptations, which were largely directed at short time-scale changes in the farming environment, may be of relatively limited effect because of constraints imposed by broad changes in the soil/water base and economic environment occurring over longer time scales [60]. So, farmers' short-term responses may not be very effective measures to combat ongoing climate change. One financial advisor in a focus group likened it to "attempting to put a sticking plaster over a gaping and ever-growing wound."

Many of the farmers and their advisors expressed scepticism regarding human causality in climate change. However, there was no significant correlation between scepticism and on-farm responses. This contrasted to the Adelaide Hills residents surveyed where a distinct group of respondents who were more sceptical than their neighbours tended to have different views about the relationship between climate change and wildfires. They either took no related actions or removed trees around their property as a precaution against threat from wildfires. Moreover, recognition of a relationship between climate change and wildfire risk amongst all respondents did not necessarily translate into mitigation efforts, as also noted by other studies [61].

For the farmers, the nature of actions taken in response to increased heat and severe drought closely reflected the advice received via communities of practice as opposed to that from formal institutions. There was much discussion about the relationship between the farmers and these two sources of information. Farmers relied greatly on the views expressed within the communities of practice and on the advice from their trusted advisors who were often members of the latter. In contrast, the formal institutions were widely regarded as being distant and unable to supply the type of information that farmers felt they needed. From the focus groups, a general agreement was reached regarding the importance of maintaining networks and information flows to provide support to farmers and the wider rural community, in part to counter sensational media reports debunking climate change. On all sides, there was an emphasis on the need for more investment into research and development on low-rainfall agriculture so that farmers could be better placed to adapt their farming systems.

In terms of promoting practices that are likely to bring greater and more cohesive responses to climate change, adoption of a simple co-management model for the farming community could be considered as an improvement upon current arrangements. In this, there should be encouragement for groups of actors to reach a shared understanding of issues and identification of their vision for the future. The vision of each group can then be translated into action plans, with multiple cycles of joint and collaborative action supported so that individuals and groups can contribute fully to policies shaping decision making within individual households and on individual farms [62]. This process needs to involve different levels of government, the commercial private sector, civil society and local communities.

With respect to the wider community, co-management is harder to achieve, in part because appropriate and effective adaptation may not be regarded by individuals as achievable or sustainable as messages from government may imply [63,64]. Knowing exactly what to adapt to is problematic not only given the limits of scientific knowledge regarding projections of likely environmental changes but also people's understanding of the phenomenon [65]. Attempts at persuading individuals to act in a certain way often assume that everyone is receptive to a given message and then will behave in the desired fashion. The differences between the three groups distinguished in this paper, suggest that this not the case. Different messages may need to be produced for different segments of society but for this to be effective better means of conveying information to the public need to be formulated.

One factor that emerges from this analysis is that the majority of the respondents in the Adelaide Hills recognize a risk posed by climate change and link it to the likelihood of greater risk of wildfires. However, they tend to conceive of this risk as something that will produce a wildfire event at some unspecified time well into the future. This may be related to the lack of a major fire event in much of the Adelaide Hills since 1983, which has instilled a complacency in the residents. Many of these residents have no previous experience of a wildfire and some have migrated from urban areas where threat of wildfire is low.

A major concern is whether actions to reduce risk of wildfires can be implemented without producing major reverses to biodiversity. The extent of native vegetation in the Hills is diminishing and some green space is being lost to urban development [66] but will actions to offset risk of wildfire further reduce natural and semi-natural habitats? Bardsley et al. [52] concluded that those Hills' residents who recognized climate change and its influence over risk of wildfire were less likely to support vegetation management that undermines local ecological values. They may be taking some minor mitigating actions (e.g., clearing scrubland) but not in ways that could significantly diminish habitat values, such as via the more dramatic intervention of clearing large trees. Indeed, the majority of those surveyed highly valued their local environment and did not wish adaptations to compromise the 'clean and green' feel of the Hills. Such attitudes and their link to actions will need to be better recognized in future planning for reducing risk from wildfires.

This recognition could be carried into new communication strategies aimed at residents. The experience with the farmers, namely that key messages about adaptation need to be tailored to the specific audience and presented by people/organizations that are trusted, could be utilized in a different setting. For example, it seems sensible to pursue further research on what messages to present to householders about both adapting to and mitigating against climate change. The differentiation of the community into different segments also needs further investigation as does the most appropriate media and sources for information. As with the farmers, more thought should be given to how individuals and groups can be more active participants in shaping policy and co-managing responses to climate change.

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