The known unknowns of climate change: adaptation in the Southern Agricultural Region of Western Australia

David M Gray

Department of Agriculture & Food, Katanning, 10 Dore St, Katanning 6317
Email: david.gray@agric.wa.gov.au

Abstract. Each stakeholder in the Southern Agricultural Region, including farmers, local government officers and members of the community, understands the issues of climate change differently. This affects the manner in which each adapts and allocates resources. The paper offers a conceptual framework to guide the extension effort: the concern should not only be upon what is "known", but also on what is not. It presents findings of a survey of attitudes upon three dimensions relevant to adaptation: whether climate change is occurring; the appropriate response; and science as a solution. It found varying degrees of scepticism amongst stakeholders, and of acceptance of the need to respond. Trust in science and scientists varied. The confounding influences of respondents' location and self-described category somewhat limited the interpretation of results, which had been analysed by ANOVA. This work should nevertheless assist in both canvassing further the stakeholders and in comprehending their adaptation decisions.

Introduction

This paper explores some of the societal challenges facing one region in Western Australia, the Southern Agricultural Region, in adapting to climate change. This region embodies some of Western Australia's most productive agricultural landscapes, from the Esperance plains in the east to the cropping areas surrounding the Stirling Ranges and the Porongorups, to the higher rainfall hills of Kojonup down to the productive Plantagenet in the west and south to Albany.

What does the local regional community know and believe about climate change? Consultations held by the South Coast NRM, supported by the Department of Agriculture & Food, sought to address this, by identifying issues and beliefs.

Underlying this is the question: to what must we adapt? The set of local issues and beliefs contrasts with the set of knowledge held by the wider scientific community. These differences discriminate what is, and is not, known by the particular local community of agricultural stakeholders, and the extent of misconceptions and ignorance which should be redressed. A useful model with which to deal with these differences is the Johari Window, first set out by Luft and Ingham (1955). In its original form, the analyst maps the other- and self-perceived character traits of a person into four quadrants. The "knowledge window" in Table 1, where the analyst maps perceived facts into four quadrants, presents a form of this window that can guide the extension process concerning climate change.

Table 1. Window of knowledge

	Accurately perceived knowledge	Inaccurately perceived knowledge
Facts that are objectively known	*Known knowns* (proper knowledge or informed wisdom)	*Unknown knowns* (uneducated ignorance, false notions, misconceptions or wrong-headedness)
Facts that are objectively not known	*Known unknowns* (wise ignorance, or the acceptance of not knowing)	*Unknown unknowns* (absolute blindness, superstition, myths or invented truths)

The consultations about climate change noted above comprise a recent attempt in this region to engage with the agricultural community. Another recent example was the Agribusiness Forum held by DAFWA in Albany early in 2009 (Blake, 2009).

For the extension of messages about climate change to rural and agricultural communities, this paper finds that:

1. Extension efforts should ensure that not only should well-established facts be communicated but also relevant propositions, together with the degree of uncertainty about their veracity;
2. Extension agents should also communicate what is not known about Climate change;
3. Farmers and local government officials tend to be somewhat sceptical concerning various propositions about the imminence and anthropogenic nature of climate change; but
4. Many farmers and local government officials seem likely to accept that climate change is occurring and they need to respond;

5. Farmers and local government officials tend to be mildly sceptical about the role of science and scientists in forming solutions;
6. Each location in the region may differ widely from others in the attitudes of their stakeholders.

The Southern Agricultural Region

How is the knowledge window relevant to our concerns? Table 2 displays one example of the way in which beliefs, some soundly based, others not, about climate predictions exist in agricultural communities within the Southern Agricultural Region. These examples derive from personal observation. Note here that the term "objectively known" is a construct: all facts "accepted by scientific consensus" have a subjective and cultural component, as is evident in the science of climate change.

Table 2. Knowledge window for the Southern Agricultural Region

	Facts generally accurately perceived by the regional community	Facts not widely understood by the regional community
Facts that are objectively known to, or are the ruling consensus within, the wider scientific community	Quadrant 1 Much of the Southern Agricultural Region has dried appreciably since the early seventies.(It is objectively known that this is true)	Quadrant 2 Temperatures will continue to rise into the future in agriculturally significant increments in the Southern Agricultural Region. (There is a general scientific consensus this is true) Climate models cannot predict declines in rainfall or changes in intensity of rainfall events or increases in evaporation rates in the Southern Agricultural Region to levels of accuracy required to predict detailed, location-specific effects upon cropping and pastoral activities. (Global climate models are as yet not sufficiently accurate at prediction)
Facts that are not objectively known to, or are not the ruling consensus within, the wider scientific community	Quadrant 3 Some scientists have (largely unintentional) biases which lead them to over-claim the relevance or accuracy of their climate predictions	Quadrant 4 Tipping point phenomena inherent in climate systems incident on a particular region will cause the incremental predictions of Global climate models to be inaccurate in apparently random directions and magnitudes

For extension planning, an important initial step is to assess, within the limitations of cost and methodological difficulties, the range of beliefs that exist in the Southern Agricultural Region about some of the important knowns and unknowns concerning climate change. The next challenge is then to map these beliefs within the appropriate quadrants, such that the number of entries in each quadrant reflects the frequency with which particular beliefs are present. If across a range of pertinent issues we find the frequency of entries in the first quadrant is large, relative to the second, we can then conclude that the local community knows nearly as much as does the scientific community. If not, then we need extension processes to inform the local community, and move the beliefs into the top left-hand side (quadrant 1).

When we know the relative frequencies at which beliefs of the local community fall within each quadrant, we can then establish which issues require research, and which, extension, or a balance of the two.

With climate change, as for many public issues, a tension exits between "scientific knowledge" as commonly derived and "actionable knowledge". On the one hand, scientists usually require very high levels of certainty obtained through research, observation or experimentation before they will accept a given proposition. In addition, scientists usually require that a given result is plausible in the light of currently accepted paradigms about the phenomenon under investigation. On the other hand, many practical people, whether in business or community affairs, decide to act well before this point. Their view is that, if we waited until every reasonable proposition were sufficiently tested as to be beyond scientific doubt, many opportunities, either for gain or avoiding disaster, would be missed. Given this, the community should have a workable understanding of just what, at a scientific level, we *do* know about climate change, and what we *do not*. What the scientific community generally regards as "known" derives from stringent evidence or empirical (Type 1) tests upon propositions about climate change. (Type 1 error is the incorrect acceptance of a false hypothesis: Type 2 error is the incorrect rejection of a true hypothesis.) However, with climate change, the cost of Type 2 error may overwhelm that of Type 1. In such a case, perhaps we should respond before all the settled evidence is available.

What are valid goals for extension in this context? The hypothetical example depicted in Table 3 represents the position, before an extension process takes place, of community understandings about climate change. The dots (•••) in each quadrant represent the relative frequencies of understandings about a range of propositions. Table 4 represents the situation after the extension process has occurred successfully. By educating members of the community or subgroups within it, the frequency of mistakes and occurrence of ignorance would be reduced. Fewer responses that are inappropriate and fewer misallocations of resources will occur, because the prevalence of false beliefs is less.

Table 3. Establishing extension goals – the "before"

	Accurately perceived knowledge	Inaccurately perceived knowledge
Facts that are objectively known	Proper knowledge •••	Mistakes, False notions ••••••••••••••••••••••
Facts that are objectively not known	Wisdom •••	Blind ignorance •••••••••••••

Table 4. Achievement of extension goals – the "after"

	Accurately perceived knowledge	Inaccurately perceived knowledge
Facts that are objectively known	Proper knowledge ••••••••••••••••••	Mistakes, False notions •••
Facts that are objectively not known	Wisdom •••••••••••••	Blind ignorance •••

In the table, the dots (•••) in each quadrant represent the relative frequencies of the types of understanding about a range of propositions, after an extension process.

In the table, the dots (•••) in each quadrant represent the relative frequencies of the types of understanding about a range of propositions, prior to an extension process. The shifting of these beliefs is therefore a legitimate objective of the extension process. This contrasts with the more typical objective of the adoption of a particular new practice. Perhaps having the shifting of beliefs as an objective may be criticised as "soft". However, if successfully achieved, the community or subgroup within it will avoid adopting inappropriate or mistaken practices. The outcomes, which follow from these, would otherwise frequently be expensive. The links between shifts in beliefs and the reduction of such outcomes are generally hard to measure. They are, however, very important in economic terms.

An example from the region seems pertinent. If:

- it can be accepted as an objectively known fact that the climate in the wine grape growing regions of Mount Barker is likely within the next thirty years or so to increase by between 1^o and 1.5^o Centigrade; and
- vignerons accurately perceive this as true;

they may act to ameliorate the effect upon their incomes. One rational strategy would then be to reduce their reliance on white grapes and plant varieties of red grapes that produce better fruit for wine making than white varieties at those enhanced temperatures. A relatively well-known relationship exists for each variety between mean ambient temperature during ripening and the relative preponderance of grape characteristics that are optimal for wine-making. Non-transient shifts in these temperatures suggest changes in the varieties grown in a given locale (Ward G & Beard D, 2008). A planting programme to change varieties would take some time and resources to implement, even with grafting. The situation may be set out in Table 5, as follows, recognising that the table does not reflect all the possible options or nuances of views. Note that we have entered beliefs about more than one proposition in the table.

Table 5. An Example in the region: vignerons

	Knowledge about temperature increase accurately perceived by the Mount Barker Vignerons	Knowledge about temperature increase inaccurately perceived by the Mount Barker Vignerons
Wider Scientific Community accepts as fact that Mt Barker temperature will increase by from 1° to 1.5° C by 2040	Example: The belief that Mt Barker is likely to warm by from 1° to 1.5° C by 2040. Action: Manipulate canopies Plant red grapes	Example: Sceptic: the belief that Mt Barker is not likely to warm appreciably by 2030: "this is alarmist nonsense". Example: Alarmist: the belief that Mt Barker is likely to warm by from 4° to 5° C by 2040. Actions: Sceptic: do nothing Alarmist: leave industry
Wider Scientific Community does not know whether the Mt Barker temperature will increase by as much as 1° to 1.5° C by 2040	Example: The belief that climate researchers should investigate what extent of temperature change is likely in the Mount Barker vicinity. Action: Either undertake, or lobby strongly for, local climate research	Example: Sceptic: the belief that it is a media beat-up Example: Alarmist: the belief that Mt Barker is likely to warm by from 4° to 5° C by 2030- "we will all be ruined". Action: Sceptic: do nothing Alarmist: leave industry

The vignerons' choice of alternative actions will depend upon both the level of their scientific knowledge and the level of accuracy of their perceptions. The choices are sixfold:

1. manipulate canopies to alter effective incident temperatures
2. plant an alternative variety of grapes (e.g., red)
3. perform or lobby strongly for local climate research
4. do nothing
5. move south to a cooler location
6. leave the industry.

Table 5 places most of these actions within the appropriate quadrants. Each action would have a range of outcomes, depending upon whether the vigneron accurately perceived the fact situation. In each case, however, by far the harsher outcomes arise where there is dissonance between fact and perception. Appropriate actions in the proposed fact situations may often be a mixture of adaptive strategies and of further investigations at the local level.

Attitudinal survey in the Southern Agricultural Region.

The South Coast NRM Inc. ("SCNRM") has been engaged on a study about how climate change is likely to affect its region. It conducted a series of community consultations across a number of locations within its study area. The SCNRM held these consultations at each of the following locations: Denmark, Esperance, Jerramungup, Kojonup, Mount Barker and Ravensthorpe. Furthermore, at each of the meetings that the SCNRM held, attendees were asked to complete a short questionnaire.

Each respondent categorised him or herself as principally either: a consultant, a farmer, a local government officer or councillor, a researcher, a member of the public, and other (together with an explanation). In coding the cases where the respondent had ticked more than one category, the author gave precedence to the occupational description over a more general category.

The aim of the questionnaire was to reveal attitudes towards three aspects, or dimensions, of climate change:

1. whether climate change, particularly of anthropogenic nature, is occurring;
2. the extent to which individuals should respond to climate change; and
3. how the respondent felt towards the science of climate change and the scientists involved with promulgating its messages.

The questionnaires comprised one page, employed a 5-point semantic scale and were easy to complete without too much effort. Altogether, the process delivered 50 useable responses.

Related questions were grouped to probe each of the above dimensions. All of these had been field tested in the research by Evans (2009). Behind each was envisaged a single linear dimension for the response. In the first case, this ranged between on the one extreme, a climate change sceptic, to on the other, a convinced proselytizer concerning climate change. For the second case, the dimension ranged between the views that no response was required, to full acceptance of individual responsibility for responding. For the third, the dimension ranged between the belief that science and scientists were self-serving and unreliable to the full acceptance of their role. All probed the extent of shift from Quadrant 2 to 1 in Table 2.

The respondents' responses over several related questions were combined additively to form indices of the following three separate attitudinal dimensions:

- The occurrence of climate change
- How we should respond
- Whether science will help solve climate change.

Results

Short titles for the attitudinal dimensions are helpful, respectively: occurrence, response, and science solution. The scales for each index gave values ranging between 1 and 5 as the extreme values, consistent with the scales of the original questions. Table 6 indicates that these indices correlate one with each other, and at high levels of significance (1% level, see Table 7). The science solution dimension is running in the opposite direction to the others: respondents, who score highly upon the other dimensions of attitude, will tend to have a low score on science solution, and vice versa. This makes sense when one considers the specific questions that make up the index.

Table 6. Correlation coefficients

	Occurrence	Response
Occurrence		
Response	0.592	
Science	-0.655	-0.415

Table 7. Significance of coefficients

	Occurrence	Response
Occurrence		
Response	p<0.001	
Science	p<0.001	p=0.003

The analysis then examined the effect on attitudes of self-reported category of the respondent, using the technique known as the analysis of variance ("ANOVA"). Table 8 shows the mean responses for occurrence by category of respondent (using short titles) and their significance revealed by the use of analysis of variance.

Table 8. Attitudes to climate change by category of respondent

	Farmer	Local Government	Member of Community	Other	Total	Significance ANOVA
Number of Respondents	17	10	12	11	50	
Occurrence	3.941	3.867	4.611	4.303	4.17	P=0.047
Response	3.691	3.550	4.146	3.841	3.81	P=0.095
Science Solution	3.478	3.275	2.604	3.000	3.12	P<0.001

When interpreting the results, the reader is reminded that that the scales are linear and scaled to be from 1 to 5. The analysis of variance appeared to show that the differences observed between categories of respondent in their attitudes towards occurrence are unlikely to arise from chance alone (p=0.047), reasonably unlikely in their attitudes towards response (p=0.095), and very unlikely in their attitudes towards science solution (p<0.001). In other words, a relationship between category of respondent and their attitudes to each of occurrence, response, and science solution probably does exist.

The analysis then computed the Least Significant Differences ("LSDs") between each of the categories for each attitudinal dimension. There being four categories, there are six pairs. This showed that for occurrence there was, at the 5% level, a significant difference between the following pair-wise comparisons of categories:

- member : farmer
- member : local government

It also showed that for response there was, at the 5% level, a significant difference between the following pair-wise comparisons of categories:

- member : farmer
- member : local government

Finally, it also showed that for science solution there was, at the 5% level, a significant difference between the following pair-wise comparisons of categories:

- member : farmer
- member : local government
- member : other
- other : farmer

The second analysis examined the effect on attitudes of the location of the respondent. Table 9 shows the mean responses by location of respondent and the statistical significance achieved. The analysis of variance showed that the differences observed between locations of respondent in their attitudes towards occurrence are very unlikely to arise from chance alone (p=0.002), may possibly arise through chance in the case of their attitudes towards response (p=0.222), and are very unlikely insofar as their attitudes towards science solution (p<0.001) are concerned. In other words, a relationship between location of respondent and their attitudes to each of occurrence and science solution probably exists, but the evidence shows this is no so for response, using this criterion.

Table 9. Attitudes to climate change by location of respondent

	Denmark	Esperance	Kojonup	Mt Barker	Ravensthorpe Jerramungup	Total	Significance ANOVA
Number of Respondents	13	7	7	15	8	50	
Occurrence	4.59	4.67	4.24	3.64	3.96	4.17	P=0.002
Response	3.87	4.07	4.07	3.55	3.72	3.81	P=0.222
Science Solution	2.83	2.57	3.45	3.33	3.41	3.12	P<0.001

The analysis then computed the Least Significant Differences between each of the locations for each attitudinal dimension. There being five locations, there are ten combinations for pair-wise comparison. For the dimension of occurrence, the relevant LSDs showed that there was, at the 5% level, a significant difference between the following pairs:

- Mount Barker : Denmark
- Mount Barker : Esperance
- Mount Barker : Kojonup
- Denmark : Ravensthorpe/Jerramungup
- Esperance : Ravensthorpe/Jerramungup.

For the dimension of response, the relevant LSDs showed that there was, at the 5% level, no significant difference between each of all possible pair-wise comparisons of locations.

For the dimension of science solution, the relevant LSDs showed that there was, at the 5% level, a significant difference between each of all possible pair-wise comparisons of locations, except for the following pairs:

- Denmark : Esperance
- Mount Barker : Ravensthorpe/Jerramungup
- Kojonup : Mount Barker
- Kojonup : Ravensthorpe/Jerramungup.

The analysis shows that, when examining the attitudinal responses of any given category, the location of the respondent confounds any full or complete explanation. Both are having an apparent influence, although it is plausible that category of respondent is the stronger influence. A set of two-way tables (Tables 10, 11 & 12 below) demonstrates the less than proportionate distribution of members of a category across location and *vice versa*.

Table 10 implies that the Mount Barker and Ravensthorpe and Jerramungup farmers tended to be somewhat more sceptical towards the occurrence of climate change. Denmark & Esperance exhibited reasonable levels of belief across all categories.

Table 10. Occurrence: attitudes by category and location of respondent concerning whether climate change is occurring

	Denmark	Esperance	Kojonup	Mount Barker	Ravensthorpe Jerramungup	Number	Mean
Farmer	4.17	-	4.11	3.73	3.83	17	3.94
Local Government	5.00	5.00	-	3.38	-	10	3.87
Member of Community	4.54	4.75	-	-	-	12	4.61
Other	5.00	4.33	5.00	4.11	4.08	11	4.30
Number of Respondents	13	7	7	15	8	50	
Mean	4.59	4.67	4.24	3.64	3.96		

Table 11, indicates that the Denmark, Mount Barker, Ravensthorpe and Jerramungup farmers tended to be somewhat more dubious about the need to respond climate change.

Table 11. Response: Attitudes by category and location of respondent about the need to respond to climate change

	Denmark	Esperance	Kojonup	Mount Barker	Ravensthorpe Jerramungup	Number	Mean
Farmer	3.38	-	4.00	3.45	3.69	17	3.69
Local Government	3.88	3.25	-	3.50	-	10	3.55
Member of Community	4.03	4.38	-	-	-	12	4.15
Other	3.5	3.88	4.50	3.83	3.75	11	3.84
Number of Respondents	13	7	7	15	8	50	
Mean	3.87	4.07	4.07	3.55	3.72		

In Table12, a low score out of five indicates the respondent's strong belief in science and scientists in arriving at solutions to climate change. Members of the community and local government officers from Denmark and Esperance displayed stronger belief in science than those from Mount Barker, Kojonup and Ravensthorpe/Jerramungup.

The above results indicate that the respondents' location and category were confounding each other in explaining the underlying relationships. As attendance at the community consultations was voluntary and the total numbers answering the questionnaire were limited, the option of a stratified random sample was not available. Rather, this analysis attempts to place a straightforward and reasonable explanation of how and why the respondents varied in their views.

Table 12. Science Solution: attitudes by category and location of respondent about whether science & scientists are the solution to climate change

	Denmark	Esperance	Kojonup	Mount Barker	Ravensthorpe Jerramungup	Number	Mean
Farmer	3.75	-	3.46	3.30	3.59	17	3.48
Local Government	2.75	2.75	-	3.50	-	10	3.28
Member of Community	2.64	2.53	-	-	-	12	2.60
Other	2.63	2.56	3.38	3.00	3.22	11	3.00
Number of Respondents	13	7	7	15	8	50	
Mean	2.83	2.57	3.45	3.33	3.41		

Interpretation of Results

The analysis examined three separate attitudinal dimensions:

- The occurrence of climate change
- How we should respond
- Whether science and scientists will help solve climate change.

The questions in the survey addressed quadrants 1 and 2 in Table 2: the questionnaire focussed upon the potential shifts from 2 to 1. A future analysis would be needed to consider quadrants 3 and 4.

Occurrence

Local government councillors and officials displayed more scepticism towards climate change than farmers, who in turn were much more sceptical than were members of the community. The latter were inclined to accept much of the climate change message. However, the mean scores of all categories were still above the mid (or indifference) point of the five-point scale, showing some degree of belief in climate change.

Response

Members of the community were more likely than other categories to accept that appropriate responses were necessary. The least accepting of this need to respond were local government councillors and officials. Again, however, the mean scores were beyond the indifference point of the five-point scale, showing some acceptance of the need to respond.

Science Solutions

Members of the community and the category “other” were more likely than other categories to have strong positive beliefs in science and the scientists who promulgate it. By contrast, local government officers and some farmers seemed to display considerable scepticism and uncertainty about the value of science and scientists in arriving at solutions to climate change. Their mean scores tended to be above the mid-way point of the five-point scale (which ran in the opposite direction to the above dimensions), showing at least mild scepticism.

Conclusions from the Survey

Whilst the relatively small numbers in the sample do not support strong conclusions, the results are consistent with the recent work performed (Evans and Storer, 2009) concerning attitudes towards climate change and adaptation. The results also showed what appear to be significant differences by location in attitudes towards climate change.

The well-established and important component of the science of climate change (the body of “known knowns”) seems to have been inadequately communicated to the target groups of farmers (and presumably their advisers) and officers and councillors of local government. These target groups appear to find it difficult to discern which pieces of information, of those that emerge in the media and farm press, belong to the “known knowns” or are just speculation (“known unknowns”).

Conclusions

The research described in this paper sheds some light on prevailing attitudes within stakeholders within the Southern Agricultural Region. It would be valuable to continue to conduct attitudinal "snapshots" of the farming and farm advisory communities. Through this, we should be able to monitor and enhance the success of extension campaigns.

The concepts set out in this paper will guide those engaged in extension to facilitate benign adaptations in the agricultural community. This should lead to better resource allocation. Undertaking scientifically based extension on the "known knowns" and the "known unknowns" of climate change to regional agricultural and community decision makers should be a matter of priority. The extension agents should carefully design these campaigns, with clarity between what is, and is not, known.

Acknowledgements

David Beard, Eliza Dowling and Fiona Evans, of the Department of Agriculture & Food, WA, Chris Evans and Christine Storer of Curtin University and Melanie Price of Coffey Environments.

References

Blake J, Beard D and Gray D, 2009, Agribusiness Forum, Department of Agriculture and Food, Albany, April, 2009 (Proceedings Forthcoming)

Evans C and Storer C, 2009 Rural Communities Attitudes & Opinions to Climate Change, Paper given at Climate 21: Understanding Climate Change and how to manage it, Department of Agriculture and Food, Burswood, March 27, 2009 (Proceedings Forthcoming)

Luft J and Ingham H, 1955, The Johari window, a graphic model of interpersonal awareness, Proceedings of the western training laboratory in group development. Los Angeles: UCLA

Ward G and Beard D, 2009, Planning and Managing Vineyards in a Variable and Changing Climate, Paper given at Climate 21: Understanding Climate Change and how to manage it, Department of Agriculture and Food, Burswood, March 27, 2009 (Proceedings Forthcoming)