Communicating Climate Change Consequences

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EXTENDED ABSTRACT

Climate change has been identified by UK and Scottish sustainable development strategies as a key threat to rural communities. Yet for many land management stakeholders the issues of climate change and sustainable development are swamped by other policy and market changes with more immediate consequences. There is, however, the need for effective engagement between researchers and stakeholders if adequate adaptation and mitigation measures are to be enacted.

For the land use policy domain there remain significant gaps between the claims of the research community, the rhetoric of the policy community and the use of research based outcomes by stakeholders and actors These gaps reflect a naive modernist/positivist conceptualisation of the capabilities of science combined with an information deficit based explanation for actor behaviour. This perspective places undue weight on improving the quality of science or technical innovation rather than facing up to the problems of the *process* of communicating research outcomes and the inevitable intrusion of politics into any multi-stakeholder decision making.

Drawing on an analysis of the nature of the science-stakeholder gap the authors present the science-stakeholder engagement process for a research project concerned with communicating the consequences of climate change for farming systems in Scotland. This engagement strategy was based on the use of NGO facilitated workshops where stakeholders deliberated on alternative adaptive strategies using the outputs from regional climate models, simulation modelling and empirical analysis.

A framework of climatic change indicators and presentation methods were developed with NGO stakeholders. The initial testing presented a wide range of both meteorological summaries and agro-meteorological metrics. For the latter some were simple single-variable derived metrics – date based (e.g. growing season starts); count based (e.g. frost days); accumulations (e.g. growing day degrees) and indices (e.g. seasonality). Further multi-variable metrics were included (e.g. length of field capacity). These latter were included to test reaction to more complex metrics and in particular to model-based metrics. It was anticipated that while it is possible to communicate the nature of climate change through the use of summary meteorological statistics it is not easy (or perhaps even possible) for stakeholders and actors to assess the consequences of such change since the metrics do not relate to information used in their operational decision making. A wide range of presentational formats were also tested so that preferences for indicators were not confounded by inadequate representations of the data. The deliberative processes with stakeholders and actors were intended to identify and refine the metrics that could serve as decision supporting indicators.

Four pilot and four subsequent workshops were conducted with NGO groups representing a range of agricultural and environmental interests. The numbers of stakeholders attending and the quality of participation achieved indicated that there is a significant desire for information on climate change and that the science-stakeholder gap can be crossed with sufficient investment in the design, implementation and evaluation of processes.

As expected using the agro-meteorological metrics framework with stakeholders was more effective in communicating the implications of the climate change scenarios than meteorological summaries alone. The agro-meteorological metrics were particularly effective in encouraging stakeholders to consider both impacts and adaptation. The stakeholders were willing and able to engage with the more complex metrics where they could see their potential benefits as decision making indicators. In particular there was no problem in the use of model based indicators where the credibility of the model could be established, first by an adequate explanation of what the model did (if not the particular details of how) and second that the model performed well for historical cases. The outputs from these more complex analyses also stimulated the stakeholders to question further the nature of the changes in patterns of weather and thus close the circle from impacts and adaptations to the climate drivers and their causes.

1. INTRODUCTION

The interactions between climate change and land use are increasingly seen as a key issue for policy makers across the EU, within individual member states and for regional governments; each recognising three interlinked aspects: mitigation (reducing the net release of green house gasses), impacts and adaptation (HM Government, 2006). While mitigation is the most immediately pressing issue, there is political recognition that the form and magnitude of likely impacts needs to be anticipated and support provided for land managers and others to adapt (Scottish Executive, 2006).

One of the problems faced by policy makers, however, is that climate change has yet to become a high priority issue for land managers. Adaptation to climate change is overshadowed by the direct and immediate financial consequences of ongoing changes to the way agriculture and other land uses activities are supported in the EU (through direct payments, other incentives and via export subsidies and tariff barriers). The outcomes of climate change research are also strongly contested in the definitions of future emissions scenarios and the forecasting of their consequences by global and regional climate models (GCMs and RCMs). Finally "marginal warming" when considered in isolation can even be seen as parochially desirable!

Against this background, this paper presents the outcomes of a pilot scheme to improve the engagement between research, policy and practitioner communities on the climate change issue. This project used a flexible, model-based framework of climate change indicators as the focus for deliberation with stakeholders on the issues of impact and adaptation facing agriculture and LUCF.

2. RELATED WORK

2.1. Communicating Complex Contested Issues

The issues of effectively communicating the outcomes of research with a view to influencing the actions of a range of stakeholders is one that continues to tax both policy maker and research communities (Scottish Executive, 2005). The *deficit model's* premise that more or even better quality information *per se* results in better decisions or altered behaviours have been shown to be false both in industrial and agricultural decision support (McCown, 2002b; McCown et al., 2005). Amongst the crucial factors identified by McCown was that the outcomes of research need to be tailored to fit within the social processes of decision making, taking particular roles that do not detract from the agency of the decision maker. For most agri-environmental decisions, however, the situation is further complicated since there are multiple stakeholders with direct or indirect interests and influence. With multiple stakeholders involved the subjective aspects of the selection and assessment of evidence (i.e. their preferences in setting standards or goals against which an outcome is judged) may be as important as any objective measurement of particular phenomena.

The limitations of research in providing irrefutable evidence and the inevitability of contestation are well known (see for example French and Geldermann's (2005) typology of issues – known, knowable, complex and chaotic). Furthermore in a milieu with conflicting interests researchers cannot simply deliver discrete packages of evidence but need to provide support for inclusive processes that supports deliberation (reasoned-based debate) on particular issues (Dryzek, 2000). Conversely an uncritical positivist modernism is particularly unhelpful since it creates a credibility gap between researchers' claims and the realised utility of their research since they frequently ignore complex political issues such as equity and social justice. There is increasing evidence for the success of more plural approaches to organising expert input into policy and for their acceptance by policy makers (Stilgoe et al., 2006; Verweij and Thompson, 2006). In such processes there is perhaps a key role for modelling based research in making explicit trade-offs between outcomes, or stakeholders (Matthews et al., 2006a).

However the interactions between individual researchers, stakeholders and decision makers are organised, the key factor in the researcher being influential is credibility (McCown, 2002a). Credibility is underpinned by the transparency of the methods used and by adequate auditing and quality assurance of models and data (Scholten and Kassahun, 2006). While necessary such formal processes of validation and peer review are not on their own sufficient to ensure credibility. To be credible the outcomes of research must not, where they are comparable, contradict existing stakeholder knowledge of systems gained through experiential learning (Carberry et al., 2002). For modelling, transparency is often used synonymously with simplicity. This would, however, be to misunderstand what is desired by stakeholders. They primarily desire the openness of assumptions (what is left out as well as what put in), and then a *functional* balance of realism, precision, generality and tractability (REF).

A further factor that complicates the communication of research outcomes is the uncertainty inherent in all forecasts. Two difficulties arise. The first is in overcoming the idea that all uncertainty is the result of errors or mistakes within the research process rather than an inevitable outcome of bounded knowledge, the scenarios chosen, model parameterisation, model structure, how the system is represented and practical limits on the availability of data (Rauschmayer and Wittmer, 2006). The second and more fundamental issue is that, however good the research is, it is still only the currently best available answer, and may be a partial answer where systems are complex. For climate change research the conundrum is therefore how best to manage the expectations of stakeholders? Can researchers communicate uncertainty such that stakeholders faced when with decisions have an appropriate degree of both urgency and confidence? This is particularly problematic when vested interests can exploit uncertainty to sensationalise an issue or to preserve the *status quo*.

3. MATERIALS AND METHODS

3.1. Objectives

Against this background, the aim of the research was to credibly communicate the outcomes of climate change research to communities of interest concerned with land use. The intention was to develop a flexible and customisable framework of agro-meteorological indicators (meaningful to stakeholder management decisions) and to use this to characterise both current observations of climate and future scenarios. The information provided by the framework would be used as a boundary object (Jakku and Thorburn, 2004) to facilitate processes of deliberation on impact and adaptation between researchers and stakeholders.

Four specific questions were addressed:
1. Are agro-meteorological metrics more useful in communicating climate change than simple meteorological summaries?
2. Which metrics are usefuls as indicators?
3. How complex can indicators be before they are no longer interpretable by stakeholders?
4. Are model based indicators inherently less credible?

3.2. Climate and Climate Change Data

The range of possible metrics was constrained by restricting the analysis either to climatic variables identified, for future scenarios, as most reliable (Hulme et al., 2002) or those identified as key drivers of agricultural processes (Rivington et al., 2006). Data for observed climate were provided by the British Atmospheric Data Centre (BADC). The observed variables were daily precipitation (P in mm), maximum (T_{max}) and minimum (T_{min}) air temperature (ºC) and total downward surface shortwave flux (direct and diffuse solar radiation, So , MJ m2 day-1). The data used for the case studies are for the period 1961-90 for 5 meteorological stations in Scotland. The five sites were chosen for their proximity to the workshop venues and since they had long term (n>20 consecutive years) runs of data. The BADC also provided hindcast data (1961-90) and future data (2071-2100) from the HADRM3 RCM configured for the Special Report on Emissions Scenarios (SRES) A2c (medium-high, run c) (UKCIP02 2002).

Data from the appropriate RCM grid cell (50x50km) are downscaled to allow direct comparison with site-specific observations. The downscaling factors are derived using empirical methods that compare observed and hindcast data. The downscaling factors attempt to eliminate differences such as the systematic bias in the So data, seasonal bias in the T_{min} and T_{max} data and the size distribution of rainfall events. These methods are currently being peer reviewed (Rivington et al., 2007)

3.3. Metrics

The meteorological summaries using simple descriptive statistics were calculated for the 30 year climate normal period for both observed and future scenario data and presented as monthly summaries (e.g. for temperature and rainfall values) and time series with yearly monthly and daily temporal resolutions.

The agro-meteorological metrics implemented are set out in Table 1 (at end of paper). Metrics were generated for the 5 sites using observed data and the downscaled HadRM3-A2c cell data. There are four types: *date* where the first or last incidence of a phenomenon occurs; *count* recording the number of days on which a criterion are met; the *accumulation* of a variable above or below a threshold value and finally *indices* where an index value is calculated and compared against a standard. Since the intention was not to test particularly new or innovative metrics these metrics were drawn from both older agro-climatic sources (Francis, 1981) and more recent sources with a climate change focus (Barnett et al., 2006). Most of the metrics in Table 1 relate to a single variable but to illustrate interactions between variables metrics based on soil water balance were implemented.

3.4. Testing the utility of the framework with stakeholders

The testing of the framework's outputs with stakeholders was conducted either through group-interviews or in focus groups. The individuals chosen were either existing contacts from agencies and NGO's with an interest in climate change or were recommended as participants by the existing contacts. The organisations involved were National Farmers Union (Scotland), Soil Association and Farming and Wildlife Advisory Group. For both group interviews and focus groups the stakeholders were provided with example outputs and supporting explanatory materials before the meeting. Within the interview or focus group the initial phase was a discussion of the stakeholders' interest in climate change. This was followed by either a group-interview or focus group discussion of the utility of metrics and how best to communicate them. Specific issues addressed were the number and form of indicators, preferences for presentation. The discussion was supported using the case-study examples as appropriate. The outcome of the interviews and focus groups was a prioritised list of agro-meteorological indicators (including both those exemplar indicators developed by the authors and those suggested by stakeholders).

4. RESULTS

4.1. Utility of Meteorological Summaries

The monthly summaries were useful in starting the process of discussing climate change and agriculture since the graphs were seen as easy to comprehend and encouraged participants to ask questions that could only be answered by other datasets or formulations of the meteorological data.

The usefulness of the time series was greatest where there were the biggest differences between current and future. Despite the publicity of climate change there still seems to be a view that weather changes but climate stays the same (despite stakeholders awareness of anecdotal evidence of consistent changes at a decadal scale). Information that confirms something stays the same is less valued than indications of change yet still needs to be communicated effectively. The other statistical summaries included in the pilot phase were seen as too complex.

4.2. Utility of Agro-meteorological Metrics

Assessments of the utility of the metrics as indicators for decision making were made as part of the focus group discussions, and often served as a useful way of coming to a definite conclusion from broader deliberation and questioning. Their usefulness was assessed on a simple four point scale to allow for some interpretation of degree of utility and the results for each of the metrics are reported in Table 1 with votes by each focus group shown by a ☑.

From Table 1 it can be seen from the scoring for the *very* category, that the metrics related to dates were seen as most useful as indicators. This is particularly evident for the end-of- and return-to field capacity since this is a fundamental constraint on access to land both for machinery and livestock. There was interest in the particular pattern of change (similar dates for access in the spring but with longer access in the autumn).

There was also interest in the start and end of the growing season but concerns with the formulation of the metric. The start of field operations metric (Tsum200) was seen to overcome these formulation problems and to produce less erratic predictions and could be used in place of the start of the growing season indicator. There was, however, no equivalent metric for end of growing season. Length of growing season was seen as potentially important for horticulture (for how many crops could be scheduled) and grassland systems (for the time stock could be outside on grass, dependent of course on access). Also of utility was the growing day degrees metric – but this needed to be related to specific crop requirements (phenological thresholds) and to have probabilities of achieving these values to allow the assessment or risk. Maps of the growing day degrees were also seen as desirable.

The frost related metrics were for farming systems in general seen as marginally useful. For particular systems, outdoor horticulture, soft and orchard fruits, late frosts of either variety (grass or air) were a real risk factor that needed to be managed for. The decreasing risk of frost under the predicted climate change scenario was seen by some as a potential opportunity but also as a problem with increased incidence of pests and disease likely (particularly by those concerned with organic agriculture). At the other end of the temperature spectrum it was recognised that an indicator for plant heat stress was seen as very desirable and that a model-based indicator of plant stress would be acceptable.

The soil water balance metrics were in general highly rated by the stakeholders despite their greater complexity. The ability to customise the soil used as part of the model (depth, texture and organic matter content) was seen as valuable, and the post-pilot presentations used a shallower soil (50cm rather than 100cm), that was more consistent with the stakeholders experience. The potential for erosion (both through water and wind) was raised particularly in relation to bare soils in dryer autumns. This highlighted the potential for including further metrics built around simple, customisable models of erosion processes.

None of the water (other than minimum soil water), waves or index-based metrics was highly rated as indicators, though several attendees found them interesting (this is reflected in the predominance of marginal ratings). These metrics did not relate to real management decisions and thus failed to be useful as indicators.

5. DISCUSSION

The case-study based analysis was effective in ensuring that the stakeholders were able to engage with the research data being presented. The use of a range of cases in the presentations was seen as helpful since it provided both a local case to compare with experience and others with which to assess the consistency of changes. The expertise of stakeholders in taking the data presented and relating it to their personal circumstances was evident. This reinforced the authors' previous positive experience (Matthews et al., 2006b) of the potential for effective dialogue and deliberation using model based outputs, if the communication process is well designed and implemented. Part of that effective management process was in facilitating initial discussions based on a briefing paper that had set out the intentions of the meeting and some of the background to the research. This initial session, combined with the use of a roundtable format using workbooks or large format printouts was effective in establishing and maintaining the active participation of the attendees in contrast to a seminar format where results are presented to, rather than discussed with, attendees. Such a format is limited in the numbers that can be coped with. The authors experience, however is that the successful communication of complex, uncertain and potentially confronting ideas requires interactive and iterative processes, with considerable flexibility on the part of the researchers. Where it is necessary to achieve a wider dissemination of the messages then perhaps this can be achieved by conducting the in-depth and ongoing dialogues with key opinion formers, advisers and representatives and using their well developed networks of contacts to pass on and interpret the research outcomes. Through eliciting stakeholder preferences for the content and format of presentations it may also be possible to tailor some of the research outcomes for dissemination via the mass media but with the inevitable loss of credibility due to the one way flow of information and the compromises in presentation.

The use of several sites was also effective in emphasising the consistency of change, thereby avoiding the potential inference that projected changes were simply an artefact of the site chosen. The stakeholders were very keen to get into the detail of projected changes (magnitudes and significances), the nature of the modelling process that produces the data and particularly the uncertainties in estimates. There is an appetite for climate change research but the nature of the timescales and the uncertainty in the predictions can mean that other drivers such as policy change are the overwhelming concern of land managers since policy can be more directly influenced. The stakeholder audience is, however, perhaps becoming more receptive to research based assessments of the nature of possible changes. There is a growing recognition that, whatever the drivers, climate (rather than weather) is dynamic, the dynamic may have discernable trends and these will need to be managed for. There is demand for information on what changes, but paradoxically little desire for information confirming what may stay more or less the same under the new regime. This presents researchers with a quandary of which data sets show significant change? This is particularly difficult when significance depends not on statistical measures but on the interpretation within particular and often localised circumstances. In this situation it is inevitable that some redundant (from a stakeholder perspective) data gets presented.

The process was successful in eliciting suggestions of customisations both for the formulation of the metrics and how they were presented. In contrast with the authors previous processes which had a land use planning focus, however, it was not possible to elicit new experiential heuristics that could serve as the basis for additional metrics. Where the process was successful, was in eliciting recombinations of the proposed metrics to form composite indicators. In this regard the provision of many but simple metrics by the research team was seen as desirable. There was also the desire for more direct indicators where the metric is clearly linked to observable effects, rather than proxy indicators where there is more uncertainty in the linkage between the metric and the management decision. In further developments of the indicators we would intend to use simple erosion and plant stress models as indicators.

The nature of the analysis (with a small number of workshops) emphasises depth in terms of the quality of deliberation over the breadth that could have been achieved with a survey based approach. Yet it is unlikely the richness of communication and the social learning could have been achieved using large scale processes. This is not to say that the research could not have been enhanced by undertaking further studies with other groups in additional geographic areas or with different perspectives. The other main limitation of the analysis was in the availability of alternative RCM scenarios with hindcasts that would allow the use of the downscaling procedures. Access to daily weather variables for climate normal periods is essential for the meaningful calculation of agro-meteorological metrics.

6. CONCLUSIONS

The use of the agro-meteorological metrics framework with stakeholders was more effective in communicating the implications of the climate change scenarios than meteorological summaries alone. While the meteorological summaries were effective in highlighting the nature of the change the agro-meteorological metrics were a useful means of encouraging stakeholders to consider possible impacts on their land use systems and how they might adapt. Preferences were for metrics that would directly inform management decisions such as access periods, growing seasons and the potential for losses in yield or quality due to drought. The credibility of the indicator framework and the case study data was enhanced by the interactive process of explanation where the basis of the metrics could be debated and if necessary the metrics modified. Deliberately seeking stakeholder’s views on the utility of the framework was also a key to establishing cooperation between the research team and the stakeholder groups.

The stakeholders were willing and able to engage with the more complex metrics where they could see their potential benefits as decision making indicators. In particular there was no problem in the use of model based indicators where the credibility of the model could be established, first by an adequate explanation of what the model did (if not the particular details of how). The credibility of the model based indicators depended on their ability to replicate events within the experience of stakeholders. By presenting time series of the soil water balance metrics for example it was possible to identify particular iconic events in the historical dataset and to make comparisons with the future scenarios both in quantitative and qualitative terms. The outputs from these more complex analyses that integrate several weather variables also stimulated the stakeholders to question further the nature of the changes in patterns of weather and thus close the circle from impacts and adaptations to the climate drivers and their causes.

Table 1: Metrics within the climate change communication framework.

Type	Indicator	Utility			
		Very	Quite	Marginal	Not
Dates	Start Growing Season	☑☑	☑	☑	
	Start of Field Operations	☑☑	☑☑		
	End of Field Capacity	☑☑☑☑			☑
	Last Air Frost (Spring)	☑☑☑	☑	☑☑☑	
	Last Grass Frost (Spring)	☑☑	☑	☑☑☑	☑
	Date of Max SMD		☑		☑☑☑
	Wettest Week				☑☑☑☑
	First Grass Frost(Autumn)		☑☑	☑	☑☑
	First Air Frost (Autumn)		☑☑	☑	☑☑
	Return to Field Capacity	☑☑☑☑			
	End Growing Season	☑☑	☑	☑	
Day Cts	Air Frost			☑☑☑	☑
	Grass Frost		☑	☑☑	☑
	Grow Season Range		☑	☑☑☑	
	Grow Season Length	☑	☑☑☑	☑	
	Access Period Range	☑		☑☑☑	
	Access Period Length	☑	☑	☑☑	
	Dry		☑☑☑☑		
	Wet		☑☑☑☑		
	Plant Heat Stress	☑☑	☑	☑	
	Dry Soil Days	☑☑☑☑			
Ddy	Accumulated Frost	☑☑	☑	☑	☑
	Growing Degree Days		☑☑☑☑	☑	
	Heating Degree Days		☑	☑☑	☑
Wtr	Excess Winter Rainfall		☑	☑☑	☑
	Wettest Week - Amount		☑	☑☑	☑
	Min soil water	☑☑	☑	☑	
Waves	Heat Wave			☑☑☑	☑
	Cold Spell			☑☑☑☑	
	Dry Spell		☑	☑☑	☑
	Wet Spell			☑☑☑	☑
Ind	P intensity		☑	☑	☑☑
	P seasonality		☑☑		☑☑
	P heterogeneity				☑☑☑☑

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