Perceptions of climate change risk in four disaster impacted rural Australian towns

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Abstract

Australia, a country which has regularly experienced various natural disasters is now set to face more intense and frequent disasters in the 21st century as a result of climate change. Prior research indicates that in Australia the perceived risks of climate change are mixed and becoming less prevalent across rural and urban locations, posing a threat to the public's adoption of mitigation and adaptation strategies.

Research was conducted in four disaster impacted rural Australian towns to investigate whether prior disaster experience, trust in climate change risk communications and specific location predicted climate change risk perceptions. Four case study sites were chosen exemplifying communities impacted by different types of disaster events. The case study towns were Beechworth (wildfire, 2009) and Bendigo (drought, 2002-2008) in Victoria; Ingham (flood, 2009) and Innisfail (cyclone, 2006) in Queensland.

Structural equation modelling analyses of surveys returned by a sample of 1008 householders across the four towns showed that prior disaster experience had no impact upon climate change risk perceptions. Instead climate change risk perceptions were predicted by trust in climate change communications, climate change knowledge and the geographic location of the sample, suggesting the need for targeted, place specific contextual communication interventions that consider the needs and socioeconomic characteristics of the community in question.

Keywords: Climate Change, Risk, Disaster, Rural, Australia, Trust, Communications, Structural equation modelling.

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Australia is, and has historically been, regularly impacted by various natural disasters. Now it faces the grim prospect that these disasters will become more intense and frequent in the 21st century (IPCC 2012; Hennessy et al. 2007). Moreover, as populations and the built environment continue to develop in hazard-prone areas across Australia, the vulnerability of individuals and communities to natural disasters increases (Council of Australian Governments (COAG) 2002).

The prediction that natural disasters are very likely to increase in frequency and severity as a result of climate change (IPCC 2012) has led researchers to question whether disaster experiences lead to increased risk perceptions, because it is assumed that attitudinal changes are a precursor to adaptation and mitigation behaviours for climate change. Climate change risk perceptions refer to individuals' beliefs that climate change is brought about by human activities and that it is problematic for the future (Myers et al. 2013). It is axiomatic that climate change is not itself directly observable by individuals; climate science relies upon complex modelling data over a time scale which crosses the human lifespan (Kollmuss and Agyeman 2002). Nor can the influence of climate change on a particular natural disaster be accurately determined. Nonetheless, it has been assumed for the purposes of research that the experience of a natural disaster will highlight the gravity of future climate change scenarios. Indeed this assumption was supported when nearly 60 % of Americans indicated they believed climate change was adding to the severity of recent extreme weather events such as Hurricane Sandy in a post-hurricane poll (Zogby 2012).The experience of a natural disaster therefore might bring the abstract concept of climate change into temporal and physical proximity for the observer, resulting in important mitigation and adaptation behaviours because of an enhanced realisation of the risks of climate change. An examination therefore of the links between disaster experiences and climate change risk perceptions is warranted.

Research findings on the link between experience of natural disasters and perceptions of climate change risk are mixed. For example, Spence et al. (2011) examined the links between direct flooding experience and perceptions of climate change risk in the UK. They found that those who experienced flooding had greater climate change risk perceptions and felt more confident that their actions will have an effect on climate change. Other research, however, failed to identify links between flood experience and climate change risk perceptions (Whitmarsh 2008). Climate change risk perceptions have been strongly linked to political preferences, age, religious beliefs, education and gender (The Climate Institute 2010; Reser et al. 2012). Research has also shown that people's existing climate change risk perceptions can shape their interpretations of environmental conditions (Myers et al. 2013). In a longitudinal study of over 1000 Americans, Myers et al. (2013) found that existing risk perceptions in those who were engaged with the climate change, that is those who had an interest in and studied the phenomenon, whether accepting climate change or denying it, influenced their interpretation of environmental events in such a way as to strengthen their pre-conceived ideas, thus avoiding cognitive dissonance effects (Festinger 1957). On the other hand those who were not especially engaged in the issue were more likely to change their climate change risk perceptions in light of experience of environmental events.

Lorenzoni, Nicholson-Cole and Whitmarsh (2007) identified some barriers to adopting mitigation actions for climate change in a UK sample:

- Lack of knowledge about the causes, consequences and potential solutions;
- Uncertainty and scepticism about the causes of climate change, effectiveness of actions from international to individual levels;
- Distrust in information sources;
- Externalising responsibility and blame on the causes and solutions, expecting governments and industry to take the lead;
- Climate change is perceived to be a distant threat in space and time;
- Fatalism, the perception that one cannot effectively contribute;
- Reluctance to change lifestyles due to threat of mitigation action on standard of living;
- Social norms and expectations which prevent one from acting if others are not also doing so.

A review conducted by Roser-Renouf and Nisbet's (2008) examining theoretical and empirically derived constructs for measuring climate change risk perceptions corroborated Lorenzoni et al.'s (2007) findings. They added that the statistical link between knowledge and climate change risk perceptions is moderated by factors like religiosity, ideology and other socially and contextually salient factors relevant to individuals. For example religiosity tended to diminish the perceived risks of climate change. Whitmarsh (2011) confirmed findings with a UK sample, revealing that factors of location, lifestyle and trust in communications increased perceived risks of climate change more than knowledge or education. In addition, researchers have documented that the direct 'lived experience' of changing weather and seasonal patterns, such as recurrent droughts, floods or cyclones,

may not be attributed to climate change and might, in fact, inure the public against recognising climate change risks (Li 2009; Morrissey and Reser 2007; Swim et al. 2011; Whitmarsh, Seyfang and O'Neill 2011)

Although little research has examined Australians' direct experience of natural disasters and its relationship with climate change risk perceptions, empirical studies indicate most Australians acknowledge the occurrence of climate change. A survey of 5,036 Australians showed that most believed climate change is real, though half ascribed it to anthropogenic carbon emissions and half to a natural cycle (Leviston and Walker 2011). However, these results did not distinguish between disaster impacted individuals and others.

The public's acknowledgement of climate change as a serious problem caused by human activities is one of the necessary prerequisites for mitigation action (Reser and Swim 2011). Research to date however, has not documented how this view varies across Australia and what key factors influence it. While the majority of scientists agree that it is very likely (a 90% chance) that anthropogenic carbon emissions are the main cause of climate change (IPCC 2012; Somerville 2010), Australians

appear to be less than unanimous in their acceptance of the causes of climate change, and public concern for climate change has been declining (Gallup 2011; Lewandowsky, Gignac and Vaughan 2013). One reason proposed for this decline is the creation of doubt by political and media bodies, challenging the existence of scientific consensus (Bacon 2011; O'Neill 2013).

Leviston and Walker (2011) examined which sources of climate change information Australians trust. They found university scientists were ranked highest, above environmental and industry scientists, with government generated information ranked close to the bottom. Family and friends rated relatively highly, particularly by those who believed climate change was part of a natural cycle. Such results highlight that people's socio- political views and, as a result, the lens they apply to the evaluation of communications and facts about climate change, tend to reflect the norms of their social network (Kahan, Jenkins-Smith and Braman 2011), and presumably they in turn are partly a function of the geographical location of their residence and their occupation. Levinson et al.'s survey did not examine Australians' trust in media sources, which in Australia have been historically important in determining the agenda and issues that are open to debate (Cunningham and Turner 1997). Carvalho (2010) reported that research has shown the media to be the main source of information and the main factor shaping people's climate change risk perceptions. In Australia, Speck (2010) argued that empirical data showed Australians' climate change risk perceptions were primarily informed by the media. If this is the case, the trust Australians place on media communications invites inquiry.

To address the question of trust in the media Ashworth et al. (2011) asked respondents how they thought climate change issues were treated by the media. Results of their online survey of Australians (n= 1,602), comprising 55% urban, 16% rural and 27% regional town residents, showed that only 17% of respondents believed "media treatment was fair and balanced on both sides". Respondents who were unsure about climate change most commonly cited a lack of knowledge and the presence of conflicting opinions in the media about the nature of climate change as the reasons for their views. Ashworth et al.'s (2011) findings showed that Australians rated communications from scientific bodies, and friends / family higher than government communications, reproducing Leviston and Walker's (2011) findings. However, Ashworth et al. (2011) did not distinguish differences between urban and other Australian residents and, like Leviston and Walker (2011), their sample did not represent individuals who had recently experienced a natural disaster.

The relationship between location of residence and climate risk perceptions is unclear, although one's employment industry appears to influence climate change risk perceptions. Leviston et al. (2011) reported marked differences in climate change risk perceptions between urban Australians and rural primary producers. They found urban Australians were more likely to attribute climate change to anthropogenic causes. Further, a smaller but significant difference was noted between rural and urban dwellers' climate change risk perceptions with urban dwellers perceiving higher risks. WIDCORP (2009) studied climate change risk perceptions of 1,503 Victorian farmers across seven agricultural sectors and 12 geographic regions. By contrast to national surveys, responses varied by employment industry and local regional concerns. Another small scale research, representing the views of 23 rural Australians, showed a similar divide in opinions with concomitant conflicting views as to the most appropriate adaptation behaviours (Buys, Miller and van

Megen 2012). Additionally, Evans (2012) reported on 411 rural Western Australian's climate change risk perceptions and their views of the role of government, in four contrasting geographical regions. Echoing the WIDCORP (2009) study, climate change risk perceptions differed from the national surveys, showing regional variability. Only a third of farmers surveyed accepted that climate change was happening, and of those only a quarter ascribed it to anthropogenic carbon dioxide emissions. Farmers held cynical views about government motives and believed politicians used climate change science for personal and political agendas (Evans 2012). More recently Higginbotham, Connor and Baker (2014) examined differences in a sample of 1,162 Hunter Valley coastal and rural residents in New

South Wales. They found that respondents' climate change risk perceptions were a function of impacts perceived to affect their local areas. Farmers feared climate change would affect their productivity through drought, while urban coastal residents were apprehensive about how changes in sea level would impact property values.

The differences outlined above and the identified research gap in relation to the links between disaster experiences and climate change risk perceptions gave rise to this reported. Survey data were obtained during the implementation of a larger project designed to examine community resilience to natural disasters. Rural communities struck by disasters face considerable hardship, including mental health problems, as a result of disaster impacts upon their livelihoods (Morrissey and Reser 2007; Hart, Berry and Tonna 2011). It was therefore considered imperative for them to adapt to climate change (Buys et al. 2012). Drawing upon a sample from four rural Australian towns which had experienced natural disasters, this paper describes their climate change risk perceptions and their trust in a range of climate change communication sources. The four sites of interest were chosen because they exemplified communities impacted by different types of disaster events. The case study sites were Beechworth (wildfire, 2009) and Bendigo (drought, 2002-2008) in Victoria; Ingham (flood, 2009) and Innisfail (cyclone, 2006) in Queensland (Figure 1).

Place Figure 1 about here

The category 5 Cyclone Larry resulted in the evacuation of over 300 people from Innisfail (pop. 9,222) resulting in insurance claims of over $369 million. Innisfail is a sugar and banana producer.

Ingham (pop. 4,767), concerned with sugar production, tourism, dairy and beef cattle husbandry and aquaculture, experienced two severe riverine floods which directly affected 2,900 residences and businesses, with estimates of infrastructure damage of $120 million.

The Beechworth (pop. 3,559) bushfires were part of the more extensive Black Saturday fires which affected 78 towns, claimed two lives, burnt through 30,000 ha and destroyed several homes. Land was used mainly for tourism, forestry, wood chipping, viticulture, agriculture, timber processing and manufacturing. The Bushfires Royal Commission estimated the cost of the Black Saturday fire disaster at $4.4 billion (Boon et al. 2012).

Bendigo (pop. 5,774), part of a larger region known for wine production, was affected by a slow onset drought, Australia's so-called Millennium drought, mirroring a potential future scenario of climate change. Impacts ranging from deteriorating mental health, to economic and infrastructure

ramifications were felt by residents. Farmers repeatedly faced crop failures, the death of trees and starving stock due to lack of rain; heat stress on humans led to increased rates of hospital admissions and deaths; public amenities deteriorated as recreational facilities, parks and gardens declined due to water restrictions, impacting community connectedness and mental health (Boon et al. 2012). The cost of the disaster is not known precisely.

Methods

The research question of this study was based on a gap in the Australian literature concerning how disaster experiences, perceived climate change knowledge and geographic location impact upon climate change risk perceptions. To examine the research questions a survey instrument was constructed. First a pilot study was conducted to test whether the survey questions adopted for the research were appropriate for use in the four towns. The pilot survey was applied to a sample of 112 respondents who had experienced cyclone Yasi in North Queensland. Results from the pilot survey were analysed using Latent Trait Theory/Rasch modelling to ensure that the survey items were correctly designed to elicit meaningful responses (for fit indices refer to Boon et al. 2012). The pilot survey results were used to refine the survey instrument which was employed for the main study. The pilot and subsequent main survey items used were derived from research conducted in Australia (Reser et al. 2011). The items were ranked on a Likert scale; responses were coded from 1 (definitely disagree) to 4 (definitely agree) with "Don't Know" coded 0.

They items were:

I feel I know a lot about climate change

I trust what scientists say about the environment

I am concerned about climate change (global warming) I trust what the government says about the environment I trust what the media says about the environment

I think climate change is caused by human activities I think climate change is a serious problem right now

Rasch modelling was employed to ensure that the final survey items and hypothesized factors or constructs worked in the way that they were intended to work across all sites, using the program Winsteps. Survey items

should not behave differently for particular subgroups of a sample. If an item functions differently for certain groups, the item reduces the validity of the measure for that variable or construct (Bond and Fox 2007). The assumptions of the Rasch model include unidimensionality (i.e., whether the items form a unitary latent trait) and local independence (i.e., the likelihood of the person correctly responding to an item is independent from the other items in the test). The items thought to comprise each construct were modelled by Winsteps to ensure that each item loaded to the

proposed construct appropriately. Winsteps was then used to compute a measure of that construct for each respondent (see Boon et al. 2012 for the full description of the analytical methods).

The sampling method adopted was random cluster sampling (Burns 2000) using grid points on maps to locate areas in each community to deliver the surveys. Surveys were hand-delivered to clusters of households in each community. Householders were asked if they had been present during the disaster in question and only those residents who confirmed that they had lived through the respective disasters in each town were asked to participate. Surveys were collected by arrangement with the householders a few days later. A total of 1008 useable surveys were returned (Ingham N= 287, Innisfail N= 231, Beechworth N= 249, and Bendigo N= 241). The response rate ranged between 92- 94% across the four sites. The data collection took place in the second half of 2011.

To assess significant differences in climate change risk perceptions between the four community groups, analyses of variance (ANOVA) were conducted on all climate change items used. The statistical program IBM SPSS was employed to perform all statistical computations. To test the relationships between constructs structural equation modelling (SEM) was employed (Byrne 2001) with the construction of a model based on theory. The primary purpose of the study was to examine the structural relationships between disaster experiences, climate change risk perceptions, location and climate change knowledge and to evaluate the extent to which these held across the four communities. SEM is also known as covariance structure modelling and simultaneous equation modelling. SEM is very useful for multi-sample modelling, wherein a model is fit simultaneously to sample data from different populations (MacCallum and Austin, 2000). SEM also helps to overcome the problems associated with the effects of measurement error and correlated measurement error on the outcome variable (Baron and Kenny, 1986) which attenuate the estimation of relationships between observed variables (Kline, 2010; Maruyama, 1998). Multiple predictor variables can be simultaneously modelled and their relative contribution to the outcome variable estimated, resulting in a more accurate weighting of influences for a particular outcome. This is not possible with association tests performed for each predictor variable. Moreover, SEM techniques permit the use of dichotomous categorical predictor variables in a model without the need to employ more complicated logistic regression models (Joreskog and Sorbom, 1984; Muthen, 1984). Where data is not continuous, as in the case with the construct called “prior disaster experience”, SEM provides a valuable analytical tool by permitting the use of dichotomous variables. In sum, SEM is considered as a better way to conduct multiple regression analyses.

Results

Characteristics of the sample are displayed in Table 1. The Ingham and Innisfail (Queensland) participants were younger than the Victorian ones and had completed fewer years of formal education. In addition, residents in the different sites had experienced significantly different numbers of disasters ($F(3, 977) = 48.2$, $p < 0.001$), with Queenslanders indicating a higher level of exposure to weather related disasters. These characteristics are broadly in line with each town’s demographics (ABS 2010a; 2010b; 2010c; 2010d; 2012a; 2012b).

Place Table 1 about here

Place Table 2 about here

Climate change survey items were significantly different across sites except for the items:

I feel I know a lot about climate change (global warming) and

I trust what the government says about the environment.

This result indicated a perceived lack of climate change knowledge and a mistrust of government communications, in line with previous findings (Evans 2012; Leviston et al. 2011).

Most respondents in each site agreed or strongly agreed that climate change is a serious problem right now

(Innisfail 57.7%; Beechworth 60.1%; Bendigo 59.4%) except in Ingham where the figure fell to 49.5%. Similarly, across all sites most respondents endorsed the statement I am concerned about climate change (Ingham 53.6%; Innisfail 55.6%; Beechworth 60.4%; Bendigo 63.8%). Significant division occurred, however, between Queenslanders and Victorians about whether climate change is caused by human activities: 43.1% of respondents in Ingham agreed or strongly agreed, 45.9% in Innisfail, 57.7% in Beechworth and 54.1% in Bendigo. Responses also differed on the question: I feel I know a lot about climate change. Although ANOVAs did not show significant differences between sites, 50.2% disagreed or strongly disagreed in Ingham, 56.9% in Innisfail, 41.7% in Beechworth and 40.5% in Bendigo, suggesting that Victorians were more confident in their knowledge about climate change.

Respondents were asked if they trusted various communication sources about the environment: scientists, the media and the government. Over half of Queenslanders did not trust scientists' communications (Ingham 51.9%; Innisfail 52.7%). This result was significantly different from Victorian results; they placed greatest trust in communications from scientists, conforming to prior Australian findings (e.g., Leviston and Walker 2011).

Across all sites, respondents did not trust media communications (Ingham 75.3%; Innisfail 70.1%; Beechworth 76.5%; Bendigo 79.3%), or government communications (Ingham 67.5%; Innisfail 65.5%; Beechworth 64.9%; Bendigo 67.3%) echoing Leviston and Walker (2011) and Ashworth et al. (2011).

Next ANOVAs were conducted to examine climate change risk perception differences between those who had not previously experienced a disaster (n = 461) and others who had been through natural disasters before the most recent one (n = 647). This was based on the assumption that those who

had only experienced the most recent disaster might be more likely to ascribe the disaster to climate change because they would not have been inured to disaster experience (Li 2009; Morrissey and Reser 2007; Swim et al. 2011; Whitworth et al. 2011).

Results, however, showed no significant differences on any items. This result might indicate that ideas about climate change are entrenched and therefore experience with weather events simply confirm already held beliefs as Myers et al. (2013) found with their American sample.

To examine whether differences between sites were based on education, the links between education and climate change attitudes were analysed; results are shown in Figure 2. A pattern emerged showing rising levels of climate change concern, awareness and trust in scientific climate change communications by higher educational attainment. Multivariate analysis of variance (MANOVA) results, using an additive model of effects (Model =intercept + five groups), showed there were significant differences between the 5 groups, Wilk's lambda, Λ =0.24, $F(7, 3098) = 4.5$, $p<0.001$, partial eta squared (η^2) = 0.04, a small size effect. Univariate ANOVAs revealed differences were connected to I trust what scientists say about the environment, $F(4,865) = 11.6$, $p<0.001$, partial eta squared (η^2) =0.05, a moderate size effect, to I am concerned about climate change, $F(4,865) = 9.4$, $p<0.001$, partial eta squared (η^2) = 0.04, a moderate size effect, to I trust what the government says about the environment, $F(4,865) = 3.9$, $p<0.001$, partial eta squared (η^2) = 0.02, a small size effect; to I think climate change is caused by human activities, $F(4,865) = 5.8$, $p<0.001$, partial eta squared (η^2) = 0.03 a small size effect; to I think climate change is a serious problem right now , $F(4,865) = 9.7$, $p<0.001$, partial eta squared (η^2) = 0.04, a moderate size effect and I feel I know a lot about climate change, $F(4,865) = 17.4$, $p<0.001$, partial eta squared (η 2) = 0.08, a large effect size. Climate change risk perceptions therefore increased with education as did knowledge of climate change and trust in scientific communications about climate change. These findings reflect Leviston et al.'s 2011 results which showed that in Australia graduates were more likely to be concerned about climate change. Findings here also confirm other studies which suggest that information about climate change may be poorly understood by many Australians because climate change knowledge is confined to a small percentage of the population (Ashworth et al. 2011). These patterns were more prevalent within Victorian sites which comprised of more graduates than in Queensland (Table 1).

Place Figure 2 about here

One of the aims of the research was to reveal any links between climate change risk perceptions and repeated disaster experiences, using SEM. A construct climate change risk perceptions was derived from 3 indicators: I think climate change is caused by human activities; I think climate change is a serious problem right now; I am concerned about climate change, and another construct, trust in climate change communication was derived from 3 indicators: I trust what scientists say about the environment, I trust what the media says about the environment, I trust what the government says about the environment. The constructs were validated using Rasch analyses through the software program Winsteps 3.68.1. Rasch analysis is a method for obtaining linear measures (qualified by standard errors and quality-control fit statistics) from stochastic observations of ordered

category responses (Linacre 2008, p. 27). Measures for all constructs were thus calculated. The resulting model, which included "location" and "climate change knowledge" as exogenous (independent, measured) variables, explained 38% of the variance (R2) in climate change risk perceptions, a sizeable proportion given the possible influences impacting upon an individual's cognitive and affective responses to climate change risk perceptions. All constructs were measured and therefore are depicted as rectangles (Byrne 2001).

In fitting the model, prior disaster experience, a construct indicating more than one disaster experience, was found to be negatively correlated to residential location (r = - 0.35) an expected result based on the descriptive analyses (Table 1) since Bendigo residents reported lowest incidence of prior disaster experience while Ingham and Innisfail residents' prior disaster experience was very prevalent. Prior disaster experience also had a non- significant pathway to climate change risk perceptions, so this pathway was deleted from the final model. On the other hand location predicted climate change risk perceptions, (standardised regression weight (β) = 0.10), which verifies the Beechworth and Bendigo ANOVA results showing that they had higher levels of climate change risk perceptions than the Queensland residents. Multiple disaster experiences were so common for Ingham and Innisfail residents that their regression effects were not observed. (Location was coded 1 for Ingham, 2 for Innisfail, 3 for Beechworth and 4 for Bendigo.). The finding that the experience of multiple disasters does not predict higher climate change risk perceptions shows than in this rural sample disaster experience is probably viewed as a normal part of the Australian climate, supporting the proposition that the "lived experience" of environmental disasters could inure the public to climate change risks (Li 2009; Morrissey and Reser 2007; Swim et al. 2011; Whitmarsh, Seyfang and O'Neill 2011). This result, in line with the ANOVA results which showed that multiple disaster experiences did not lead to significant differences in climate change risk perceptions between groups, does not clarify whether the samples here were inured to change in their climate change risk perceptions by experienced climate vicissitudes, or entrenched in their views regardless of experience, a manifestation of cognitive dissonance effects (Festinger 1957). Either or both explanations are possible.

Figure 3 shows the strength of the associations between climate change risk perceptions and the other factors. All standardised regression weights (β) were significant at $p<0.001$. Climate change knowledge was a small predictor of climate change risk perceptions (standardised regression weight (β) = 0.15), supporting earlier findings (Roser-Renouf and Nisbet, 2008; Whitmarsh 2011) and showing that complex cognitive processes that go beyond knowledge are involved in appraisals of climate change as was recently revealed by Myers et al. (2013). The strongest predictor of climate change risk perceptions was trust in climate change communications (standardised regression weights (β) = 0.56). Although such results have been demonstrated before in Americans (Malka, Krosnick, and Langer 2009), they are demonstrated in a rural Australian sample for the first time in this study. Fit indices for the model were excellent, $\chi 2 /df = 0.12$, $p = 0.73$ (Kline 2010; Chen, Curran, Bollen, Kirby and Paxton, 2008).

Two alternative models were tested. One tested whether climate change risk perceptions influenced trust in climate change communications, a plausible scenario. This model yielded poorer fit indices $\chi 2 /df = 2.24$, $p =$

0.14 and non-significant pathway from climate change knowledge to climate change trust which is a counterintuitive result because, given the descriptive results, we would expect a negative pathway between these two constructs. A further analysis tested a model whereby trust in climate change communications mediated the effects of climate change knowledge and the experience of disasters upon climate change risk perceptions. This model too was rejected as it yielded much poorer fit indices ($\chi 2 /df = 17.6$, $p = .001$).

Place Figure 3 about here

Discussion

Most of the respondents in this study (a half to two thirds across sites) expressed concern for climate change, indicating that they believed it to be a serious problem right now, reflecting previous Australian research (Reser, Bradley and Glendon 2012). Unlike Reser, Bradley and Glendon's (2012) study however, respondents were divided about whether climate change is caused by human activities, with Victorians more likely to agree than Queenslanders. Therefore location and contextual factors seem to play a role in shaping perceptions as per the Higginbotham et al. (2014) research in rural NSW. This study may be distinguished by the composition of the sample (rural), its selection (via cluster sampling) and methodological differences based on the survey instrument used. Reser Bradley and Glendon (2012) reported modest but significant differences between rural and urban respondents with respect to climate change risk perceptions, climate change concern, and trust in government communications, with rural respondents endorsing lower acceptance of, and concern about, climate

change, and slightly less trust in government communications. Their results therefore are supported by findings here. Moreover, results here echo Leviston et al. (2011) and Buys et al. (2012) rural communities' reports, suggesting that there is very likely an urban-rural divide in opinions about climate change in Australia, and perhaps a North-South divide stemming from sociocultural differences between Queenslanders and Victorians. It is to be noted that the Queensland communities are both more distant from large urban centres than either of the Victorian communities.

Political party affiliation has been found to be a determinant of climate change risk perceptions in America (Malka, Krosnick and Langer 2009) and in Australia (Leviston et al. 2011). Leviston et al. (2011) noted that those most likely to endorse the view that climate change is due to human activity were those who voted for the Labour and Green Party rather than the more conservative Liberal Party in Australia. Indeed, voting behaviour in past elections shows that the Bendigo area is mainly a

Labour Party stronghold, while the other three communities voted for independent candidates representing the interests of rural communities1. It would be useful to examine the prevalence of the links between political affiliation and climate change risk perceptions across Australian rural communities, and whether differences between rural and urban Australians' beliefs about the causes of climate change can be linked to other factors, such as local geomorphology and competing industry interests as Higginbotham et al. (2014) found in their Australian study. Nevertheless, findings here are significant as a failure to recognise the relationship between human activities and climate change may prevent individuals from taking action to support climate change mitigation and adaptation activities, issues of prime importance in the current global political and environmental agenda.

Unlike earlier research in the UK (Spence et al. 2011) and Australian (Reser, Bradley and Glendon 2012), the present study did not establish a significant link between multiple disaster experiences and climate change risk perceptions. Reser, Bradley and Glendon (2012) reported a small but significant association between disaster experiences and climate change concern ($r = 0.12$). Results of this study support the contentions of others (Li 2009; Morrissey and Reser 2007; Swim et al. 2011; Whitmarsh, Seyfang and O'Neill 2011) that when disasters are experienced on a regular basis they form part of the normal fabric of life. However, when these disasters occur infrequently in an individual's lifetime, these may be interpreted differently and may increase the perceived threat of climate change. Certainly our results show those who have frequent experience of disasters like the Ingham or Innisfail residents view climate change as less pressing or serious. Reser, Bradley and Glendon (2012) noted that the most often-mentioned environmental threats in response to open-ended qualitative questions in their survey were water scarcity and drought, suggesting that their sample were more familiar with these kinds of disasters than the flood and cyclone scenarios of this study. Given that our Victorian samples' results more closely approximate Reser et al.'s (2012) results, it is suggested that geographical location and particular disaster experiences are probable underlying influences of these views, in addition to the other socioeconomic factors that impact upon the cognitive appraisal of climate change as noted by Lorenzoni et al. (2007).

Further research is necessary to fully explore the distinctions between disaster experience and climate change risk perceptions because one of the limitations of this study could be deemed to be the time that elapsed between each disaster and data collection. Perhaps, the experience of drought which is prolonged and tests people's endurance makes a stronger impact upon their perceptions, hence helping to facilitate their acceptance of climate change as a serious concern. Another limitation in relation to disaster experience and climate change risk perceptions is that we did not collect pre and post disaster survey data. These might have yielded a clearer understanding of the impacts of disaster experience, although our analyses comparing those who had sustained only one disaster with those who had experienced many yielded no significant differences.

The most important findings of this research, which must be heeded by governments, scientists and environmental lobby groups, are the links revealed between rural residents' trust in climate change communications, their climate change knowledge and their climate change risk perceptions; results which were to an extent community specific, with Queenslanders exhibiting different levels of trust, climate change risk perceptions and knowledge to Victorians. They showed that knowledge

predicted climate change risk perceptions independently of trust in climate change communications, a finding that needs to be considered in light of previous assertions that knowledge was not as important in influencing climate change risk perceptions as other personal characteristics and beliefs (Reser Renouf and Nisbet 2008; Whitmarsh 2011). Declarative knowledge which consists of understanding the science of climate change, i.e. how does the greenhouse effect

1 Namely Bob Katter in Queensland and Cathy McGowan in Beechworth, both more Liberal than Labour or Green in affiliation (Australian Electoral Commission 2013).

work, what behaviors are necessary to mitigate climate change and their effectiveness has been recently cited as being more important than previously thought (Truelove and Parks 2012). It is possible that respondents in this study who rated their climate change knowledge highly possessed all three types of climate change knowledge.

These findings are important in the context of government policy development to support future public mitigation and adaptation strategies (IPCC 2012). Adapting to the impacts of climate change requires cooperation not only between scientists, but also between policy makers and, in a democracy, the public. Successful adaptation decision-making requires skillful communication between scientific research bodies, policy-makers and stakeholders (Hanger et at. 2013; Speck 2010). Translating the immensely complex climate change science into language that is clear to the public is an extremely challenging task (Simpson 2011), with the general public frequently struggling to interpret the scientific jargon, understand climate change risk and relate global scenarios to their personal experience (Leviston et al. 2011; Swim et al. 2011; Weber and Stern 2011). Cognitive barriers such as the long time frames and uncertain impacts associated with climate change make understanding and acceptance difficult and, as a result, adaptation challenging for many people.

Moreover, the tendency for individuals to avoid cognitive dissonance by acknowledging those observations which confirm their strongly held views (Myers et al. 2013) makes the task of getting public support a very difficult one. Complicating possible solutions to disengagement, sociological perspectives argue that a dissonance based explanation of the issue is incomplete (e.g., Burgess, Harrison and Filius 1998; Shove, 2010). This is because climate change mitigation action is widely perceived to be the responsibility of governments and industry (e.g., Lorenzoni et al. 2007) and therefore interventions targeting individuals might not be successful.

Notwithstanding the above, as important in this context, and underscored by our results, is the erosion of public trust in scientific communications. All respondents indicated that they did not trust the media or government communication for the provision of information about the environment, echoing previous findings (Ashworth et al. 2011). In addition, when respondents were asked about whether they trusted what scientists say about the environment, the results varied by site. Most respondents from the Queensland sites did not trust communications from scientists while in Victoria, respondents were almost equally divided about this issue.

This finding is significant because successful adaptation to climate change requires actions by individuals and support of government initiatives by individuals (for example the purchase of solar panels for household energy generation, or carpooling and the like). It is difficult to see how government and scientific institutions are able to persuade individuals to change their behavior to ensure climate change adaptation if their communications are not considered credible, or if, as outlined above, some respondents do not consider human activities to be partly responsible for climate change. The so-called "climategate scandal" which resulted in claims that climate experts had been manipulating scientific data to suit a pro-global warming agenda, left the public bewildered and uncertain, more mistrustful of scientific claims than ever and doubting scientists' credibility (Leiserowitz et al. 2013), the only trusted source of communications that the Australian public endorsed in various studies (e.g. Leviston et al. 2011; Ashwoth et al. 2011). Mixed messages, academic controversy and political posturing confuse the public, and results here reflect these public frustrations. Clear and unambiguous information is necessary to promote adaptive behaviour, but information is not enough on its own; other factors must also be present to motivate behaviour. Key variables in this domain include personal and social norms (Myers et al.

2013; Truelove and Parks 2012; Swim et al. 2011) which point to the need to situate the information in the context of the community in question. This is particularly the case, as shown by the community specific results here, because adaptation problems do not occur in isolation, but in the context of social, demographic, political and economic factors (Hanger et al. 2013). For example, information on climate related threats, such as the risk of inundation or coastal erosion due to sea level rise need to be made available to Australian communities for specific properties. This will allow individuals to make investment decisions that reflect future climate risk, and reinforce the idea that climate change risks are the responsibility of individuals and normal market processes.

Further, results point strongly to an educational association between perceptions of climate change risks and trust in scientific communications. This has additional potential complications for the communication of climate change science and communications from policymakers to rural communities. Findings here suggest that "place- based climate change education strategies which highlight the local impacts of climate change in a manner that can be experienced by people with their senses" (Myers et al. 2013, p.3) might help rural Australians to understand the importance of mitigation behaviours.

In sum, communication by scientists needs to be more accessible to those who are less interested in science in general, perhaps ethnic minorities and those who are not educated to tertiary levels (Swim et al. 2011) and media reporting scientific research need to ensure that they do not sensationalise certain news items, like the East Anglia University "climategate" leak. Most importantly, local hubs of information about local climate

change impacts need to be established to ensure that the issue becomes more situated and tangible to residents (Myers et al. 2013; Vaughan 1995; Simpson 2011).

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Authors' Response to Reviewers' Comments

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Dear Prof Cramer,

The paper submitted now is a second revision as requested for the original submission Ms. No. REC-D-13-00111.

All changes to the manuscript are indicated with a yellow highlighter so you can see the changes easily.

Please note that the website has some problems. Even when I re-order the figures and tables to be included in the file upload the website does not follow the instructions.

Similarly, there is no option to upload a title page separately from the manuscript on the website which is why in the previous R1 submission you could not see the title page as it was placed by the website after the Tables.

I also wonder if my responses to the reviewers' initial comments were easily seen as they were placed in between the manuscript and the figures.

Thank you for the opportunity to refine the paper.

Thank you for your time, Kind regards,

Helen Boon

Figure 1 Location of study sites: Innisfail, Ingham, Bendigo and Beechworth.

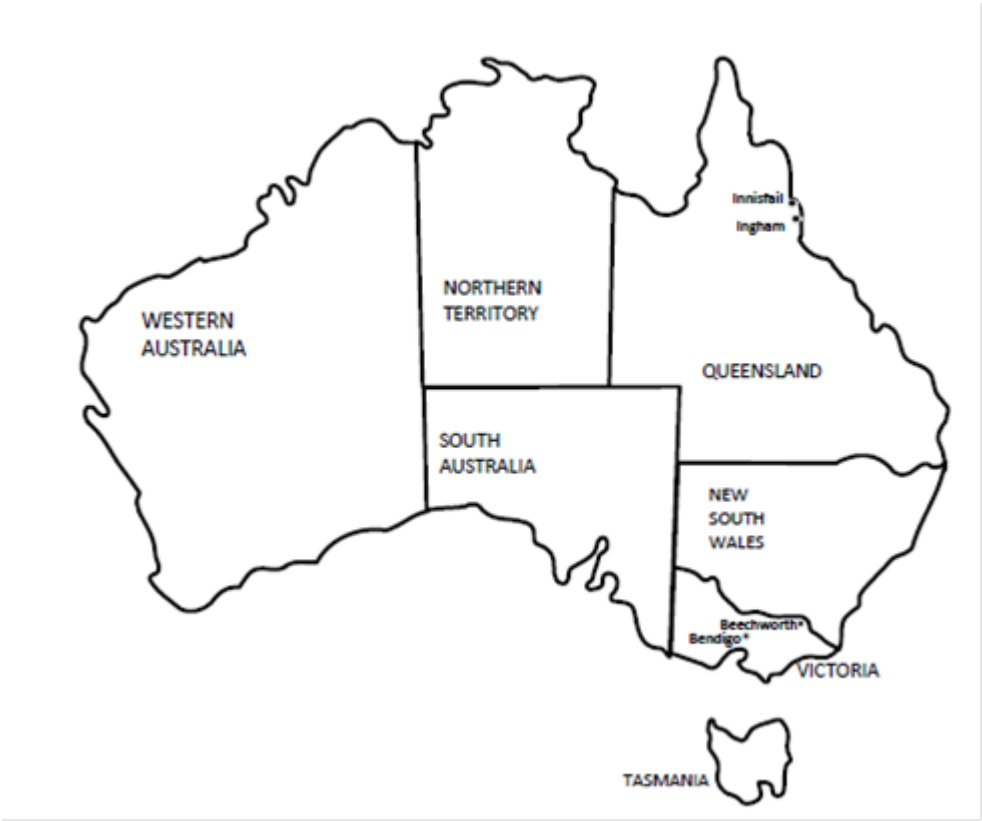

Figure 2 Climate change concerns by highest educational qualification

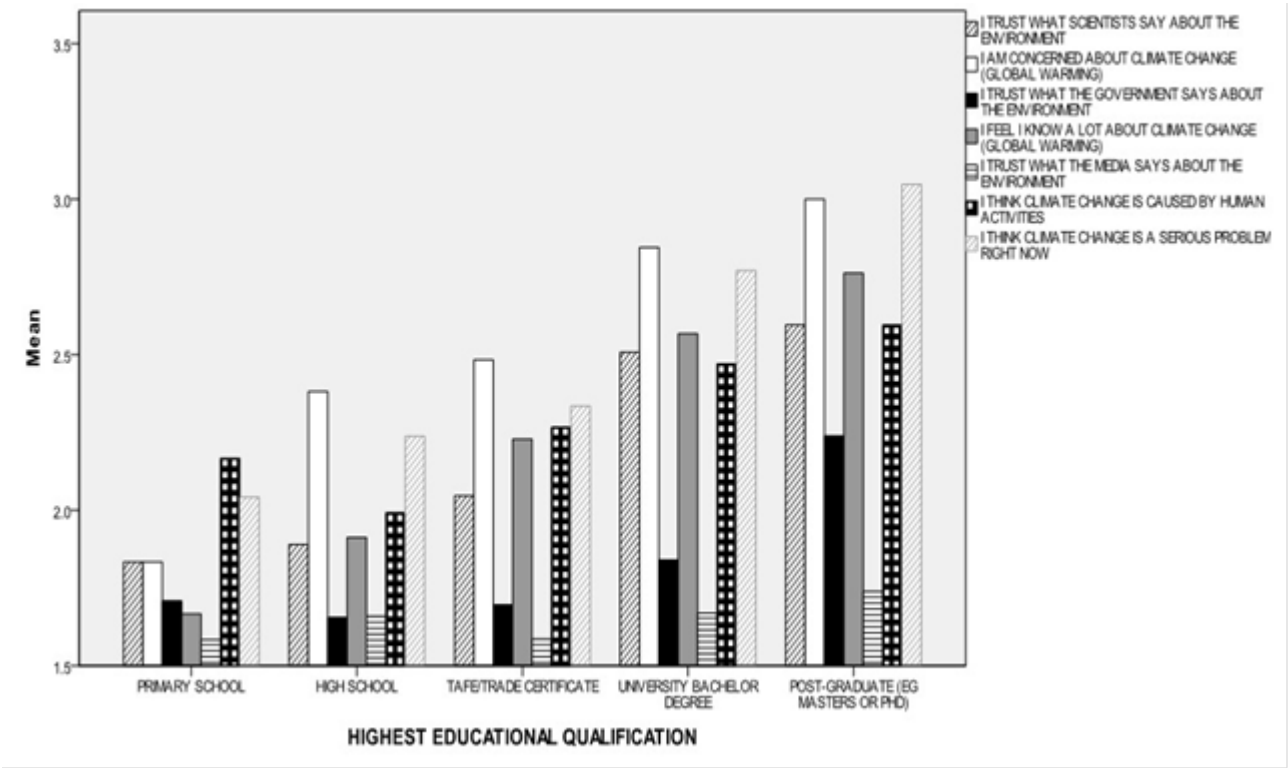

Figure 3 Model of hypothesised influences to climate change risk perceptions.

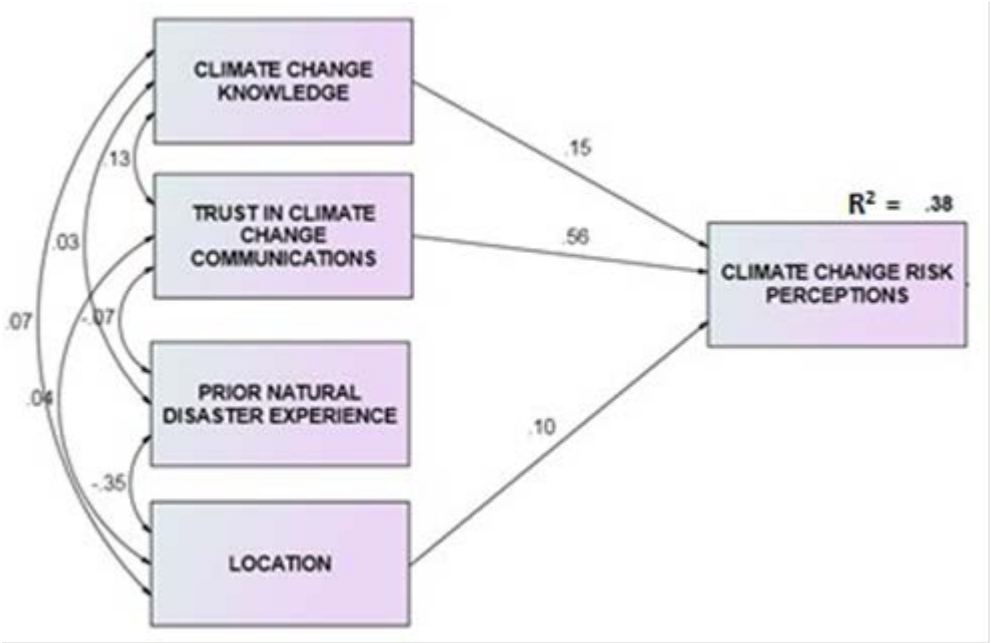

Table 1 Sample characteristics by site (N= 1008)

Demographic questions		**Ingham**	**Innisfail**	**Beechworth**	**Bendigo**
		N= 287	**N= 231**	**N= 249**	**N= 241**
		N %	N %	N %	N %
Age group	18-25	8.9	5.3	2.5	3.4
	26-40	15.6	23.5	16.3	15.3
	41-55	41.1	36.3	25.5	35.2
	55+	34.4	35	55.6	46.2
Highest educational qualification attained	Primary school	4.3	4.5	0.8	1.3
	High School	42.2	55.4	35.1	32.3
	TAFE/trade certificate	31.4	27.9	27.6	31
	University Degree	17.7	10.4	30.5	28.4
	Post-graduate	4.3	1.8	5.9	6.9
I have experienced a disaster prior to this one		88.5	79.6	62.5	46.0

Table 2 Responses to survey items (Means, Standard Deviations (SD)) by site

Survey Items	LOCATION								ANOVA test statistic
	Ingham		Innisfail		Beechworth		Bendigo		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
I trust what scientists say about the environment	1.96	1.13	1.99	1.06	2.27	1.24	2.19	1.21	$F(3, 951)=4.1$ $p< 0.005$
I am concerned about climate change	2.38	1.16	2.41	1.08	2.64	1.17	2.66	1.17	$F(3, 962)=4.0$ $p< 0.005$
I trust what the government says about the environment	1.66	1.02	1.80	1.01	1.78	0.99	1.70	1.01	NS
I feel I know a lot about climate change	2.08	1.03	2.12	0.99	2.22	1.18	2.27	1.13	NS
I trust what the media says about the environment	1.65	0.89	1.77	0.94	1.65	0.88	1.50	0.84	$F(3, 962)=3.7$ $p< 0.01$
I think climate change is caused by human activities	2.05	1.22	2.13	1.21	2.35	1.32	2.28	1.35	$F(3, 950)=3.0$ $p< 0.05$
I think climate change is a serious problem right now	2.24	1.23	2.40	1.15	2.54	1.29	2.53	1.22	$F(3, 966)=3.4$ $p< 0.01$