

available at [www.sciencedirect.com](http://www.sciencedirect.com)journal homepage: [www.elsevier.com/locate/envsci](http://www.elsevier.com/locate/envsci)

# Using adaptive governance to rethink the way science supports Australian drought policy

Rohan Nelson \*, Mark Howden, Mark Stafford Smith

CSIRO Climate Adaptation Flagship<sup>1</sup>, GPO Box 284, Canberra ACT 2601, Australia

## ARTICLE INFO

### Keywords:

Adaptive governance  
Drought policy  
Centralised expert management  
Science/policy engagement  
Climate

## ABSTRACT

In this paper we show how ideas from a longstanding but little recognised literature on adaptive governance can be used to rethink the way science supports Australian drought policy. We compare and contrast alternative ways of using science to support policy in order to critique traditional commentary on Australian drought policy. We find that criticism from narrow disciplinary and institutional perspectives has provided few practical options for policy makers managing these complex and interacting goals. In contrast, ideas from a longstanding but little recognised literature on adaptive governance have potential to create innovative policy options for addressing the multiple interacting goals of Australian drought policy.

From an adaptive governance perspective, the deep concern held by Australian society for rural communities affected by drought can be viewed as a common property resource that can be sustainably managed by governments in cooperation with rural communities. Managing drought assistance as a common property resource can be facilitated through nested and polycentric systems of governance similar to those that have already evolved in other arenas of natural resource management in Australia, such as Landcare groups and Catchment Management Authorities. Essential to delivering these options is the creation of flexible, regionally distributed scientific support for drought policy capable of integrating local knowledge and informing the livelihood outcomes of critical importance to governments and rural communities.

© 2008 Elsevier Ltd. All rights reserved.

## 1. Introduction

Australian society is concerned for the welfare of rural communities facing the prospect of more frequent and severe droughts as a result of climate change. Governments responding to this concern face a significant moral hazard in identifying which farmers to assist because of a lack of information on farm management and performance. The challenge faced by governments is to provide a standard of welfare for drought-affected farm families that is acceptable

to the rest of Australian society while meeting sustainability and economic efficiency goals. As we will show below, however, attempts to meet the multiple goals of drought policy are frequently criticised by analysts from narrow disciplinary and/or institutional perspectives. Without entering into this debate, we will show that most criticisms of drought policy tend to focus on a limited subset of its multiple goals, providing few practical options for tackling the complex and interacting issues faced by policy makers. Our purpose in revisiting this debate is to rethink the way science supports

\* Corresponding author. Tel.: +61 2 6242 1524; fax: +61 6242 1505.  
E-mail address: [rohan.nelson@csiro.au](mailto:rohan.nelson@csiro.au) (R. Nelson).

<sup>1</sup> <http://www.csiro.au/org/ClimateAdaptationFlagship.html>.  
1462-9011/\$ – see front matter © 2008 Elsevier Ltd. All rights reserved.  
doi:10.1016/j.envsci.2008.06.005

Australian drought policy. We seek to show how ideas from a longstanding but little recognised literature on adaptive governance have potential to create innovative and practical policy options for addressing the multiple interacting goals of Australian drought policy.

This paper begins by reviewing the distinction between adaptive governance of natural resources and its conceptual opposite, *centralised expert management*, to demonstrate the diverse perspectives from which drought science can be approached. We will briefly describe drought policy in Australia as background to a critique of traditional commentary on its objectives, administration and scientific support. Concepts from the evolving literature on adaptive governance are then used to develop a more constructive perspective for analysing Australian drought policy that leads to innovative options for addressing its multiple goals. Amongst these innovative options emerges new evidence for expanding an old idea—the creation of a missing tier of community-based regional governance that has already begun to evolve in other branches of Australian natural resource management policy.

## 2. Conceptual framework—a spectrum of governance systems

It is not always recognised that there are many alternative ways in which science can be used to support policy influencing the management of the environment and natural resources, including drought policy. In Australia, the term natural resource management is used to refer to environmental policy relating to agriculture, in which natural resources are used for a range of production, conservation and amenity outcomes. A simple tool for analysing some of the more common models of science/policy engagement is a continuous spectrum spanning from *centralised expert management* at one end, to adaptive governance at the other. This is merely an analytical construct. In real world application, both forms of governance are rarely fully expressed in their extreme form, partly because they can coexist at different scales (Brunner and Steelman, 2005). Differences in social, economic and environmental history can also result in governance systems sitting anywhere along this continuum, and moving backwards and forwards along it over time. The most essential common feature of all governance systems along this spectrum is that both depend on science to inform decision-making. They differ radically, however, in the types of knowledge considered to be scientific and the engagement processes via which science is integrated with decision-making. They especially differ in the role conceived of for those living and working with natural resources in local communities in the process of making resource allocation decisions.

### 2.1. Centralised expert management

The proponents of adaptive governance argue that the tragedy of the commons (Hardin, 1968) combined with positivism (see Lacey, 2005) tends to drive natural resource governance toward top down, centralised institutional arrangements that over-rely on reductionist science (Brunner and Steelman, 2005, Dietz et al., 2003, Holling, 1978, Ostrom, 1990,1999).

Through self-interest, Hardin argued, resource users become trapped in a commons dilemma, requiring external regulation to achieve sustainable use of common property resources such as forests, fisheries and ground water. Combined with the pervasive influence of positivism in the latter half of the 20th century (Brunner and Steelman, 2005), this has led to the growing dominance of what has been termed a *scientific management* paradigm in environmental policy (Brunner and Steelman, 2005, Ostrom, 1999). From a positivist perspective, reductionist science is seen as the preferred or, in the extreme, only acceptable source of knowledge (Lacey, 2005). This ideological perspective risks displacing other important sources of knowledge, particularly those that are local and informal (Brunner and Steelman, 2005, Ostrom, 1999). It leads to the idea that objective external experts need to intervene to free uncooperative and poorly informed local resource users from a cycle of exploitation that threatens sustainable resource use (Dietz et al., 2003, Ostrom, 1999).

As a philosophical construct, scientific management is not so much advocated as perceived by those reflecting on natural resource policy in a range of contexts, most of whom recognise the valuable pathway that reductionism provides to certain types of knowledge (Brunner and Steelman, 2005, Holling, 1978). In this paper, we use an alternative term, *centralised expert management*, to reflect the fact that both adaptive governance and scientific management describe alternative ways of using science to support policy. The core issue at stake is whether sole or over reliance on reductionist science in environmental policy has limitations. Holling (1978) identified a misconception evolving during the 1970s that increasingly sophisticated reductionist science could remove much of the complexity and uncertainty inherent in environmental policy. This misconception was inferred from efforts to create uniform policies independent of local contexts and able to endure changing circumstances without significant revision.

While reductionist science plays an important role in furthering human understanding, it is fundamentally unable to remove the complexity and uncertainty inherent in natural resource governance. Human-environment systems are inherently complex and unpredictable because of their non-linear and open nature, making it impossible to build a complete body of scientific knowledge that allows full prediction and control (Brunner and Steelman, 2005, Dietz et al., 2003, Jiggins and Roling, 2000). They are complex systems with diverse components interacting at multiple scales, differing subtly between a myriad of local contexts and continuously changing under the influence of social, economic and environmental pressures (Dietz et al., 2003, Holling, 1978, Ostrom, 1999). The complexity of natural resource management systems means that narrowly disciplinary and reductionist study of individual system components provides few insights into the emergent properties of whole resource systems (Holling, 1978). Attempts to sum reductionist studies into baselines to understand the emergent properties of natural resource management systems tend to be enormously costly and slow, and are quickly overtaken by changing circumstances (Holling, 1978).

Sole or over-reliance on narrow reductionist science in the face of irreducible complexity and uncertainty results in institutional weaknesses and blind spots. Holling argued that

“however intensively or extensively data are collected, however much we know of how the system functions, the domain of our knowledge of specific ecological and social systems is small compare to that of our ignorance” (Holling, 1978: pg7). At any one time, our knowledge based on reductionist science is fragmented by disciplinary interests and differential rates of progress across diverse fields of inquiry (Brunner and Steelman, 2005). Over-reliance on quantitative approaches risks narrowing the focus of inquiry to aspects that are easier to measure (Backhouse, 2002). As recognised by the Scottish philosopher David Hume in the eighteenth century, the backward looking nature of empirical inference also reduces its ability to handle new and unexpected future conditions (Nagel, 2005). More recently, Lowe (2002) has argued that many environmental problems are actually the result of applying narrow, specialised knowledge to complex systems. He describes modern science as “islands of understanding in oceans of ignorance” and calls for “scientists and practitioners to work together to produce trustworthy knowledge that combines scientific excellence with social relevance”.

Contrary to the intention, over reliance on reductionist science can shift the burden of complexity and uncertainty in natural resource policy from scientists to policy makers (Fig. 1). A high degree of clarity needs to be predetermined in policy goals in order for scientists to select systems components for study and to apply narrowly disciplinary methods for understanding specific causal relationships within individual system components (Brunner and Steelman, 2005). In complex natural resource systems the goals of policy may be far from clear and emerge only later in the process due to diffuse centres of authority and control, and the trade-offs required between multiple competing interests (Holling, 1978, Brunner and Steelman, 2005). Pressure placed on policy makers by scientists to reduce and predefine inflexible policy targets can lead to conflict at later stages of implementation (Holling, 1978). Pressure to reduce policy goals to fit scientific method means that analytical systems designed to inform policy development and implementation may not measure the appropriate variables at the required spatial scales and temporal intervals, or within boundaries meaningful to inform policy (Brunner and Steelman, 2005, Ostrom, 1999). Pre-designed and inflexible analytical systems become increasingly inappropriate over time as social values, economic incentives and environmental conditions change.

The uniformity and centralisation identified by Holling (1978) that flows from a centralised expert management paradigm has implications for the way communities dependent on natural resources are engaged in policy processes. Over-reliance on centralised expert management can crowd out local and informal forms of governance, in some cases converting common property to open-access resources (Dietz et al., 2003, Ostrom, 1999, Pearce and Warford, 1993). Centralised intervention works best in situations where there are few resource users, the relationships between resource use and conditions are easy to monitor, and monitoring systems are well resourced. Centralised governance is less successful where resource use is diffuse and difficult to monitor, governments lack the will or resources to enforce compliance, or sustainable use depends

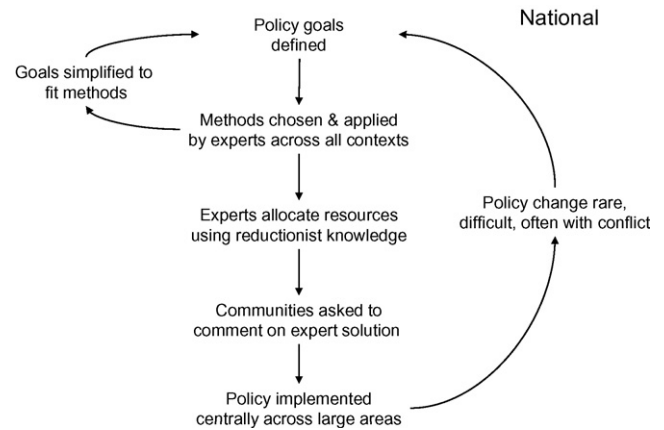


Fig. 1 – The process of centralised expert management.

on encouraging innovation rather than prohibiting existing practices. Inappropriate monitoring regimes and sanctions for non-compliance can lead to general resistance and evasion by resource users (Dietz et al., 2003, Ostrom, 1999).

It can be difficult for centralised expert management regimes to constructively integrate local knowledge into analytical support systems, and build on the communication and sanctioning processes that local stakeholders use to manage natural resources (Brunner and Steelman, 2005, Dietz et al., 2003, Ostrom, 1999, Pearce and Warford, 1993). If resource use is diffuse with subtle but important differences between local contexts, reliance on “highly aggregated information may ignore or average out local information that is important in identifying future problems and developing solutions” (Dietz et al., 2003: pg 1908). Public comment or criticism may be actively rejected by scientists as a threat to their objectivity, with public participation reduced to “ritual rationalisation or legitimisation” of decision-making by experts (Brunner and Steelman, 2005: pg 34).

## 2.2. Adaptive governance

Adaptive governance integrates principles from adaptive management with empirical and experimental evidence that communities can self-organise to overcome the tragedy of the commons (Dietz et al., 2003, Ostrom, 1999). A defining feature is recognition of behavioural complexity and the importance of understanding local contexts. This includes recognising the potential for local participants to use their context specific knowledge to inform resource allocation decisions made collectively with other local participants and governments. Adaptive governance explores ways in which government and community-based institutional arrangements complement each other to improve natural resource management, integrating scientific and local knowledge. The evolving principles of adaptive governance have been inferred from the diversity of institutional arrangements that local communities have evolved to manage common property resources in a range of contexts. Behavioural insights derived from hundreds of case studies are supported by experiments in game theory exploring the conditions under which people have been found to choose mutually beneficial outcomes over narrow self-interest.

Ostrom (1999) comprehensively reviewed experiments in game theory exploring the conditions under which people cooperate to jointly manage common property resources. The overwhelming evidence was that most, but not all, participants choose to cooperate with each other, especially when they can communicate and make joint decisions. Through repeated iterations, individuals develop and apply heuristics (trial and error leading to rules of thumb) to deal with the complex interactions of jointly determining resource allocation. Communication and joint decision-making supports the development of norms and trust, and sanctions for non-compliance. Many, but not all, individuals are willing to comply with jointly determined strategies, and are prepared to use sanctions that are personally costly in order to penalise non-compliance by others. However, a residual incentive to default means that effective governance systems are those that “cope better than others with the ongoing need to encourage high levels of trust while also monitoring actions and sanctioning rule infractions” (Ostrom, 1999: pg 508).

Dietz et al. (2003) and Ostrom (1999) have also comprehensively reviewed the characteristics of adaptive governance from “hundreds of documented examples” (Dietz et al., 2003: pg 1908) of community-based natural resource governance systems (Fig. 2). Community-based governance often includes rules that determine who can access resources, and under what conditions. Restricting use to local users who know each other enhances communication which facilitates the development of trust and a sense of mutual obligation toward protecting the long-term sustainability of a resource. It also facilitates mutual monitoring of resource use and the development of informal sanctions for non-compliance. Long-term resource users can develop norms for resource use based on accurate mental models of resource dynamics, including response to management. An understanding developed across a diversity of local contexts provides building blocks for understanding complexity at larger scales. Trial and error across a myriad of local contexts provides redundancy that protects larger systems from collapsing if local governance systems fail.

Adaptive governance recognises that much of the complexity and uncertainty in natural resource policy arises from the

need to negotiate trade-offs between multiple, diffuse and changing interests (Brunner and Steelman, 2005, Dietz et al., 2003). These multiple interests operate at different spatial and temporal scales (including future generations) of which only a very few can ever be informed by contemporary science. Knowledge gaps and value-based trade-offs (Dietz et al., 2003) necessitate political rather than scientific balancing of multiple interests where possible, and stronger intervention to integrate them where necessary (Brunner and Steelman, 2005). Conflict resolution mechanisms are an essential feature of adaptive governance systems (Dietz et al., 2003). Within an adaptive governance paradigm the policy problem becomes one of addressing discrepancies between evolving multiple goals and the achievement of past and projected outcomes. This contrasts with a centralised expert management paradigm in which the goal is to meet predetermined and unchanging scientific targets. Under adaptive governance, the nature of the policy problem determines the relevance of available science, rather than policy problems being redesigned to fit available scientific methodologies. Under adaptive governance science serves rather than dictates the information needs of policy makers and resource users, facilitating “analytic deliberation” between scientists and resource users to integrate local knowledge (Dietz et al., 2003; pg 1910).

The literature on adaptive governance challenges the idea that the design of natural resource policy is a relatively simple analytical task of realigning the incentives of resource uses to meet clearly determined scientific targets (Brunner and Steelman, 2005, Dietz et al., 2003, Ostrom, 1999). Uncertainty means that policy development is a continual experiment proceeding via informed trial and error to evolve solutions in response to conflicting goals, knowledge gaps, and continuous change in social, economic and environmental conditions (Dietz et al., 2003, Holling, 1978, Ostrom, 1999). Governance systems become adaptive by facilitating continual renegotiation of trade-offs between competing resource use interests to establish policy goals (Brunner and Steelman, 2005). Communities are engaged wherever possible to ensure shared ownership and responsibility for uncertainty with governments. The risk involved in trial and error policy experimentation is managed through the redundancy created by myriad local contexts requiring diverse and contextually adapted policy. This can be difficult in systems that are irreducible in scale (Ostrom, 1999). Failure at a local scale can and does happen, but trial and error with redundancy results in governance systems that are resilient because of, rather than in spite of, variability and change (Holling, 1978).

Adaptive governance is very different to devolution or decentralisation, in which responsibility and authority are simply transferred from central to local tiers of governance. In contrast, adaptive governance recognises the complementary role that governments and local communities play in natural resource management, and the value of integrating local knowledge into more formal scientific understanding of natural resource systems. Governments have an important role to play in addressing issues of equity, local tyranny and discrimination that may arise from historical conflict or power imbalances (Ostrom, 1999). Over reliance on local knowledge can increase the vulnerability of community-based governance by inhibiting innovation and the capacity to adapt to

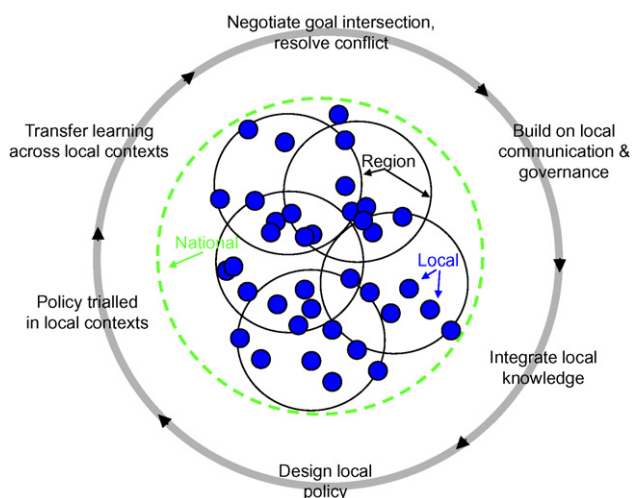


Fig. 2 – The process of adaptive governance.

changing circumstances (Jiggins and Roling, 2000, Ostrom, 1999, Woolcock, 1998). It may be difficult for local communities to tackle resource governance issues at larger scales (Jiggins and Roling, 2000), and overcome indecision and inaction under extreme uncertainty (Ostrom, 1999). Even well organised local governance systems can fail, and governments can provide contingent systems.

Governments also have a major role to play in adaptive governance by providing social, scientific and physical infrastructure. Independence and authority enable governments to facilitate the development of participatory engagement mechanisms used to negotiate policy goals and trade-offs between multiple conflicting interests. This objectivity can also help to balance local interests against broader resource management goals at larger scales, and ensure that local governance is informed by external ideas, innovations and resources (Woolcock, 1998). Governments can also invest in multi-disciplinary and devolved forms of science capable of supporting the systems-level outcomes in which collective values and visions for resource use are often expressed (Olsson et al., 2004). Physical infrastructure influences the extent to which resources can be exploited (e.g. roads), wastes from resource use can be reduced (e.g. R&D) and resource use monitored (e.g. communications) (Dietz et al., 2003).

The complementary role of central governments and local communities in adaptive governance systems suggests a need for polycentric (Ostrom, 1999) or nested (Dietz et al., 2003) organisational structures for resource governance. Ostrom's (1999) use of the term polycentric stresses that multi-tiered governance structures may be largely self-organising, in that the role of centralised intervention is collectively determined as part of the process. Science devolved to a local level using standards rather than centralisation to achieve consistency becomes a communication medium which nests tiers of governance at different scales. Devolving some responsibility for governance enables local participants to take advantage of their context specific knowledge. This increases the rapidity of trial and error policy experiments while providing the redundancy that protects the system at larger scales.

### 3. Applying these ideas to policy analysis

*Centralised expert management* and adaptive governance are somewhat abstract constructs that describe a continuous spectrum of governance systems, and may coexist at different scales (Brunner and Steelman, 2005, Dietz et al., 2003). Differences in social, economic and environmental history may result in specific governance systems sitting anywhere along this continuum, and moving backwards and forwards along the spectrum over time. To relate these abstract constructs more tangibly to Australian drought policy, it is useful to compare them across three inter-related structural components common to most forms of natural resource policy (derived from Brunner and Steelman (2005) and Dietz et al. (2003)):

1 Policy objectives: the institutional structures and processes for determining the objectives of drought policy.

*Centralised expert management*: Top down design of global and unchanging scientific targets by scientific experts in consultation with policy advisers for components of the system that are measurable using reductionist scientific methodologies.

*Adaptive governance*: Evolving and locally context-specific balancing and integration of alternative interests through participatory engagement between governments and communities facilitated by the integration of local and scientific knowledge.

2 Policy administration: the institutional structures and processes for implementing drought policy.

*Centralised expert management*: Pre-determined scientific targets are met through the simple analytical task of realigning the incentives of resource users.

*Adaptive governance*: A continual experiment proceeding via trial and error, replicated locally for faster learning, that rapidly evolves solutions in response to conflicting goals, knowledge gaps, and continuous change in social, economic and environmental conditions.

3 Analytical support: the data, modelling and reporting systems used to support the development and implementation of drought policy.

*Centralised expert management*: Reductionist science is the only acceptable form of knowledge and policy goals are conformed to the limitations of scientific methods.

*Adaptive governance*: the integration of scientific and local knowledge facilitates participatory engagement between governments and communities in an evolutionary process of policy design and implementation.

#### 3.1. Australian drought policy

##### 3.1.1. Policy objectives

The objectives of Australia's national drought policy have been described in detail by DAFF (2006a), and their history and development have been comprehensively reviewed by Botterill (2005), with early history reviewed by James (1973). In policy development since the early 1990s, drought has been considered a natural characteristic of Australia's variable and changing climate, with successful management of climate risk recognised to be a definitive characteristic of farming excellence (see for example Blackadder, 2005). With this focus on self-reliance, the rationale for providing financial support to farmers has been "to ensure that farmers with long-term prospects for viability will not be forced to leave the land due to short-term adverse events that are beyond their ability to manage" (DAFF, 2005). The policy has multiple objectives which include:

1. Encouraging self-reliant approaches to managing climate variability;
2. Protecting the natural resource base during times of extreme climate stress;
3. Ensuring adequate welfare support for farm families commensurate with that available to other Australians;
4. Ensuring that the policy does not impede structural adjustment in the farm sector; and

5. A high level of awareness and understanding of drought and drought policy. (Adapted from Drought Policy Task Force (1997), cited in Botterill (2005).)

The two key forms of assistance provided under national drought policy are interest rate subsidies and income support for farmers in areas declared to be suffering a severe and prolonged downturn in income caused by drought, termed *exceptional circumstances*. This is complemented by a national system of farm management deposits designed to assist farmers to smooth income variability from year to year. State governments also provide various transaction subsidies for fodder and livestock transport to facilitate the agistment of livestock. The focus of this paper is the institutional arrangements governing the administration of exceptional circumstances assistance.

While drought has historically been the focal point of climate policy in Australian agriculture, the prospect of more frequent and severe droughts has led to growing recognition of the need to adapt to climate change (Hennessy et al., 2008). Climate policy in Australian agriculture, including drought policy, has tended to focus on the management of climate risk within existing farming systems and rural livelihood strategies. This approach to drought policy is at risk of being stranded by the uncertainty surrounding climate change, because the maintenance of existing farming systems and livelihood strategies may no longer be possible. Consequently, there is an urgent need to replace traditional climate risk management with adaptive approaches better suited to managing uncertainty.

The need for more innovative and holistic approaches to climate change adaptation in Australian agricultural policy has been partly recognised in the National Agriculture & Climate Change Action Plan (NACCAP) (DAFF, 2006b). This document begins by recognising the uncertainty surrounding future climate change - “the size and scope of the impacts of climate change are still beyond our grasp but the threat is very real” (DAFF, 2006b: pg iii). The NACCAP goes on to outline a policy framework that builds on but transcends traditional risk management and sustainable farming practices to promote a culture of innovation and responsiveness in response to global change. The action plan identifies four areas for transformative science and policy:

- Adaptation strategies to build resilience into agricultural systems;
- Mitigation strategies to reduce greenhouse gas emissions;
- Research and development to enhance the agricultural sector’s capacity to respond to climate change; and
- Awareness and communication to inform decision-making by primary producers and rural communities.

At the time of writing this paper in October 2007, the implications of the NACCAP for Australian drought policy remained unclear. What is clear, however, is that the integration of drought and climate change policy in Australian agriculture is an emerging policy challenge for which adaptive systems of governance are likely to be critical.

### 3.1.2. Policy administration

The process through which exceptional circumstances assistance is granted has been described by DAFF (2005) (Fig. 3). Local

and/or industry-based groups independently initiate the process by seeking support from their State or Territory governments to develop an application for assistance to the Australian Government Minister for Agriculture, Fisheries and Forestry. A database, the National Agricultural Monitoring System (NAMS), has been developed to assist community and industry groups to prepare exceptional circumstances applications (<http://www.nams.gov.au>). State governments assess whether the criteria for declaring an area affected by exceptional circumstances have been met, and if so, assist in the collation of data and preparation of an application to the Australian Government. Once submitted, it is then at the discretion of the Minister to determine whether a *prima facie* case for assistance has been established. If granted, the Minister then has discretion to refer the case to a National Rural Advisory Council (NRAC) appointed by the Minister for advice.

NRAC is comprised of current and past officials of the National Farmers Federation, other national and state industry organisations, and state and national government officials (Truss, 2005). In deciding whether to declare a region as affected by exceptional circumstances, NRAC and the Minister must decide whether (DAFF, 2005):

1. the event is rare and severe, occurring on average once in 20 to 25 years, and on a significant scale in terms of the area and proportion of farm businesses affected;
2. the event has resulted in a rare and severe downturn in farm income over a prolonged period;
3. the event cannot be planned for or managed as part of farmers’ normal risk management strategies; and
4. the event was not predictable or part of a process of structural adjustment.

In assessing these criteria, NRAC draws on scientific and financial advice from Australian Government organisations supplemented by information from industry, with optional field visits to affected regions to consult farmers (DAFF, 2005). NRAC presents its findings to the Minister, who consults with Cabinet before deciding whether to declare exceptional circumstances in each region.

The difficulty of administering the above criteria for exceptional circumstances is highlighted by regional patterns of drought declaration, the cost of drought assistance and its

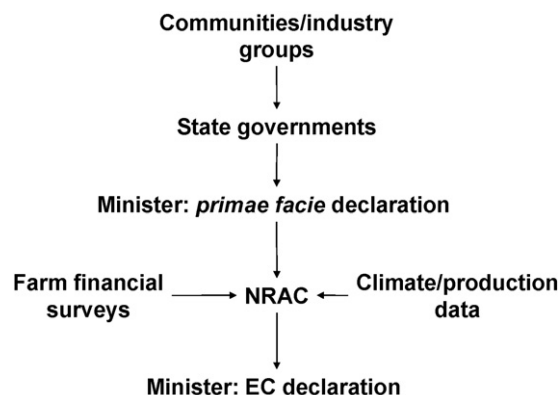


Fig. 3 – The process for granting exceptional circumstance’s assistance (DAFF, 2005).

incidence favouring farms with high debt. Most of Australia's intensive southern agricultural regions have historically been drought declared (DAFF, 2007) in a far greater proportion of years than specified by the above criteria. Although a national time series of drought declared regions is not routinely published or analysed, monthly updates are regularly published at <http://www.daff.gov.au/agriculture-food/drought/ec>. Over time, this website reveals that most agricultural regions of southern Australia were drought declared continuously from 2002-03 until this paper was submitted in October 2007. A statistical implication of the exceptional circumstances criteria is that regions that have been drought declared for 4 continuous years should, on average, not be due for additional assistance for another 80–100 years. This is not a recent phenomenon. A much more rigorous and long-term analysis by Day et al. (2003) showed that some shires in Queensland have been drought declared in more than twenty percent of years since 1964.

Ongoing provision of exceptional circumstances assistance has proved costly. At the time this paper was submitted in October 2007, the Australian Government had committed \$2.8 billion to drought assistance since 2001 (Howard, 2007). An additional \$714 million committed in September 2007 (Howard, 2007) took this total to over \$3.5 billion, or around \$50,000 on average for each of the nearly 70,000 commercial farms in Australia (ABARE, 2003).

The incidence of expenditure on exceptional circumstances assistance was studied in detail by Martin et al. (2005, 2006) using farm financial data provided by farmers through annual surveys to the Australian Bureau of Agricultural and Resource Economics (ABARE). Because the business support component of exceptional circumstances assistance has been delivered primarily as interest rate subsidies, it favours farms with the most debt. Farms with high debt also receive more welfare assistance than those without debt. Martin et al. argued that this was somewhat contrary to the intention of the policy in that farms with debt are often larger, expanding farms with sound long-term prospects. More in line with the objectives of the policy, farms not considered viable in the long term by their owner-managers either did not receive business assistance or received mainly welfare support.

### 3.1.3. Analytical support

The scientific advice provided to NRAC in assessing applications for exceptional circumstances assistance has been described by Laughlin and Clark (2000) and a series of websites removed shortly before this paper was submitted (BRS, 2006a–c). It is described as: “objective scientific advice based on the integration of available scientific evidence, providing interpretation with the aid of models and expert opinion” (BRS, 2006a). The advice provided by the Bureau of Rural Sciences (BRS) to NRAC has focused on biophysical definitions of agricultural, meteorological and hydrological drought to establish whether a drought event is rare and severe (BRS, 2006c). Rainfall analysis, remote sensing, soil water analysis and plant growth simulation are used to map these biophysical dimensions of climate risk across Australia (BRS, 2006b). At the time this paper was submitted in October 2007, this narrow biophysical emphasis remained in the newly developed National Agricultural Monitoring System ([\[www.nams.gov.au\]\(http://www.nams.gov.au\)\). NRAC also draws information on the impacts of drought from farm surveys conducted by the ABARE \(DAFF, 2005\).](http://</a></p>
</div>
<div data-bbox=)

## 4. Traditional criticisms of drought policy

All three aspects of Australian drought policy – its objectives, administration and analytical support – have been repeatedly criticised by analysts from narrow disciplinary and institutional perspectives. Whether or not we agree or disagree with these criticisms is irrelevant for the purposes of this paper. We review them here to provide context against which to demonstrate an alternative perspective that adaptive governance can provide for analysis of Australian drought policy. In particular, we highlight that most criticisms of drought policy tend to focus on one or a small subset of its multiple objectives. This is often because of the narrow disciplinary perspective from which the criticism arises. We demonstrate the limitations of traditional commentary on Australian drought policy to highlight the alternative provided by an integrated disciplinary perspective via adaptive governance.

### 4.1. Policy objectives

Many criticisms of drought policy focus on one or more of the objectives of the policy, with scant regard for the complexity faced by policy makers in balancing its multiple interacting goals. Economists, for example, tend to focus on economic efficiency goals and hence question whether there is sufficient evidence of market failure to justify government intervention in drought policy (O'Meagher, 2005, Stoneham et al., 2004). Evidence of different types of market failure has been extensively sought and found to be lacking. Amongst the forms of market failure explored and dismissed are restricted access to credit and insurance markets, distortions in fodder or transport markets, and restricted access by rural communities to the welfare system (Hertzler, 2005, O'Meagher, 2005, Botterill and Chapman, 2004, Stoneham et al., 2004). The availability of income insurance to small businesses in other sectors of the economy, and the availability of general farm household insurance, suggests that issues of moral hazard or transaction costs are not sufficient to prevent a market for farm income insurance developing. As early as 1973, Heathcote suggested that it was “...no longer possible to argue that drought insurance is impracticable for lack of information” (pg 37, italics are original). From an economic perspective, systematic risk resulting from the broad geographic impact of drought along with the crowding out of private investment by government assistance are often cited as the main factors constraining self-insurance markets from developing (Hertzler, 2005, Stoneham et al., 2004).

Criticism by scientists, on the other hand, tends to stem from their perception that the objectives of drought policy are modified in an ad-hoc or at least unsystematic way. Political debate over drought policy tends to intensify during drought, with more strategic approaches slipping off political agendas when favourable seasons return (Botterill, 2005, White et al., 2005, O'Meagher, 2005). This is sometimes referred to as the *hydro-illogical cycle* (Wilhite, 1993, NDMC, 2003). As documented

comprehensively by Botterill (2005), Australian drought policy tends to progress in sequential small quantum steps via national inquiries following major drought events. This process has often been described in colourful language by advocates of a scientific approach to drought policy. Hence amendments to drought policy are described as taking place "...against a background of hardship and political point scoring" (Botterill, 2005: pg 62). White et al. (2005) has argued that the "workable" and "robust" scientific basis for drought policy established in the mid 1990s has since been "undermined" and "seriously compromised" by the reintroduction of welfare payments through the political process (White et al., 2005: pgs 100, 101).

#### 4.2. Policy administration

Economists and other policy analysts have long criticised drought policy on the basis that it is difficult, if not impossible, to administer welfare support to farm families affected by drought without undermining incentives for self-reliance, maintenance of the natural resource base and structural adjustment (Heathcote, 1973, Botterill, 2005, O'Meagher, 2005). This concern is widely held, including amongst farmers themselves. According to the Drought Review Panel (2004) and the Agriculture and Food Policy Reference Group (2006), many farmers, particularly younger farmers, are supportive of welfare payments to drought-affected families, but critical of drought related transaction and business subsidies:

"Many see it as rewarding poor management, propping up farmers who fail to respond to changed business conditions or take imprudent risks. It can delay change and reform by keeping otherwise unviable farms in business for longer than would otherwise be the case" (Agriculture and Food Policy Reference Group, 2006: pg 188).

Some policy analysts go further, suggesting that the integration of farm family finance and their business interests mean that welfare payments can act as de facto business support (Botterill, 2005). From this perspective, even welfare assistance to meet basic human needs can impede the exit of non-viable farms from the industry, and reduce incentives for drought preparedness and management. This is a variant of the poverty-environment trap (Pearce and Warford, 1993) in which perverse economic incentives "...can trap farmers in a situation which generates social, economic and environmental problems" (Botterill, 2005: pg 62).

The sequential process through which exceptional circumstance applications are assessed has frequently been criticised for being slow and providing incentives for lobbying in pursuit of assistance (Botterill, 2005). Analysis of this assessment process (DAFF, 2005) reveals that exceptional circumstances applications are potentially assessed five times. Firstly by the local or industry groups preparing them, secondly by state government departments of agriculture, thirdly through the assessment of *prima facie* cases by the Minister, and fourthly by NRAC with advice from BRS and ABARE, and finally in the Minister's assessment of advice from NRAC in making a recommendation to Cabinet. Although a National Agricultural Monitoring system has been set up ostensibly to streamline

this application process, it is unclear whether access to data rather than the multiple repeated steps of assessment have caused the process to be slow. Apart from being slow, "Every step of this process invites publicity and political point scoring" (Botterill, 2005:pg 108). This argument suggests that at each stage in the assessment process, proponents of exceptional circumstances applications have an incentive to organise coalitions to get their application through the next stage. With imperfect knowledge about each farm business, there is always a risk that the assessment process will select farmers who have given less attention to managing climate risk, at the expense of active managers of climate risk (Hayman and Cox, 2005). An unintended consequence of the process described above is that it effectively shifts the burden for most of this uncertainty back onto the Minister in declaring exceptional circumstances.

The current system of administering exceptional circumstances policy has also been criticised by analysts from various disciplines on equity grounds. From this perspective, it is suggested that equity issues arise between farmers and other small businesses that are affected by drought but do not receive exceptional circumstances payments (Botterill, 2005). A similar argument for inequity between farmers and the rest of Australian society arises because farmers are not subject to the same eligibility tests for drought assistance that other welfare recipients are subject to (Botterill, 2005, O'Meagher, 2005). It has also been suggested that exceptional circumstances assistance is regressive in a lifetime sense because farmers are asset-rich compared to most salary-earning taxpayers (Botterill and Chapman, 2004). Others suggest that equity issues can even arise between farmers because not all regions and industries have equal capacity to mount a case for assistance (White et al., 2005). In addition, the administrative boundaries used for these assessments can bear little relationship to the geographical incidence of drought, and create inequity along the margins (Botterill, 2005). The creation of buffer zones around exceptional circumstances areas apparently to solve this last problem simply shifts this aspect of complexity from the scientists providing drought advice to NRAC and ultimately the Minister.

#### 4.3. Analytical support

Scientists and economists have also questioned the relevance of the scientific data and modelling systems used to provide analytical support for Australian drought policy to its original objectives (Thompson and Powell, 1998, Stafford Smith, 2005, Kokic et al., 2007, Nelson et al., 2007). This criticism arises because Australian drought policy is focused on ameliorating the impacts of drought on the welfare of farm families, business viability and environmental outcomes. However, the data and modelling systems used to inform drought policy are heavily dominated by reductionist scientific measures of inputs to agricultural production such as rainfall and plant growth (BRS, 2006b). Proponents of this criticism point out that while rainfall and plant growth provide useful measures of the exposure of rural communities to climate variability and change, they provide few insights into the socioeconomic dimensions of their capacity to cope with it (Nelson et al., 2007, Meinke et al., 2006, Wilhite, 2005). During the major drought of

2002–03 and 2003–04, expenditure on scientific advice for exceptional circumstances determinations was around ten times greater than expenditure on economic advice (Nelson and Kokic, 2004), and there is little or no reference to the formal use of social data in the assessment of exceptional circumstances events (BRS, 2006b). This almost exclusive reliance on reductionist science effectively shifts the complexity for finding and integrating social, economic and environmental data from scientists back onto policy advisers, NRAC and ultimately the Minister.

The data and modelling systems used to support drought policy have been criticised, mainly by scientists, for being highly centralised (White et al., 2005), slow (Botterill, 2005), overly reliant on historical biophysical data rather than future socioeconomic outcomes (Nelson et al., 2007), and for using broad national climate data of questionable local relevance (Stafford Smith, 2005). As a result, this science is locked in to an engineering style of risk management focused on predicting and managing the impacts of drought within existing farming systems and livelihood strategies. The proponents of this *centralised expert management* approach assert that ongoing developments in scientific method should improve its objectivity (White et al., 2005). However, it has long been recognised that the interests of scientists can be narrow and may reflect the history of a particular discipline or its institutional affiliations (Holling, 1978, Brunner and Steelman, 2005). Day et al. (2003), for example, suggest that there has been significant duplication within the Australian Government of analytical systems similar to those developed within State governments. The establishment of an independent drought monitoring authority is often cited as an option for improving the objectivity of scientific advice provided to support Australian drought policy (Botterill, 2005, White et al., 2005).

## 5. An adaptive governance perspective on drought policy

### 5.1. Policy objectives

Adaptive governance provides a completely different perspective for analysing Australian drought policy. From this perspective, much of the complexity and uncertainty involved in setting policy objectives arises from the need to constantly balance and exploit synergies between multiple, diverse and changing interests (Brunner and Steelman, 2005, Dietz et al., 2003). Fundamental to this is recognising the diverse political, social and economic drivers of drought policy. For example, much of the impetus for Australian drought policy arises from agrarianism—an intrinsic concern throughout Australian society, including the urban population, for the welfare of rural communities (Botterill, 2005, White et al., 2005, Hayman and Cox, 2005). Agrarianism is often attacked as archaic and the root of a farm welfare mentality that breeds inefficiency. We propose an alternative view that concedes that agrarianism will continue to be a driver of agricultural policy into the future. This alternative is to view the agrarian sentiment that provides farm families with welfare and business support in times of drought as a common property resource provided by

the rest of Australian society. Increasing debate over the cost and equity implications of assistance following major droughts provides evidence that it is a depletable resource, while political intervention to increase assistance at the onset of droughts indicates that it is renewable. Adopting this alternative perspective creates an opportunity to reframe drought assistance from an overexploited open-access resource into a common property resource that can be sustainably managed by governments and rural communities.

From this alternative perspective, the rest of Australian society can be accepted as a legitimate stakeholder in drought policy, while agrarian sentiment can be accepted as a legitimate motivation for political intervention. Traditional economic critiques of Australian drought policy tend to be based on an assumption that government intervention is justified only by market failure, narrowly defined on economic efficiency grounds (Stoneham et al., 2004). In contrast, the historical and cultural reality of agrarianism means that wider Australian society has focused more on the failure of markets to ensure a socially acceptable degree of welfare for farm families affected by drought (Heathcote, 1973). Some commentators see these sentiments as a norm integral to Australian culture (Hayman and Cox, 2005) to be accepted as a defining characteristic of the social context within which drought policy needs to be formed (Botterill, 2005, Botterill and Chapman, 2004). Others refer to them disparagingly as “lingering agrarianism” with “distinctly moral overtones” (White et al., 2005: pg 105) that have supported the politicisation of drought policy and “prevented a more objective approach from being implemented” (White et al., 2005: pg 100).

Instead of political processes in Australian society failing the *centralised expert management* of drought policy by imposing social welfare outcomes, an alternative view is that *centralised expert management* has failed Australian society by not delivering socially acceptable welfare outcomes during droughts. From an adaptive governance perspective, socially responsive policy is necessary because advancing one interest depends on accommodating others, and is particularly desirable when all interested parties are engaged to advance the common interest (Brunner and Steelman, 2005). A history of government intervention in Australian drought policy suggests that successive governments have judged that the social benefits of additional drought support outweigh the economic efficiency costs. Critics of this intervention question the extent to which politically and socially desirable outcomes converge, suggesting that political intervention is related to the electoral cycle (White et al., 2005). However, criticisms of political interference in the *centralised expert management* of drought policy need to be balanced by equal reflection on the potential self-interest of scientists in maintaining particular drought assessment regimes (Holling, 1978, Brunner and Steelman, 2005). Needless to say, self-criticism by scientists of the quality and relevance of their advice to drought policy advisers is much rarer in the literature than criticism of political interference with drought science.

### 5.2. Policy administration

Stafford Smith (2005) has already flagged the potential advantages of governance structures for Australian drought

policy in which policy development is coordinated nationally with regional implementation. This means facilitating the development of what [Stafford Smith \(2005\)](#) has referred to as a “missing level of local community governance” (pg 9). Examples of nested and polycentric governance structures already exist in Australian natural resource management policy, from which community institutions for administering drought policy could be developed. Through Landcare, for example, the Australian Government has facilitated the creation of a previously under-developed tier of community governance even in areas with sparse and/or isolated populations ([Stafford Smith, 2005](#)). The Catchment Management Authorities established to implement policies under the Natural Heritage Trust are another example. As mentioned earlier, it is important to stress that adaptive governance is very different to devolution or decentralisation in that it seeks to integrate the best possible characteristics of government and locally evolved resource governance systems.

Adaptive governance draws attention to a number of possible advantages of increased local engagement in enhancing shared ownership and mutual responsibility in the administration of drought assistance. Governance systems that provide communities with authority to allocate finite amounts of assistance determined prior to droughts would reduce current incentives to seek open-ended assistance, encouraging the conservation of scarce fiscal resources. Limits on drought assistance and rules for its governance pre-agreed with local communities could help to free governments of criticism surrounding intervention during drought. Communities and governments could co-design governance systems in which participants self-select their access to drought assistance according to jointly determined standards of farm and environmental management, including drought preparedness. Self-selection mechanisms supported by local monitoring according to independently set standards would remove the need for multiple central assessments, with potential to greatly improve the responsiveness of drought policy administration to changing seasonal conditions. Local Drought Committees and Rural Lands Protection Boards already play an important role in local consultation and exceptional circumstances declaration in the states of Queensland and New South Wales, and these could be integrated into a nationally coordinated system.

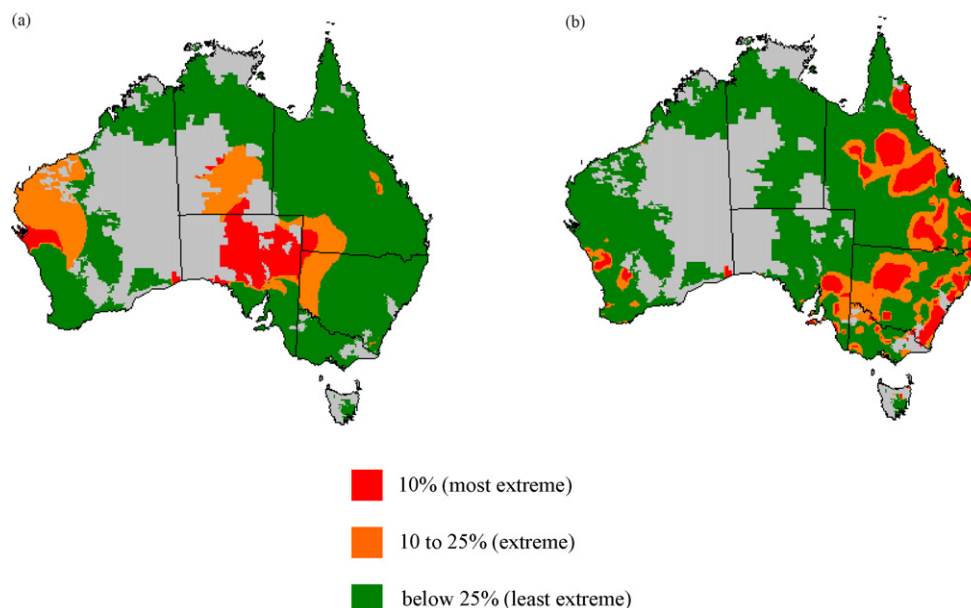
The development of nested and polycentric systems of governance to administer locally relevant rules for accessing drought assistance is not a new idea. As stated by [Heathcote \(1973\)](#), “Planning for the pastoralist must have different criteria for the wheat farmer, there can be no single plan or legislation which could cover all possible contingencies” (pg 37). Ongoing access to drought assistance could be conditional on maintaining locally interpreted and monitored standards of environmental management. This could be complemented by expanding the existing *Work for the Dole Drought Force* scheme beyond agricultural production to include activities designed to mitigate the environmental impacts of drought. The development of self-selection mechanisms would also help to reduce the moral hazard that otherwise compromises the structural adjustment objectives of drought policy. Communities and governments could work together to develop locally relevant conditions for mutual responsibility that do not impede the exit of non-viable farms from the industry.

Governments could also work with local communities to reduce issues of inequity between farmers and society more generally by making drought assistance increasingly revenue neutral. Revenue neutral schemes with a high degree of local ownership have potential to ensure future access to drought assistance as attitudes in the rest of Australian society change under increasing urbanisation and globalisation. For example, the income contingent loans scheme devised by [Botterill and Chapman \(2004\)](#) shares the cost of drought assistance to address inequity between farmers and other taxpayers, but does little to overcome issues of moral hazard and the consequent need for central monitoring ([Stoneham et al., 2004](#)). In contrast, the drought assistance contracts proposed by [Stoneham et al. \(2004\)](#) combine revenue neutrality with self-selection, therefore addressing both equity and administrative efficiency concerns.

### 5.3. Analytical support systems

From an adaptive governance perspective, analytical support systems for drought policy should facilitate participatory engagement between governments and communities, and enable local knowledge to be integrated with more formal scientific knowledge ([Dietz et al., 2003](#)). A high degree of flexibility and relevance to local contexts is required to enable policy to develop via informed trial and error across diverse local contexts ([Ostrom, 1999](#)). In the context of Australian drought policy, this could be facilitated by coordinating regional or industry relevant analytical systems that facilitate joint decision-making and shared ownership between communities and governments. In 1973, R.L. Heathcote wrote that “Local opinions on drought definitions for a particular resource use need to be canvassed and compared with the available scientific data to provide rule-of-thumb practical measurements” (pg 37). An example of this type of technology is the *Carrying Capacity Calculator* of [Johnston et al. \(1996\)](#), which combines an objective assessment of carrying capacity of different land units with a consensus amongst local landholders as to acceptable practice for long-term stocking rates.

The principles of adaptive governance suggest a number of ways that the analytical systems used to support drought policy could be redesigned to integrate local and scientific forms of knowledge. For example, a shift in mindset from national centralisation to distributed regional data and modelling systems coordinated nationally could be implemented by the adoption of flexible and evolving data quality and interpretation standards. These standards would preserve a high degree of local flexibility in the types of information that communities, industry and state governments could use to support drought policy, legitimising the integration of local knowledge. Decentralisation and enhanced regional distribution of science capacity would also facilitate participatory engagement between governments, science agencies and local communities. The advantages of community and industry participation are likely to be similar to those achieved in other areas of Australian natural resource management policy. These include joint ownership of issues and the responsibility for evolving and implementing solutions, resulting in responsive policy processes that adapt to changing societal priorities.



**Fig. 4 – (a) The exposure of Australian broadacre farms to climate risk using a measure of extreme pasture growth conditions (left); and (b) the vulnerability of Australian broadacre farms using combined measures of human, social, natural, physical and financial capital (right) (Reproduced from Nelson et al., 2005, see also Meinke et al., 2006).**

The analytical support for Australian drought policy could also be enhanced by using multi-disciplinary approaches to integrate social, economic and environmental data to inform the outcomes that are of most interest to governments and rural communities. Scientific effort could be redirected from attempts to achieve objectivity through uniform measures of *inputs* such as rainfall and plant growth, to provide interpretive measures of important *outcomes* such as farm incomes, the sustainability of household livelihoods more generally, and regional outcomes such as employment and economic growth. This would also provide an opportunity for a much greater array of local data to be integrated into assessment processes. Integrating local knowledge into the implementation of drought policy will become increasingly critical as the diverse regional impacts of climate change demand locally relevant adaptation.

Recent research has shown that it is possible to produce outcome-focused measures of the socioeconomic impacts of climate variability and change that are of most relevance to governments and rural communities. Kocic et al. (2007) and Nelson et al. (2007) have demonstrated how bioeconomic modelling can be used to objectively forecast the impact of climate variability on farm incomes. This overcomes the moral hazard and timing issues that have been used to justify an almost exclusive use of biophysical data to support Australian drought policy. A negative correlation between climate induced income variability and diversity of farm incomes across Australia's wheat belt uncovered in this research also provides a constructive and tractable focus for drought preparedness policy.

Advances have also been made in understanding and measuring the vulnerability and capacity of rural communities to adapt to climate variability and change. This research has begun to overcome the problems created by a narrow engineering approach to risk management of locking rural

communities into existing farming systems and livelihood strategies in response to the uncertainty surrounding climate change. Nelson et al. (2005) used the rural livelihoods analysis of Ellis (2000) to integrate the social, human, natural, physical and financial dimensions of the vulnerability of Australian rural communities dependent on broadacre agriculture. They showed that biophysical measures of exposure to climate risk provide little indication of the multiple biophysical, social and economic factors through which governments and rural communities can build capacity to cope with drought (Fig. 4). Holistic measures of the vulnerability, adaptive capacity and the resilience of rural communities will be essential for informing drought policy under the uncertainty introduced by climate change.

## 6. Conclusions

Ideas from a longstanding but little recognised literature on adaptive governance have potential to transform the way science supports Australian drought policy. Most criticisms of drought policy focus on a limited subset of its multiple, interacting objectives, and comment on them from narrow disciplinary or institutional perspectives. The result has been limited development of practical or constructive options for tackling the complex issues faced by drought policy advisers. Adaptive governance provides a completely different perspective for critiquing traditional commentary on drought policy. From this alternative perspective, the current system of administering Australian drought policy has many of the characteristics of a *centralised expert management* regime, inflexible to changing social or environmental conditions. The balanced social, economic and environmental objectives of the policy are not well reflected in the science used to

administer drought assistance, which has been heavily dominated by biophysical input measures of climate risk rather than the socioeconomic outcomes important to decision makers. This has had the unintended consequence of forcing much of the complexity and uncertainty surrounding drought policy from scientists back onto policy advisers and Australian Government Ministers for Agriculture.

Adaptive governance provides an alternative perspective for analysing Australian drought policy with potential to create practical and constructive options for policy makers seeking to balance its multiple objectives. From an adaptive governance perspective, the deep concern held by Australian society for rural communities affected by drought can be viewed as a depletable but renewable common property resource that can be sustainably managed by governments in cooperation with rural communities. Sustainable management of this resource could be facilitated through nested and polycentric governance systems similar to those that have already evolved in other arenas of natural resource management in Australia. The creation of a community-based regional tier of governance similar to Landcare groups and Catchment Management Authorities is an innovative and constructive option for managing the moral hazard issues that inevitably extend beyond the reach of traditional *centralised expert management*. They also provide a pathway to locally owned, contextually relevant systems for sharing responsibility for climate risk between communities and governments. To be effective, interactions between government and resource users in local communities need to be supported by regionally distributed scientific support capable of integrating local knowledge and informing the livelihood outcomes of critical importance to both rural communities and policy advisers.

## Acknowledgements

The authors acknowledge with thanks the significant contribution made by Steve Hatfield-Dodds to instigating and mentoring this research, without attributing any responsibility to him for its ultimate form or conclusions. Perspectives on the administration of Australian drought policy and critiques on the ideas presented in this paper were provided by policy advisers in the Australian Government Department of Agriculture, Fisheries and Forestry, who are in no way responsible for the views expressed in this paper. Thanks to Steve Crimp, Holger Meinke and two anonymous referees for helpful comments on earlier drafts. Thanks are also due to the many landholders and colleagues in Landcare, Catchment Management Authorities and State governments who motivated and informed this research.

## REFERENCES

- ABARE, 2003. Australian farm survey report. Australian Bureau of Agriculture and Resource Economics, Canberra.
- Agriculture and Food Policy Reference Group, 2006. Creating our future: agriculture and food policy for the next generation. Report to the Minister for Agriculture, Fisheries and Forestry, Canberra, February.
- Backhouse, R., 2002. The Penguin history of economics. Penguin Books, London.
- Blackadder, J., 2005. Masters of the climate: innovative farmers coming through drought. Managing Climate Variability Research and Development Program, Land & Water Australia, Canberra.
- Botterill, L., 2005. Late twentieth century approaches to living with uncertainty: the national drought policy. In: Botterill, L.C., Wilhite, D. (Eds.), From Disaster Response to Risk Management: Australia's National Drought Policy. Springer, Dordrecht.
- Botterill, L., Chapman, B., 2004. An income-related loans proposal for drought relief for farm businesses. Journal of Public Administration 63 10–19.
- Brunner, R., Steelman, T., 2005. Beyond scientific management. In: Brunner, R., Steelman, T., Coe-Juell, L., Cromley, C., Edwards, C., Tucker, D. (Eds.), Adaptive Governance: Integrating Science, Policy and Decision Making. Columbia University Press, New York.
- BRS, 2006a. BRS's role in exceptional circumstances. Australian Government Bureau of Rural Sciences: <http://www.daff.gov.au/content/output.cfm?ObjectID=4D6D2320-CA30-45E4-B90683F6A3DF97FD>, January.
- BRS, 2006b. Scientific evaluation of drought events. Australian Government Bureau of Rural Sciences: <http://www.affa.gov.au/content/output.cfm?ObjectID=BB52664E-530A-411C-A4CCA49107C70F93>, January.
- BRS, 2006c. Drought. Australian Government Bureau of Rural Sciences: <http://www.affa.gov.au/content/output.cfm?ObjectID=D2C48F86-BA1A-11A1-A220060B0A06289>, January.
- DAFF, 2007. Exceptional Circumstances. Australian Government Department of Agriculture, Fisheries and Forestry: <http://www.daff.gov.au/agriculture-food/drought/ec>, October.
- DAFF, 2006a. Australian Government drought assistance programs. Australian Government Department of Agriculture, Fisheries and Forestry: <http://www.daff.gov.au/content/output.cfm?ObjectID=9BCC9B12-B1B0-4C6D-98FD8D37ADAF229F&contType=outputs>, January.
- DAFF, 2006b. National agriculture & climate change action plan 2006–2009. Department of Agriculture, Fisheries and Forestry, Canberra.
- DAFF, 2005. Information handbook: exceptional circumstances assistance. Australian Government Department of Agriculture, Fisheries and Forestry, <http://www.affa.gov.au/content/publications.cfm?ObjectID=D43AC96E-FEB9-42A0-9A6BBCD98FA5A401>, October.
- Day, K., Ahrens, D., McKeon, G., 2003. Simulating historical droughts: some lessons for drought policy. In: Stone, R., Partridge, I. (Eds.), Science for Drought: Proceedings of the National Drought Forum. Queensland Department of Primary Industries & Fisheries, Brisbane, pp. 141–151.
- Dietz, T., Ostrom, E., Stern, P., 2003. The struggle to govern the commons. Science 302, 1907–1912.
- Drought Policy Task Force, 1997. Review of the national drought policy. Task force of officials from the Commonwealth, State and Territory Governments, Canberra.
- Drought Review Panel, 2004. Consultations on national drought policy: preparing for the future. Drought Review Panel, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.
- Ellis, F., 2000. Rural Livelihoods and Diversity in Developing Countries. Oxford University Press, Oxford.
- Hardin, G., 1968. The tragedy of the commons. Science 162, 1243–1248.
- Hayman, P., Cox, P., 2005. Drought risk as a negotiated construct. In: Botterill, L.C., Wilhite, D. (Eds.), From Disaster Response to Risk Management: Australia's National Drought Policy. Springer, Dordrecht.

- Heathcote, R., 1973. Drought perception. In: Lovett, J. (Ed.), *The Environmental, Economic and Social Significance of Drought*. Angus and Robertson, Sydney, pp. 17–40.
- Hennessy, K., Fawcett, R., Kirono, D., Mpelasoka, F., Jones, D., Bathols, J., Whetton, P., Stafford Smith, M., Howden, M., Mitchell, C., Plummer, N., 2008. An assessment of the impact of climate change on the nature and frequency of exceptional climatic events. CSIRO and the Australian Bureau of Meteorology, Melbourne, 31 pp. <http://www.bom.gov.au/climate/droughtec/>.
- Hertzler, G., 2005. Prospects for insuring against drought in Australia. In: Botterill, L.C., Wilhite, D. (Eds.), *From Disaster Response to Risk Management: Australia's National Drought Policy*. Springer, Dordrecht.
- Holling, C. (Ed.), 1978. *Adaptive Environmental Assessment and Management*. The Blackburn Press, Caldwell.
- Howard, J., 2007. Australian Government strengthens drought support. Media Release 25 September 2007, Prime Minister of Australia, The Hon. John Howard. [http://www.pm.gov.au/media/Release/2007/Media\\_Release24586.cfm](http://www.pm.gov.au/media/Release/2007/Media_Release24586.cfm)
- James, P., 1973. Economic policy for drought. In: Lovett, J. (Ed.), *The Environmental, Economic and Social Significance of Drought*. Angus and Robertson, Sydney, pp. 245–262.
- Jiggins, J., Roling, N., 2000. Adaptive management: potential and limitations for ecological governance. *International Journal of Agricultural Resources, Governance and Ecology* 1 28–42.
- Johnston, P., McKeon, G., Day, K., 1996. Objective “safe” grazing capacities for south-west Queensland Australia: development of a model for individual properties. *Rangeland Journal* 18, 259–269.
- Kokic, P., Nelson, R., Meinke, H., Potgieter, A., Carter, J., 2007. From rainfall to farm incomes – From rainfall to farm incomes – transforming advice for Australian drought policy: Part I—development and testing of a bioeconomic modelling system. *Australian Journal of Agricultural Research* 58 (10), 993–1003.
- Lacey, A., 2005. Positivism. In: Honderich, T. (Ed.), *The Oxford Companion to Philosophy*. second ed. Oxford University Press, Oxford.
- Laughlin, G., Clark, A., 2000. Drought science and drought policy in Australia: a risk management perspective. In: Wilhite, A., Sivakumar, M.V.K., Wood, D.A. (Eds.), *Early warning systems for drought preparedness and drought management*. Proceedings of and expert group meeting held 5–7 September, 2000, Lisbon.
- Lowe, I., 2002. The Need for Environment Literacy. ALNARC Online Forum 2002, ANTA National Literacy Project, Australian Government Department of Education, Science and Training (DEST), 15 March–19 April 2002, <http://www.staff.vu.edu.au/alnarc/onlineforum>.
- Martin, P., Hooper, S., Bilali, M., Puangsumalee, P., Phillips, P., Treadwell, R., 2006. Farm financial performance — investing in the future. *Australian Commodities* 13, 188–208.
- Martin, P., King, J., Puangsumalee, P., Tulloh, C., Treadwell, R., 2005. Australian farm survey results 2002–03 to 2004–05. In: Australian Bureau of Agricultural and Resource Economics, Canberra.
- Meinke, H., Nelson, R., Kokic, P., Stone, R., Selvaraju, R., Baethgen, W., 2006. Actionable climate knowledge: from analysis to synthesis. *Climate Research* 33, 101–110.
- Nagel, T., 2005. Induction. In: Honderich, T. (Ed.), *The Oxford Companion to Philosophy*. second ed. Oxford University Press, Oxford.
- NDMC, 2003. Planning for drought: the hydro-illogical cycle. National Drought Mitigation Center, <http://www.drought.unl.edu/plan/cycle.htm>, 9 Aug 2003.
- Nelson, R., Kokic, P., 2004. Forecasting the regional impact of climate variability on Australian crop farm incomes. In: ABARE eReport 04.23, Prepared for the Grains Research and Development Corporation, Canberra, December.
- Nelson, R., Kokic, P., Elliston, L., King, J., 2005. Structural adjustment: a vulnerability index for Australian broadacre agriculture. *Australian Commodities* 12, 171–179.
- Nelson, R., Kokic, P., Meinke, 2007. From rainfall to farm incomes—transforming advice for Australian drought policy: Part II—Forecasting farm incomes. *Australian Journal of Agricultural Research* 58 (10), 1004–1012.
- O’Meagher, B., 2005. Policy for agricultural drought in Australia: an economics perspective. In: Botterill, L.C., Wilhite, D. (Eds.), *From Disaster Response to Risk Management: Australia's National Drought Policy*. Springer, Dordrecht.
- Olsson, P., Folke, C., Berkes, F., 2004. Adaptive comanagement for building resilience in social-ecological systems. *Environmental Management* 34, 75–90.
- Ostrom, E., 1999. Coping with the tragedy of the commons. *Annual Review of Political Science* 2, 493–535.
- Ostrom, E., 1990. *Governing the Commons—The Evolution of Institutions for Collective Action*. Cambridge University Press, Cambridge.
- Pearce, D., Warford, J., 1993. *World without end: economics*. In: *Environment and Sustainable Development*, Oxford University Press, Oxford.
- Stafford Smith, M., 2005. Living in the Australian environment. In: Botterill, L.C., Wilhite, D. (Eds.), *From Disaster Response to Risk Management: Australia's National Drought Policy*. Springer, Dordrecht.
- Stoneham, G., Ha, A., Harris, J., Fisher, B., Strappazon, L., 2004. *Incentives Information and Drought Policy*. State of Victoria Department of Primary Industries, Melbourne.
- Thompson, D., Powell, R., 1998. Exceptional circumstances provisions in Australia—is there too much emphasis on drought? *Agricultural Systems* 57 (3), 469–488.
- Truss, W., 2005. New national rural advisory council members announced. Media release, Australian Government Minister for Agriculture, Fisheries and Forestry: <http://www.maff.gov.au/releases/05/05130wt.html>, 15 May.
- Wilhite, D., 2005. Drought policy and preparedness: the Australian experience in an international context. In: Botterill, L.C., Wilhite, D. (Eds.), *From Disaster Response to Risk Management: Australia's National Drought Policy*. Springer, Dordrecht.
- White, D., Botterill, L., O’Meagher, B., 2005. At the intersection of science and politics: defining exceptional drought. In: Botterill, L.C., Wilhite, D. (Eds.), *From Disaster Response to Risk Management: Australia's National Drought Policy*. Springer, Dordrecht.
- Wilhite, D.A., 1993. Planning for drought: a methodology. In: Wilhite, D.A. (Ed.), *Drought Assessment, Management, and Planning: Theory and Case Studies*. Kluwer Academic Publishers, Boston, pp. 87–108.
- Woolcock, M., 1998. Social capital and economic development: toward a theoretical synthesis and policy framework. *Theory and Society* 27, 151–208.

**Rohan Nelson** is a Resource Economist and Research Group Leader with CSIRO’s Division of Sustainable Ecosystems. He leads multi-disciplinary teams of scientists, economists and social scientists providing integrated analytical support to farmers, natural resource managers and policy advisers. Dr Nelson’s work includes the design of science-based governance systems that support rural communities and industries in their ongoing efforts to adapt

to global change. His interest in the societal relevance of science has been recognised through affiliation with the Consortium for Science Policy Outcomes (CSPO) at Arizona State University.

**Mark Howden** is the Leader of the “Adaptive Primary Industries and Enterprises” theme within CSIRO’s Climate Adaptation Flagship. Mark works with farmers, farmer groups and policy makers building their capacity to deal more effectively with climate variability and change by developing more innovative and sustainable agricultural systems in Australia. He has also developed national and international agricultural greenhouse gas emission inventories and assessed sustainable methods of reducing these emissions. Dr Howden has been a major

contributor to the Intergovernmental Panel on Climate Change (IPCC) sharing the 2007 Nobel Peace Prize with other IPCC participants and Al Gore.

**Mark Stafford Smith** is the Science Director of CSIRO’s Climate Adaptation Flagship, working with the leaders of four research themes and external partners to deliver strategies and tools that will allow Australia to minimise the risks and maximise the opportunities resulting from climate change. Previously he has worked on the science of desert living and sustainable management of Australian outback environments, with a particular focus on managing climate variability in rangelands and grazing enterprises.