Estimating adaptive capacity in Australian farming environments

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Abstract

Looking ahead, Australian agriculture is entering a period of unprecedented change as it responds to drivers such as: global warming; increasing competition for food, water and fuel resources; the ageing of the farming and scientific professions; and the purposeful realignment of farm management with environmental priorities. Tools are needed for planners and professionals—many of whom lack a multidisciplinary appreciation—to anticipate, predict and cope with the risks of this uncertain future. Of particular interest are the likely resilience of agroecosystems and the adaptive capacity of particular agricultural industries, zones and communities. This paper describes an exercise in mapping potential indicators of adaptive capacity on Australian farms. The deficiencies in this approach are discussed in relation to potential improvements. We conclude that both quantitative and qualitative tools are needed to assess the likely levels of adaptive capacity of agricultural activities, spatially and industrially.

Keywords

Drought, climate change, production risk, resilience

Introduction

The future for Australian agriculture is looking increasingly uncertain. Energy supplies are becoming scarcer and more expensive. Markets appear more volatile due to globalisation and the escalating demands of consumer groups. Climate change threatens to alter the amount and variability of rainfall, with less water for irrigation. Agricultural professionals (farmers, advisers, scientists) are getting older. These factors will expose agricultural sectors and regions to a range of threats and opportunities, which will require adaptations in land use and management that are perhaps beyond the present capacity of landowners to manage. Farm and agribusiness advisers are likely to be working in more complex social and economic environments and they will need to be aware of how their research and advice contributes to stakeholders' needs.

This paper considers adaptive capacity of management as a component of the resilience of agroecosystems. We use *resilience* in the conventional sense: the maximum amount of disturbance that a system (biological, ecological or agricultural) can experience and still return to the same equilibrium. We use *adaptive capacity* as a measure of ability—based on managers' capacity to learn and anticipate—to adjust to change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences of change. We report an attempt to identify information for estimating adaptive capacity in agriculture. Finally, we briefly discuss what can be done to increase adaptive capacity for a more resilient agriculture.

Drought, agroecosystem resilience and adaptive capacity

A recent paper (Nelson et al. 2007) notes that resilience emphasises preparation for surprises and system renewal in response to vulnerabilities that are inherent in any system. In agroecosystems, consequences of the trend towards specialisation in enterprises include higher adaptation to current conditions but a potential lessening of resilience compared with the built-in diversities and redundancies

of traditional systems. Because of this trade-off, the challenge is to identify acceptable levels of efficiency whilst maintaining an ability to respond when the systems are strongly challenged.

Consider the effect of drought. Since its beginnings in Australia, commercial agriculture has faced difficulties in managing drought. It has generally been the most severe and widespread climatic stress for Australian agriculture, although storm and flood damage can be more immediately devastating in some regions. Drought, which places existing agricultural systems under steadily increasing stress, has led to structural adjustments on farms and significant involvement by governments in the agricultural regions and industries. If the frequency of drought increases in the future, a number of resilience thresholds may be tested and the behaviour of agroecosystems may change. The process of managing droughts is strongly influenced by adaptive capacity factors, such as management skills/decisions, financial resources/strategies and the prices of inputs/products so that a range of outcomes is possible.

For example, in semi-arid Australia, fluctuations in rainfall combined with grazing and fire management can lead to changes in the relative growth of grass and woody plants (Folke et al. 2004). If a threshold in the balance of grassy and woody vegetation is crossed, a flip in the system may occur from the grassland to the woody weed state, putting further pressure on pastoralists. In some areas, the vegetation balance is traditionally managed by strategic burning or cycles of grazing and rest. If experienced people are lost from the system, the fall in adaptive capacity may be crucial for the semi-arid agroecosystems. The pathway back to a prior stable state may be difficult and prolonged. Similarly, on mixed farms in the Australian wheat-sheep belt, there are opportunities for experienced managers to cope with a drier climate by adjusting the ratio between cropping and livestock operations, by reducing or omitting some operations to save costs (for example, fertiliser applications, weed and disease sprays, seeding rates), and/or expanding the scale of operation. In the high rainfall zone livestock managers have coped with climate change primarily through adjusting stocking rates (sales and agistment), using conserved fodder or purchasing feedstuffs from elsewhere.

Estimating adaptive capacity

Any system will change over time, and how well it is adapted to its current environment will change with its context (Nelson et al. 2007). Adaptive capacity, which is considered more meaningful to analyse than adaptation *per se*, forms a central part of many of the studies of agroecosystems. Answering the question of 'What elements of adaptive capacity need strengthening now to promote effective adaptation to future stresses?' requires suitable information and tools. However, adaptive capacity is difficult to measure in practice. Approaches have come from a range of perspectives and disciplines—'risk-hazard' analyses for insurance, 'pressure and release' models for emergency management, 'vulnerability' studies for food security, 'sustainable livelihood' approaches for development studies—each having advantages and disadvantages. Different authors classify attributes in different ways (Table 1) but few have placed relative weightings on the attributes—Vincent (2007) is an exception.

Table 1. Elements of adaptive capacity

Element	National Adaptive Capacity Index (Vincent 2007)	ATEAM (Metzger et al. 2005)	Capital (Eakin and Lemos 2006)	Multi-scale assessment (O'Brien et al. 2004)
Economic well being	?, 20%	?	?	?
Demographic structure	?, 20%	?		?

Interconnectivity	?, 10%		?	?
Institutional well being	?, 40%	?	?	?
Natural resource dependence	?, 10%			?
Knowledge and literacy		?	?	?
Technology level and availability		?	?	?

There are concerns about measures of adaptive capacity, including:

• the underlying theory is not robust, with many indicators based on intuitive assumptions of the attributes underlying adaptive capacity;

• the accuracy with which any indicator measures the attribute;

• the strength of the relationship between indicator and attribute, i.e. does a change in the indicator relate to a similar change in the attribute;

• some indicators are best gained from local qualitative studies;

• matching the scale of adaptive capacity to that of the driver of change; and

• there is danger in conveying more precision than is warranted.

To illustrate some of these concerns we collate some data collected by the Australian Bureau of Statistics (Figure 1) that might relate to adaptive capacity. Presented at the Statistical Division level, these data provide a coarse spatial resolution over a consistent set of boundaries. Some but not all of the examples in Figure 1 show spatial differences in the elements. However, the real relationship between each element and adaptive capacity is unknown. There is a need for acceptable tools to gather and assess information on agroecosystem performance and resilience. Conway (1985) described the behaviour of agroecosystems using the properties of productivity, stability, sustainability and equitability. Although Conway's analysis is taught in the curricula of agricultural courses, it has never become a mainstream research tool, possibly due to difficulties with measuring the properties. An alternative classification of agroecosystem properties, one that is useful for undertaking a SWOT (strengths, weaknesses, opportunities, threats) analysis of agroecosystems, is one that employs the 'bottom line' imperatives of productivity, sustainability (incorporating stability), economic performance and social well-being. In our opinion, the analysis process is currently constrained by a lack of statistics on meaningful social indicators.

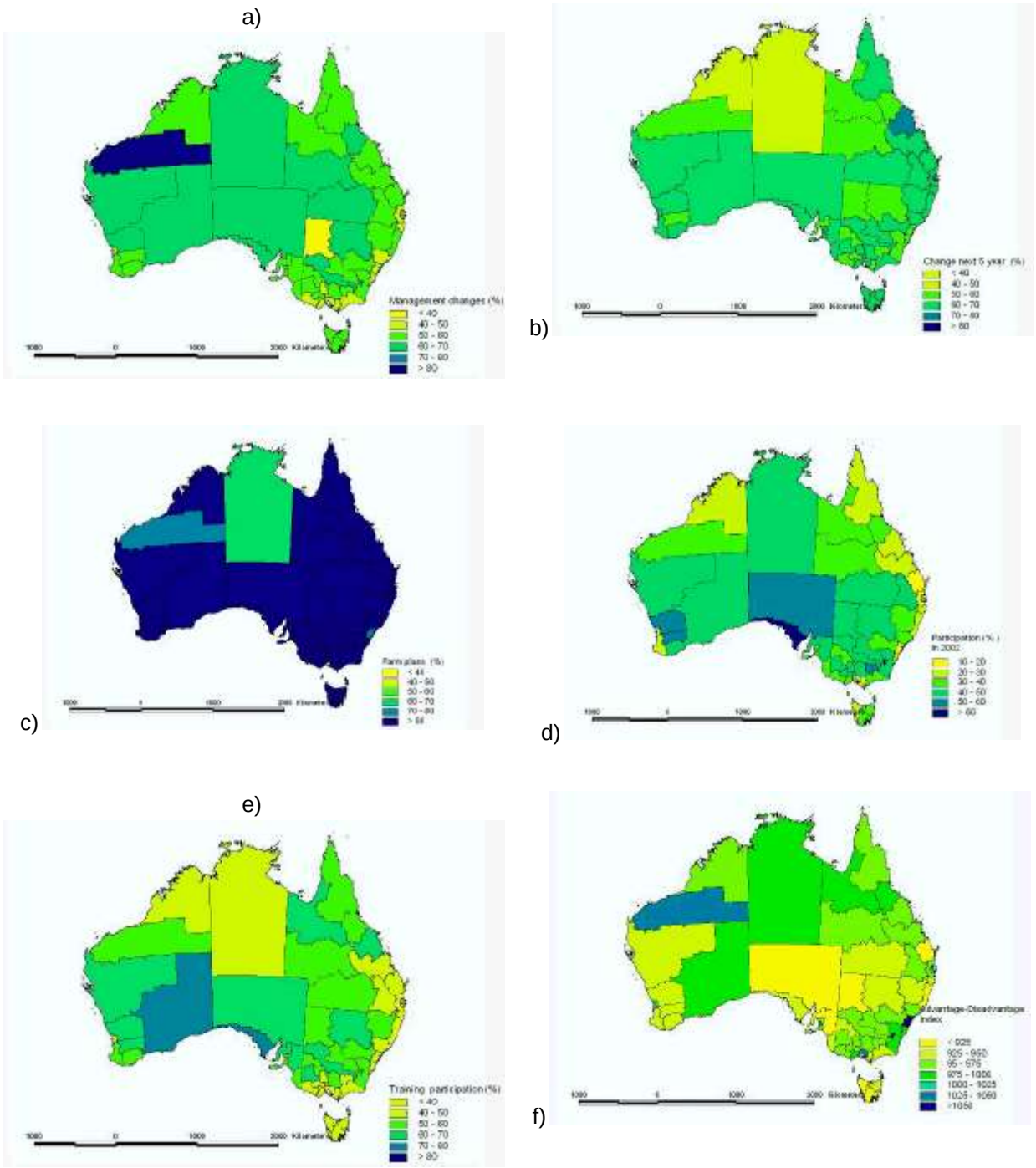

Figure 1. Some individual elements that could be correlated with or contribute to adaptive capacity: a) Farmers who have changed management practices during the 5 years before 2002 (%); b) Farmers who used computers or internet for business purposes during 2004-05 (%); c) Farms that have a whole-farm plan at 2002 (%); d) Farmers who participated in activities such as Landcare and Bushcare during 2001-02 (%); e) Farmers who undertook courses or learning activities during 2001-02 (%); and f) The advantage-disadvantage index for whole communities of ABS. Source of maps ABS Agstats series and SEIFA, shown at 2001 Statistical Division boundaries.

Discussion and Conclusions

A sufficiently resilient system should minimise the consequences of any disturbance and the time to recover from stress. We believe that, while the resilience of an agricultural system to a stressor is measurable, attempts to quantify precisely the adaptive capacity component will not be fruitful. Adaptive capacity is likely to have so many contributing factors as to be quantitatively unmanageable, particularly in deciding upon a weighting for each one and whether or not the factors interact. Some elements in Table 1, such as institutional well-being, are essentially subjective. However, adaptive capacity has conceptual utility and it can be handled qualitatively by way of a Conway (1985) analysis or a modification of this analysis. The particular value of the concept lies in grouping a range of factors for higher level discussion and priority setting, and so it has featured in studies on climate change, sustainable development and risk management.

There are components of adaptive capacity that require context-specific, location-specific analyses, actively involving the stakeholders and the decision-makers. These analyses may well require a diverse set of approaches, such as those suggested by McCown and Parton (2006), to produce useful insights. Their analysis concluded that progress in farm management depends on using simulation models (hard-systems theory and modelling) to inform a participatory (soft-systems) process undertaken between farm managers and advisors. Further research could determine the thresholds for resilience in various agricultural situations from particular factors or sets of factors, using both scientific (equation-based) and agent-based (rule-based) simulations to test responses and evaluate human-system interactions.

The study of adaptive capacity is a developing field, one where the theory is emerging rapidly, but one which is important for good land management and viability in a resilient agriculture. Improving adaptive capacity will need relevant information and methods with which to analyse and interpret this information so that it is useful for making decisions. Given the uncertainties involved in future operating environments, it would be prudent to invest in those activities that will achieve short- and medium-term benefits as well as help prepare for longer-term adaptation. There are roles for agronomists to contribute to improving adaptive capacity through a better knowledge and appreciation of new options and tools, especially relevant social indicators.

The development of adaptive capacity at a farm or industry level will depend on improving the stakeholder understanding of potential system behaviour, developed through a process of research, information gathering, education and interactive consultation. The process could identify options and develop contingency plans as well as estimate the probabilities and potential impacts of certain events and changes. Ultimately, it is farmers' ability to generate income that will need to remain the focus of their business activity (Kingwell 2006). Farmers will need to be both self-reliant and responsive to changes in climate, markets and community standards.

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