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People versus planners: Social Preferences for Adaptation to Climate Change

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Abstract

Increasing attention is being given to adaptation of natural and human systems to climate change. The academic literature covers a wide spectrum of perspectives. Policy considerations, on the other hand, are driven largely by techno-scientific considerations, including in particular a risk-management approach. However, the inherent uncertainties of climate change mean that conventional risk-management approaches are inappropriate because the risks cannot be quantified. Economic theory, in the form of 'real options', offers a conceptual alternative for specifying least-cost adaptation strategies. But little, if any, work has been undertaken to identify individuals' preferences and priorities, a necessary precondition to estimating the benefits of adaptation measures. It is therefore proposed to identify and compare the priorities and preferences of planners, communities and individuals as a first step towards estimating individuals' willingness to pay for adaptation measures.

1.0 INTRODUCTION AND BACKGROUND

When awareness of potential climate change first percolated beyond the circle of specialist scientists a quarter of a century ago, there was a degree of recognition that any mitigation of emissions of anthropogenic greenhouse gas emissions would need to be complemented by at least some adaptation to the effects of climate change. Pielke *et al* (2007, p. 597), for example, state that ‘during early policy discussions on climate change in the 1980s, adaptation was understood to be an important option for society’.

Nevertheless, the issue of adaptation was given relatively little attention compared to mitigation over about a decade or so from the mid-1990s. This is readily apparent from the reports of the Intergovernmental Panel on Climate Change since its First Assessment Report in 1990. Klein *et al* (2007, p. 753), for example, acknowledge that ‘the UNFCCC [United Nations Framework Convention on Climate Change], its subsidiary bodies and Member Parties have largely focused on mitigation’. And Schneider *et al* (2007, p. 797) concede that ‘the scientific literature on [adaptation] is less well developed than for mitigation, and the conclusions are more speculative in many cases’.

Commentators like Tol (2005, p. 572) have claimed that ‘it was politically incorrect to speak about adaptation to climate change, because it presumably implies accepting defeat in the battle against evil emissions’, and Pielke et al (2007, 597) support this view. A further contributory factor to the relative lack of attention to adaptation issues was probably a high degree of uncertainty inherent in the modelling of climate change, including clear detection of an ‘enhanced greenhouse effect’ (Wigley and Barnett 1990, p. 253).

Even today it may be that climate change scientists are generally less willing to countenance the possibility of adaptation. In an article on adaptation to climate change in a scenario of 4˚C global warming, for example, Vince (2009, p. 29) reports that:

> ‘If this happens [4˚C global warming by 2050], the ramifications are so terrifying that many scientists contacted for this article preferred not to contemplate them, saying only that we should concentrate on reducing emissions to a level where such a rise is known only in nightmares. Climatologists tend to fall into two camps: there are the cautious ones who say we need to cut emissions and won’t even think about high global temperatures; and there are the ones who tell us to run for the hills because we’re all doomed,” says Peter Cox, who studies the dynamics of climate systems at the University of Exeter, UK.’

The current discourse on climate change is becoming more inclusive, but often still precludes full consideration of adaptation, driven perhaps in part by the UNFCCC notion of ‘dangerous climate change’. One underlying theme is that adaptation is feasible up to a level such as a temperature increase of 2 C above pre-industrial levels, but that increases above this threshold need to be tackled through mitigation rather than adaptation. Adger et al (2009) explore some of the associated concepts.

This paper reviews broadly the approaches adopted by a number of different professional interest groups to the issue of adaptation and outlines an economic perspective. It then posits that the priorities and preferences of professionals and subject-matter experts may not necessarily match or reflect those of society in general. The current discourse on adaptation is therefore potentially biased in favour of issues that may be of only subsidiary interest to those Australian residents who will be affected.

An approach is outlined below that aims to identify the priorities and preferences of *all* Australian residents. To enable a better assessment of their relative priorities and preferences, it is proposed that a scoping study should be conducted to provide – for the first time – information on Australians' preferences and priorities in terms of adapting to climate change. This is a necessary first step towards conducting 'stated preference' investigations to assess Australians' willingness to pay to avoid the effects of climate change through adaptation measures. The final results will therefore facilitate the application of Cost-Benefit Analysis to specific adaptation measures that may be proposed by the various levels of government.

2.0 WHAT CONSTITUTES ADAPTATION TO CLIMATE CHANGE?

Despite being a seemingly straightforward concept, the nature of adaptation to climate change requires better definition if research and policy formulation are to develop along consistent lines.

Pielke (2005) explores the consequences of differing definitions of climate change adopted by the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). Because the UNFCCC limits the concept of climate change to 'changes in climate that result from greenhouse gas forcing of the climate system' (p. 549) it excludes consideration of changes in climate that are due to other causes such as radiation from the sun.

Although the IPCC uses a wider definition of climate change, Pielke (2005, p. 555) provides an example where its three working groups have used different definitions. The difference may seem inconsequential, but can make a significant difference in terms of policy formulation relating to adaptation to climate change.

Further, there are many ways of characterising climate change. Temperature increase, loss of ice sheets, or lower precipitation, for example, can be used as proxies for overall climate change. Berkhout (2005, p. 380) points out that climate and weather are many-faceted. In terms of adaptation, 'cold, wet and windy would be experienced differently than cold, wet and still' because higher wind speeds may require water-tightness in buildings that extends beyond flood defences, compared to higher precipitation alone. Even where a particular change in climate is specified (e.g. hotter, drier), then the effect on farmers will differ to the effect on ice-cream sellers, so that the perspective of the socio-economic group affected is also relevant to characterising desirable adaptation action.

The possibility that climate change can have differential effects within society also raises the possibility of beneficial outcomes from apparently malign climate change effects. A pertinent example is a recent study by Ludwig et al (2009) who modelled the effect of a large decline in rainfall on a number of sites in the Western Australian wheatbelt. Simulations indicated that not only did crop yields not fall, but leaching of fertiliser decreased (thus reducing costs to farmers), and the spread of dryland salinity was reduced significantly. The beneficial outcomes obtained were based partly on minor variations in planting periods for two wheat varieties.

Social perceptions of the effects of climate change will inevitably change over time, and will therefore affect concepts of requisite or desirable adaptation. For example, the summer 2003 heat wave in Europe is considered to have caused significantly more deaths among the elderly than normal, and understandably led to considerable public concern. However, one can also envisage a situation where habituation over a longer period will result in heat-related deaths among the elderly being regarded as a 'normal' aspect of European summers, a point also made by Oppenheimer (2005, p. 1404). It is therefore necessary to recognise that the perceived nature of adaptation is something that can change over time.

A working definition of adaptation provided by Working Group II in the Technical Summary (Parry et al, 2007, p. 27) of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) is used in this paper because it is sufficiently broad and flexible:

> '*Adaptation* is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.'

This definition is particularly useful because it encompasses climate change from whatever source, includes both human and natural systems, includes potential benefits, and provides for expectations as well as concrete impacts. Note that it does not include adjustment to non-physical effects such as higher carbon prices due to the implementation of mitigation policies.

Finally, some adaptation measures may involve 'spin-off' mitigation effects. For example, a farmer may adapt to a drier climate by replacing a herd of dairy cows with a tree plantation. The indirect effect of reducing greenhouse emissions is a subsidiary one. Even though it may confer an additional social benefit in the form of a positive externality, only its 'adaptation' aspect is of relevance in this paper.

3.0 POLICY FORMULATION BY AUSTRALIAN GOVERNMENTS

In December 1992, the Council of Australian Governments (COAG) endorsed a National Greenhouse Response Strategy (Commonwealth of Australia, 1992). The Strategy focused primarily on measures for reducing emissions of greenhouse gases, but also reported current and prospective research into the effects of sea level rise and extreme weather events, as well as strategies for research and planning that would take into account the effects of climate change.

However, little further active political consideration was given to the issue until February 2006, when COAG agreed to a Climate Change Plan of Action (http://www.coag.gov.au/coag_meeting_outcomes/2006-02-10/docs/attachment_c_climate_change.pdf) that included a call for development of a national adaptation framework. A further meeting, in April 2007, endorsed a National Climate Change Adaptation Framework (http://www.coag.gov.au/coag_meeting_outcomes/2007-04-13/docs/national_climate_change_adaption_framework.pdf).

Although Australian governments have generally devoted more attention in recent years to issues associated with the mitigation of greenhouse gas emissions, rather than the amelioration of climatic change through adaptation strategies, all three levels of government have now begun to focus more closely on adaptation measures.

The Commonwealth Government has also published various assessments of the potential effects of climate change, including consultants' reports by The Allen Consulting Group (2005), Voice et al (2006), Clark et al (2006), Steffen et al (2006), SMEC Australia (2007), and Amitrano et al (2007). In general, these reports share two main common features: they are risk-based, and they are necessarily (but inappropriately for work on adaptation) national rather than local in nature. They are effectively 'top-down' approaches.

Late in 2007, the Commonwealth Government announced the establishment of the National Climate Change Adaptation Research Facility (NCCARF) at Griffith University. The NCCARF aims to coordinate and lead the Australian research community in generating biophysical, social and economic information and tools that can assist adaptation to climate change. A key role of the Facility is to coordinate development of National Adaptation Research Plans (NARPs) across the eight priority areas that it has identified. Consultation with stakeholders on NARPs has begun and calls have been made for applications for grant funding.

Because NNCARF has adopted a sectoral framework (see below) that focuses on techno-scientific biophysical aspects, it would not be surprising if the bulk of its grant funding were directed to research in those areas, rather than the social sciences. If that were the case, it would follow the pattern evident in grants awarded by the Australian Research Council over the last few years.

In 2008, the Commonwealth Government let a major consultancy intended to provide an assessment of the impacts of climate change on infrastructure in the power, transport, communications, mining, tourism, defence and buildings and settlements sectors. The title of the consultancy, National Infrastructure Climate Change Adaptation Risk Assessment (NICCARA), indicates that its focus is one of risk assessment, and, presumably, risk management.

However, the Commonwealth Department of Climate Change in mid-2009 also commissioned an economic analysis of the implications of climate change impacts on Australian infrastructure. Awarded to Maunsell (now AECOM), the contract is intended to produce a series of case studies. This is a particularly encouraging and praiseworthy development, because, for what appears to be the first time, it appears to be the intention to apply genuine cost-benefit analysis rather than the more conventional risk-management approach.

State and territory governments have generally commissioned risk-based assessments. An example is State of Victoria (2007), which was undertaken largely by an engineering firm (Maunsell, now AECOM) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

State governments have also undertaken a number of large infrastructure projects, ostensibly in response to perceived climate change. For example, the NSW Government is constructing a desalination plant at Kurnell, and Victoria has commissioned one to be built in the Wonthaggi region, off the Gippsland coast. In Queensland, the Gold Coast desalination plant is already operational and other water infrastructure has been commissioned. Despite the rhetoric, however, it is not entirely clear whether such projects are driven primarily by the more current exigencies of severe water shortages combined with community resistance to recycling of waste water, rather than by longer-term responses to projected climate change.

In 2008, the new Rudd Government provided funding of $1.5 million to more than 60 local governments under its Local Adaptation Pathways Program to undertake projects aimed at identifying climate change risks, developing action plans and holding workshops. Local governments have also undertaken studies collaboratively to ensure more integrated assessments of regional needs. Sydney's coastal councils cooperate in various ways, including through joint risk-assessment studies (e.g. Preston et al, 2008). In Victoria, an example of regional cooperation is the area around Geelong where several shires have combined (Norman 2009).

Local government bodies also cooperate at various levels and through various specialist organisations. For example, the Stormwater Industry Association held a workshop entitled 'Adapt, Mitigate, or Perish: the Effects of Climate Change on Stormwater Management' in Sydney in September 2009. As might be expected, the focus of attendees was on practical matters, but a sense of frustration was also apparent because of the plethora of legal obligations faced by local government, although the uncertainties of climate change make it difficult to determine precisely what needs to be done and when.

3.1 Some possible principles for government action

While it is not the primary focus of this paper, there would seem to be scope for the development of a set of overarching principles that might guide a Federal approach to adaptation strategies.

> By definition, adaptation measures need to address local requirements, rather than 'one size fits all' national parameters. Under the organisational principle of subsidiarity, adaptation measures and strategies should be identified and implemented as closely as possible to the individual, community or local government level. Only where action is more effective on a State level – for example, constructing a desalination plant that is intended to serve a capital city or several regions – should higher levels of government be directly involved.
>
> State and Federal governments, as major collectors of public revenues will undoubtedly need to continue to fund major adaptation measures. However, further development of funding principles at an early stage would be beneficial to provide greater certainty. It may be preferable, for example, to clarify that adaptation expenditure on residential housing is the sole responsibility of private individuals, emergency services may be better funded at a State level, etc. Where externalities are involved, there is a presumption of government involvement.
>
> Both adaptation to climate change and measures to mitigate greenhouse gas emissions are likely to place additional economic burdens on the community. To minimise the use of scarce resources in the adjustments that will be required, a key principle that could be usefully adopted is that of ensuring that all major spending initiatives are subjected to a rigorous social cost-benefit analysis. Given the uncertainty that characterises climate change, an important component of any cost-benefit analysis would need to be the identification and valuation of any potential real options. Equally important, cost-benefit analyses should consider all major alternatives, including removal of regulatory barriers to adaptation.

> Establish a mechanism for transparent sharing of information on adaptation, including research, consultancy reports, and cost-benefit studies. All information should be made publicly available to promote discussion and opportunity for continuous improvement of measures and strategies.

Formulation of an agreed set of principles by the various levels of government would help ensure an orderly, integrated and efficient approach to adaptation to climate change. The 7 December 2009 COAG communiqué (Council of Australian Governments 2009, item 8) has foreshadowed more detailed consideration in early 2010 of adaptation issues.

4.0 ACADEMIC PERSPECTIVES ON ADAPTATION

The output of academic literature on adaptation to climate change has increased noticeably over the last five years or so. It covers a large range of perspectives; a range that will undoubtedly expand further as researchers attempt to amalgamate evolving climate change science with the uncertainties of many possible scenarios of the future.

It is worth noting that the approach taken in this paper contrasts with much of the literature on adaptation to climate change. Much of the literature is focussed on issues of vulnerability (the susceptibility of a natural or social system to climate change in terms of its exposure and sensitivity) and adaptive capacity (the ability of a natural or social system to adjust to climate change), often quantified on the basis of indexes or selected attributes or characteristics. In contrast, the approach here is focused on identifying the priorities and preferences of individuals in responding to actual or perceived climatic changes, and hence estimating costs and benefits to society as a whole.

The diversity of current perspectives is obvious from even a limited selection of examples. Orlove (2005) examines the collapse of the classic Mayan civilisation, the 1930s Dust Bowl in America, and the abandonment of Viking settlements in Greenland in an attempt to draw relevant anthropological lessons. Hallegatte *et al* (2007) adopt an analogue approach, positing that the Parisian climate may become more like that of Bordeaux or Cordoba, so that planners need to adapt appropriately. England (2007) and McDonald (2007) explore aspects of legal liability faced by local authorities in dealing with the effects of climate change. Berkhout *et al* (2006) examine the willingness of business entities to take adaptive action. McMichael (2004) and Woodruff *et al* (2006) fret about the spread of malaria and dengue fever. Du Vair *et al* (2002) report melting roadways and buckled rail lines. And Furnass (2007) raises the bogey of the invasion of Australia by environmental refugees.

The very diverse range of academic literature in the field is itself a good indicator of the fact that there is as yet little or no consensus on analytical methodology, or even which aspects of adaptation merit the most attention.

5.0 SECTORAL FRAMEWORKS

As can be seen from table 1 below, sectoral frameworks used by the IPCC, COAG and NCCARF reflect a common focus on specific sectoral and biophysical effects that are influenced by variables such as temperature and rainfall. Catch-all categories such as ‘industry’, ‘society’, and ‘social, economic and institutional’ appear separately as discrete considerations; virtually as afterthoughts or residuals.

The sectoral approach also appears to be highly influenced by 'top-down' perspectives, presumably because of the strong involvement of planners and bureaucrats. Obvious biophysical effects such as those affecting 'primary industries', 'water resources' and 'food, fibre and forest products' are given prominence. The same degree of attention is not given to backyard vegetable gardens, the viability of golf courses, urban forests, the building of bird baths to ensure the survival of avian species in urban areas, or a myriad of other preferences and priorities that may be dear to individuals and communities.

Economists might further wonder why primary and secondary industries are given such prominence, but the tertiary sector is included only tangentially, if at all. Historians, might well wonder why, in a country like Australia that has traditionally had to cope with climatic extremes, there is no readily apparent category for research that might draw on lessons from the past. And psychologists, lawyers and anthropologists could validly advocate the relevance of their disciplines to the analysis of future social attitudes and responses to climate change. With a bit of licence or creativity, all of these disciplines could be accommodated.

Table 1 Sectoral coverage of adaptation to climate change

IPCC (1)	COAG (2)	NCCARF (3)
health	human health	human health
coastal systems and low-lying areas	coastal regions	marine biodiversity and resources
	natural disaster management	emergency management
freshwater resources and their management	water resources	water resources and biodiversity
ecosystems	biodiversity	terrestrial biodiversity
food, fibre and forest products	agriculture, fisheries and forestry	primary industries
industry, settlements and society	settlements, infrastructure and planning	settlements and infrastructure
	building adaptive capacity (research, communication, international collaboration)	social, economic and institutional dimensions of climate change
	tourism	

Sources:
(1) M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (2007), Summary for Policymakers, p. 11
(2) Council of Australian Governments (2007)
(3) http://www.nccarf.edu.au/national-adaptation-research-plans, viewed 6 May 2009

An unfortunate side-effect of treating the social sciences as residual issues is that research effort may be wasted or hampered. Collection of data on specific biophysical effects, for example, may not easily lend itself to economic analysis if not accompanied by corresponding valuations. Further, if communities are subjected to follow-up investigations or surveys to obtain the requisite information, respondents may not be as forthcoming or willing to cooperate.

Some of the differences between the IPCC, COAG and NCCARF categorisations are also interesting. The IPCC has not separately identified a category of disaster management (which COAG communiqués now associate with climate change), possibly because of a lack of published literature in the field. However, it includes a general "industry" category, whereas COAG and NCCARF limit themselves to the primary industry sector. And the inclusion by COAG of the "tourism" sector, alone out of all other possible socio-economic inclusions, is intriguing, to say the least.

It is not entirely clear how or why the categorisations were initially conceived, although one could arguably speculate that they owe much to the preponderance of techno-scientific researchers in the climate change field over the last few decades. An alternative might be to revisit the IPCC Working Group II definition of adaptation quoted above. Table 2 indicates how the definition might be aligned with sectoral categories in a way that reflects more neutrally both natural and human systems.

Table 2 An alternative sectoral categorisation of adaptation to climate change

Natural systems	Human systems
terrestrial	producers (primary, secondary, and tertiary industries)
marine	consumers (of all goods and services, including the environment, housing, golf courses, etc)
atmospheric	government (provision of public goods and services such as Defence, as well as consumer goods such as water, etc)

The advantage of this alternative categorisation is that it is more comprehensive, as well as being simpler and less 'siloed' in nature. Inclusion of the 'government' category allows the introduction of areas such as Defence, where the Navy, for example, has an interest in adaptation to climate change. The table also reflects both supply (industry, government) and demand (consumer) aspects of socio-economic relationships. Current approaches, determined largely by planners and 'experts', tend to focus on production aspects, perhaps influenced (incorrectly) by notions that economics is concerned primarily with the level or growth of Gross Domestic Product.

6.0 SCIENTIFIC VERSUS HUMAN-SECURITY FRAMINGS

O'Brien *et al* (2007) usefully distinguish and describe two broad conceptual approaches taken by researchers to the issue of adaptation to climate change. They posit that the two streams are not readily reconcilable, primarily because their different 'framings' of the climate change problem lead them to pose different questions and seek different knowledge: framings 'determine what is on the agenda, and what is silenced' (p. 76).

Figure 1 below is used by O'Brien *et al* (2007, p. 75, figure 1) to illustrate the difference in analytical approach that is generally associated with different 'framings' of adaptation issues.

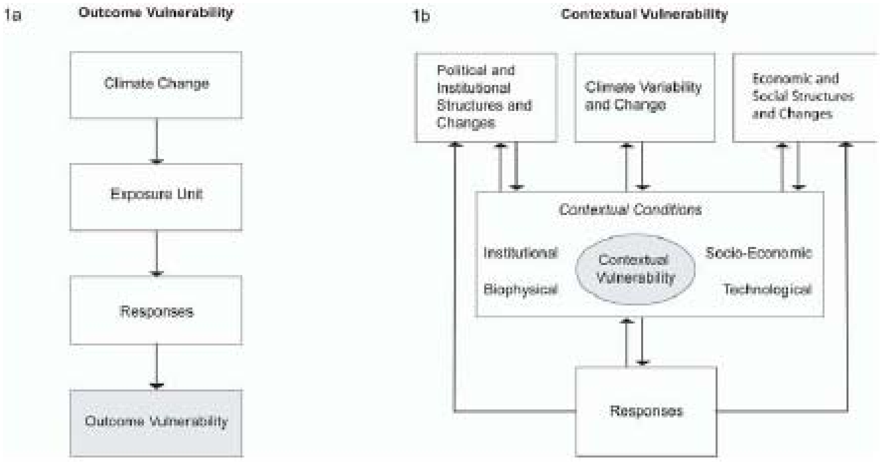


FIGURE 1 Frameworks depicting two interpretations of vulnerability to climate change: (a) outcome vulnerability; (b) contextual vulnerability.

According to O'Brien *et al* (2007, p. 76), 'scientific framings' take as a starting point that human impacts on the global climate system are the cause of the problem of climate change. Society and nature are seen as distinct entities, and research is focused on changes that can be attributed to the emission of greenhouse gases.

> 'In the scientific framing of climate change, society is typically represented as one box that both drives the process and experiences the consequences. Vulnerability is interpreted as the negative outcome of climate change on any particular exposure unit – an outcome that can be quantified and measured, and reduced through technical and sectoral adaptation measures, as well as by reducing greenhouse gas emissions. ... this framing tends to favour a physical-flows view that emphasizes the flow of matter and energy between systems components.' (p. 76)

So-called 'human-security framings', on the other hand, take as a starting point that climate change affects humans in different ways 'and focuses on the consequences of climate variability and change for individuals and societies' (p. 76). Nature and society are not distinguished in this framing, which is concerned with the whole gamut of social institutions and human behaviour in the process of adaptation.

> 'Human security may involve more than food security or economic performance, and could include such aspects as a sense of belonging, respect, social and cultural heritage, equality and distribution of wealth, dispersed settlement, access to nature-based outdoor activities, and control over one's own destiny. ... Furthermore, it may be that the more subtle impacts have greater relevance to individuals and communities (such as skiing in Norway or gardening in England), and these are often disregarded as trivial based on quantitative economic measures of vulnerability to climate change.' (O'Brien et al., 2007, p. 77)

While one can agree with O'Brien et al (2007) that some economists of a quantitative bent may focus on variables where data are readily available, economic theory – particularly welfare economics and cost-benefit analysis, which are based on the concept of 'consumer sovereignty' – requires that all relevant preferences be taken into account. The priorities of experts alone are not sufficient. However, little research appears to have been undertaken to date to identify, let alone quantify, individuals' priorities and preferences in terms of adaptation to climate change.

7.0 CURRENT AUSTRALIAN PARADIGMS: A CONCEPTUAL CUL-DE-SAC?

Although practical analyses of adaptation issues in Australia are not particularly numerous, the approach taken to date can be said to more generally fit a 'techno-scientific' framing. One or more future climate scenarios tend to be chosen, biophysical and socio-economic effects are identified by techno-experts and stakeholders, and adaptation responses are proposed. This approach can be categorised as being 'top-down', linear and deterministic.

Nevertheless, it is also possible to discern two separate, but not entirely compatible strands within this general deterministic approach.

> One strand is firmly rooted in the risk-management approach espoused by Standards Australia/Standards New Zealand (2004) and popular in technical disciplines such as engineering, and among many consultants.
> The other strand focuses on the degree of residual vulnerability of a system after adaptive action has been identified and taken.

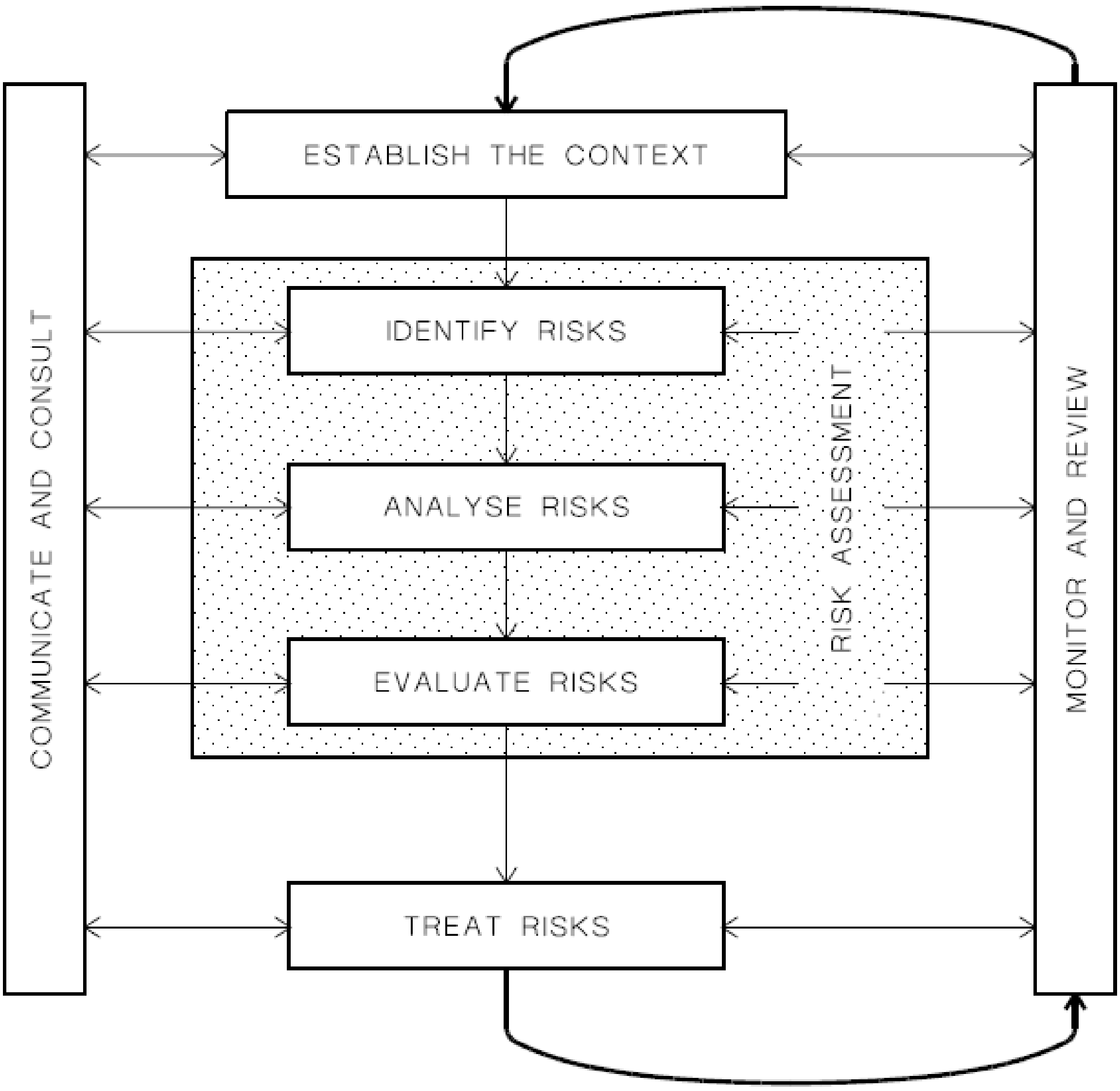
7.1 The risk-management strand

The basic features of the risk-management approach are presented in Figure 2 below, the conventional Standards Australia and Standards New Zealand depiction of the risk management (AS/NZS 4360) process. While communication and consultation, as well as monitoring and review, are specified for each stage, the thrust of the approach is to identify risks, consider their potential impact and then take action. There is a sense of developing knowledge in an objective and systematic manner, and then taking a clear course of action.

However, the AS/NZS 4360 risk management standard lacks a concept of optimality of risk (where the additional cost of reducing risk is just offset by marginal benefit achieved), and seems to assume implicitly that total elimination or significant amelioration of risk is desirable in itself. (Illustrative of this thinking is the use of the term 'climate-proofing'. Though not precisely defined, its use seems to be associated with a sense of totally eliminating, or at least largely offsetting the biophysical effects of climate change.) Financial cost and benefit is referred to in section 3.6.3 of AS/NZS 4360 regarding sharing of risk through insurance and other mechanisms, but an economic perspective appears to be lacking.

The risk-management strand forms the basis of the approach taken in Australian Greenhouse Office (2006) and in Australian Greenhouse Office (2007). It is thus unsurprising that both publications were prepared by risk-management oriented consultants such as Marsden Jacob Associates, Broadleaf Capital International and SMEC Australia.

Figure 2: overview of risk management process.



Source: Standards Australia and Standards New Zealand (2004, p. 9).

An example of the application of the risk-management approach is the review by Kinrade and Justus (2008) of the potential impacts of, and adaptation to climate change on behalf of five councils in the Western Port region of Victoria. (Of the organisations involved in the review, Marsden Jacob Associates and Broadleaf Capital International appear to have played key roles.) Following extensive consultation with various stakeholders, the study noted (p. 31) that:

> ' ... well over 200 climate change risks were identified through the course of the risk assessment phase ... Of those 200 risks, only seven were carried forward for consideration in the adaptation phase of the project. That phase, in turn, resulted in over 150 policies and measures being identified ... This outcome indicates the magnitude of the task ... and points to the critical importance (in terms of resources and efficiency) of prioritising climate change risks and adaptation response.'

Despite acknowledging the 'critical importance' of ensuring the efficient use of society's resources, the study employed multicriteria analysis (p. 13) to establish community priorities, a technique that is entirely unsuited to the task: Dobes & Bennett (2009). In short, the risk-management approach is not suited to providing decision-makers with a method of prioritising adaptation measures in terms of net benefit to. Rigorous cost-benefit analysis would be required to achieve this objective.

7.2 The net vulnerability strand

The vulnerability of a community or an ecosystem to climate change can be considered in terms of risk or potential damage in the absence of countervailing adaptation measures. Alternatively, it can be conceptualised as a residual, or 'net' concept of vulnerability *after* adaptation measures have been implemented.

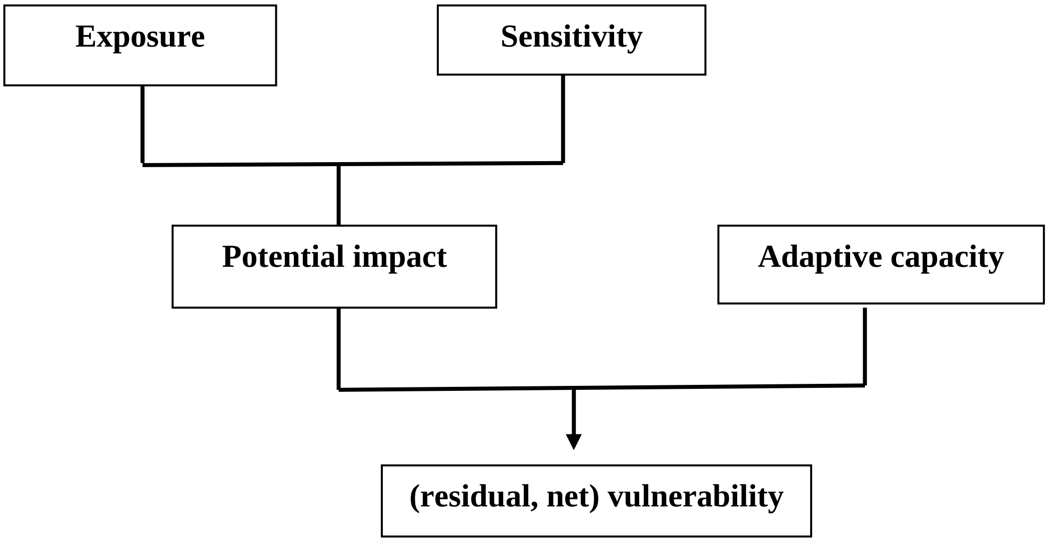
As might be expected, there is a considerable body of literature on the concept of vulnerability (see for example the review by Preston & Stafford-Smith 2009), and various definitions are used. A commonly cited definition is the one used by the Intergovernmental Panel on Climate Change (2007, glossary, p. 883):

> 'Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.'

Figure 3 illustrates the concept, and also underlines the fact that vulnerability is also based on an assessment of the impact of climate change on biophysical and socio-economic systems. Gross vulnerability itself is a function of the exposure of a system, combined with its sensitivity to climate change. The degree of final vulnerability in figure 3, however, is a 'net' concept, because it is assessed after taking into account the ability of a biophysical or socio-economic system to adapt to inherent sensitivity and exposure to climate change impacts. In other words, it is a 'residual' vulnerability. For a given level of potential (gross) vulnerability, a system with high adaptive capacity will have a lower net vulnerability.

An example of the application of this approach is Preston et al (2008), the first stage in assessing and mapping various aspects of climate change vulnerability in the Sydney coastal region. The study specified vulnerability indicators for exposure (e.g. days over 30˚C per year), sensitivity (e.g. percentage of population over 65) and adaptive capacity (e.g. percentage of population completing year 12) for heat, extreme rainfall, sea-level rise, bushfires, and ecosystems and natural resources. Indicators were then scored, and expert-determined weights (p. 41) to reflect relative perceived importance were applied to obtain overall scores of net vulnerability.

Figure 3: Vulnerability and its components



Source: adapted from Australian Greenhouse Office 2005, p. ix

Pointing out that 'irreducible uncertainty' makes quantitative prediction 'questionable' using risk-based approaches, Preston et al (2008, p. 15) nevertheless also recognise that vulnerability assessments have their own significant practical limitations:

> ' ... vulnerability does not predict explicit outcomes or the likelihood of outcomes. Rather it reflects where the greatest potential for harm lies, and elucidates the various factors that may contribute to the harm and how they interact. ... The Achilles Heel of vulnerability, however, is adaptive capacity, a concept that is challenging to quantify for the present, much less project into the future ... Researchers are poorly equipped to project relationships between drivers of environmental change and environmental responses into the future while simultaneously accounting for the changing context of the interaction due to shifts in socio-economic conditions ... Furthermore, while actions to manage current vulnerability may be argued to be robust 'no regrets' measures, it is often difficult to provide a cost justification for the investment, as the analysis necessary to demonstrate a long-term positive return on the investment is absent. ... This in turn inhibits attempts to integrate information regarding vulnerability into existing decision-making frameworks. For example, it may be self-evident that bolstering defences around a flood-prone area will reduce vulnerability to future floods, but in the absence of information regarding the cost-effectiveness of the approach, it remains unclear whether such an investment is a good one. Judging such cost-effectiveness requires knowing something about future risk. This limitation is particularly relevant to issues of climate change and local governments charged with making risk management decisions.'

An earlier study into the health impacts of climate change in Western Australia and potential adaptation strategies (Western Australian Department of Health, 2007) also used a vulnerability approach, combined with a risk assessment. It reached a similar conclusion (p. 4) about the limitations inherent in the methodology:

> ‘It was recognised that the lack of detailed knowledge of future climatic conditions in Western Australia, the future distribution and densities of populations and the development of associated infrastructure did not allow for a comprehensive and quantitative assessment of health impacts. What emerged from this project, however, was a good understanding of current activities, their adequacy with respect to health and a range of adaptations and required supporting research.’

7.3 The conceptual cul-de-sac

Implicit in both the ‘risk-management’ and the ‘net vulnerability’ approaches is the ability to identify and quantify risk in order to formulate appropriate responses. Both approaches require to some degree that underlying or residual risk can be estimated to some level of precision. However, the hallmark of climate change is that it is characterised by uncertainty[1].

Schneider (2001, p. 18) argued that policy makers require probability estimates to assess the seriousness of climate change impacts under various scenarios analysed by the Intergovernmental Panel on Climate Change (IPCC). He therefore urged the authors of the Special Report on Emissions Scenarios (Nakicenovic & Swart, eds., 2000) to provide at least subjective probability assessments for less expert users of the report.

Two of the authors of the Special Report on Emissions Scenarios, Gruebler & Nakicenovic (2001, p. 15), rejected this suggestion from a scientific perspective because of the lack of repeated experiments, lack of independent observations, and the fact that all probabilities were conditional on a multitude of socio-economic and other developments. They concluded that:

> ‘The levels of future greenhouse-gas emissions and the ensuing climate change remain uncertain; *we need adaptive response strategies that explicitly recognise these uncertainties*. ... There is a danger that Schneider’s position might lead to a dismissal of uncertainty in favour of spuriously constructed ‘expert’ opinion.’ (emphasis added)

Oppenheimer (2005) examined the issue of what constituted ‘dangerous climate change’ using the melting of the West Antarctic and Greenland Ice Sheets as example indicators, but concluded that science alone could not define the level with any degree of certainty, citing (p. 1403) others to the effect that ‘Delphi expert elicitation ... yielded a probability function for disintegration [of the ice sheets] that was essentially flat’. The implication was that all scenarios were approximately equal in probability.

Betz (2007) similarly argued that the lack of unconditional probabilities and small sample sizes do not warrant the use of a classical, frequentist approach. Bayesian methods provide one alternative by updating a prior distribution in the light of new information or evidence. However, convergence of updated posterior probabilities will only occur in the long run, so that ‘small sample sizes entail that the posterior probability is a function of the initial prior’ (Betz, 2007, p. 4). But given that the prior will depend on the model simulation chosen, it is a highly arbitrary method of determining a probability. The second alternative to classical

[1] Risk and uncertainty are used loosely in everyday speech in different ways, and often interchangeably, creating ambiguity. However, they are distinguished here on the basis that risk is measurable and its probability distribution is known or can be estimated, while uncertainty cannot be quantified due to lack of sufficient information.

statistical methods is use of expert elicitation, which is similarly subjective. Despite the controversy over the propriety of attaching probabilities to climate change scenarios, the IPCC Fourth Assessment Report did provide probability statements for a number of its model-based scenario simulations, notably temperature, and Betz advises (p. 8) decision makers to ignore them and to stick with the entire range of possible scenarios.

Given that it is not objectively possible to attach specific probabilities to different scenarios it follows that conventional risk-management approaches to addressing adaptation are inappropriate, and their continued pursuit is the equivalent of a conceptual cul-de-sac.

8.0 AN ALTERNATIVE DISCOURSE: THE ECONOMIC PERSPECTIVE

Analysis of mitigation measures is particularly problematic because the costs are generally borne fully by the party reducing their emissions, but the benefits are shared jointly across the globe. Adaptation is conceptually more straightforward, because those communities that bear the costs are generally also the direct beneficiaries, whether at a personal or a national level.

Nevertheless, the economic analysis of adaptation strategies needs to address four complicating issues.

The first of these is uncertainty about both the extent and timing of climate change. Fortunately, the identification of 'real options', both as a practical strategy, and as an analytical tool that fits neatly into cost-benefit analysis, may offer a viable solution in many cases.

Second, the cost of an adaptation measure or strategy is relatively easy to estimate. For example, estimating the cost of raising a road above expected flood levels or strengthening a bridge to withstand stronger winds is a relatively uncomplicated process. Computational ease can reinforce the tendency to undertake an obvious problem-eliminating 'engineering' solution. In essence, a 'bigger hammer' is used to solve the problem. To the extent that the 'bigger hammer' is more costly than a solution that is based on positive net social benefits, it should not be accepted by policy makers. Socially costly solutions will unnecessarily deplete the scarce resources available to a society that faces multiple adaptation needs.

The third issue is the common use of 'defensive expenditure' or 'damage avoided' methods to estimate the benefits of adaptation strategies. For example, Stewart and Li (2009) estimate the costs of retrofitting and strengthening pre-1980 houses to withstand cyclones, with benefits estimated as the avoided cost of subsequent cyclone damage. While this approach does provide some indication of benefits, it is likely to underestimate them. Economic benefits are more properly measured by willingness to pay. Conceptually, the 'damage avoided' approach is closer to a cost-effectiveness analysis than to cost-benefit analysis: it compares expenditure (cost) with costs avoided. Because the full benefit of avoiding flood damage is not captured, there may be an under-provision socially of adaptation measures.

In some cases it may be possible to use hedonic pricing or travel costs to estimate the benefits of an adaptation strategy. For example, in an area that is already subject to regular flooding, such as Pittwater in Sydney, differences in the prices of houses that are subject to flooding and similar houses that are not, may provide an estimate of willingness to pay to avoid flooding. Alternatively, if a particular road becomes impassable, the value of the additional time spent taking alternative routes may provide an estimate of willingness to pay to avoid some of the effects of flooding.

But it may not always be feasible or practical to employ methods such as hedonic pricing. Such approaches may not accurately reflect the preferences or behaviours of those affected. For example, flood-bound residents may simply prefer to work from home without feeling inconvenienced, rather than taking an alternative route to work. Similarly, house prices in flood-prone areas may be higher than elsewhere because residents prefer proximity to a lake or river, even if they are subjected to occasional flooding.

Finally, and equally importantly, a focus on the benefits associated with avoiding obvious impacts such as flooded roads or a mud-filled house is redolent of the paternalistic 'top-down' approach to adaptation favoured by subject-matter experts. It may be, for example, that some residents of a flood-prone area are more concerned with maintaining access to immediate medical assistance because they suffer from heart conditions. Others may be more concerned with damage to the local golf course. To identify the priorities and preferences particular to each locality requires additional information about social priorities and preferences. Because such information is not currently available, further research is clearly required.

8.1 An economic perspective on adaptation

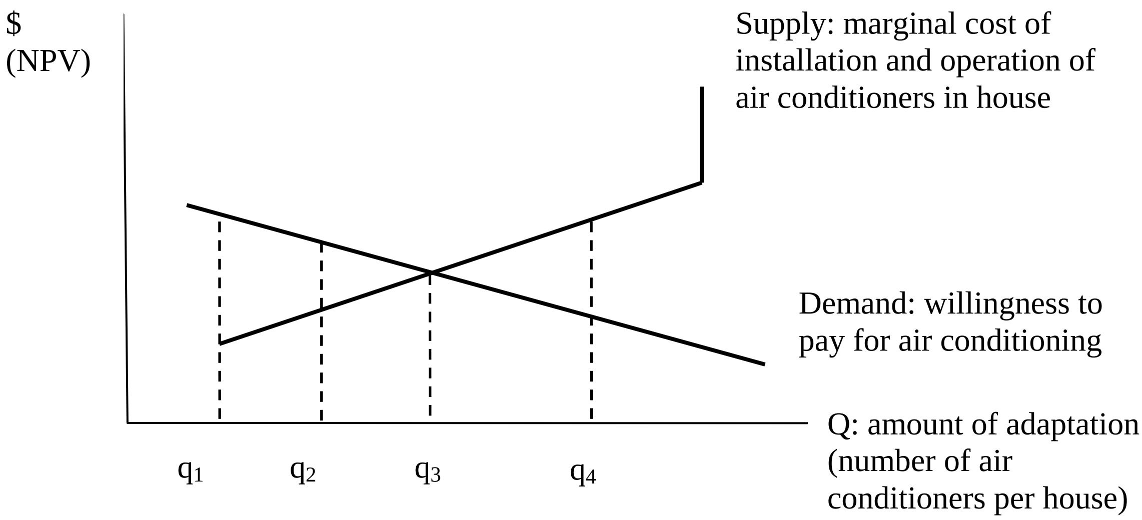
An economic approach to adaptation strategies can be illustrated with a hypothetical example of fitting air conditioners to houses.

Figure 4 presents a supply curve that indicates the marginal cost in net present value terms of supplying and operating quantities of air conditioners. Net present values are used to recognise the fact that a householder may install the air conditioners progressively over time, rather than making a 'once-for-all' decision at a single point in time. This approach is consistent with the expectation that global warming will increase progressively over the next century, but the actual timing and extent of temperature increases are unknown.

A householder may choose to install one (q_1) air conditioner under current climatic conditions[2]. (If they are highly risk adverse, they might attach two (q_2), three (q_3), four (q_4) or more air conditioners 'just in case', but it is assumed here that installation occurs on the basis of just maintaining internal temperatures at some given, pre-determined level). As the climate becomes hotter, or with more frequent extreme temperatures, the householder will install a second air conditioner, then a third, and so on. At some stage, the cost of installing more air conditioners becomes prohibitive (for example, because there is no more space in the house for them) and the supply curve becomes very steep. The demand function shows the house owner's willingness to pay for the installation and operation of additional air conditioners.

[2] The supply curve has been portrayed as continuous for illustrative purposes. Given the 'lumpy' nature of air conditioners, it would be more accurate to use a step function. However, one might also portray Q, the amount of adaptation through air conditioning, as strength or capacity of air conditioning units, in order to obtain a continuous function.

Figure 4: Supply and Demand for air conditioners



For an individual householder, the optimal amount of air conditioning (or air conditioners) will be at point q_3 where the willingness to pay for two air conditioners just matches the cost of their installation and operation in net present value terms. At q_1 and q_2 there is inadequate adaptation because the householder would be willing to pay more than the cost of installation and operation of one unit, possibly because only half the house is kept cool: perceived benefits are greater than the costs. At q_4, the degree of adaptation is excessive because the householder is not willing to pay the cost of installing and operating so many air conditioners. Clearly, the optimal point is at q_3, with points to either side representing too much (q_4) or too little (q_1 and q_2) adaptation.

The popular use of indexes of adaptive capacity and the risk-management approach, on the other hand, cannot tell us how much adaptation should occur because they do not encompass a concept of optimality. A highly risk-averse individual (or society) might seek to eliminate risk totally, a point somewhere to the right of, say, q_4, but without considering the cost of doing so. By devoting excessive resources to air conditioning, the individual (or society) would reduce their ability to engage in other adaptive measures such as building a levee bank at a nearby river. Conversely, a risk-taker may choose point q_1. A risk-management approach provides only an indeterminate range of possible adaptation responses to climate change, rather than a socially optimal solution.

8.2 The supply curve: adaptation under uncertainty and 'real options'

Society may face various risks from climate change, including extreme rainfall events, drought, fire and higher temperatures. However, it is not known how significant any of these risks might be. Nor is it known with any degree of significant certainty when they might eventuate. Risk management approaches are inappropriate in a situation of uncertainty, when risks or their timing cannot be reliably identified.

However, many investment and other decisions are taken under conditions of uncertainty as a matter of course. An economic approach that takes into account uncertainty in the timing and extent of factors affecting decisions is that of ‘real options’ (Dixit and Pindyck, 1994). Dobes (2008) outlines some potential applications of real options in adapting to climate change.

In the example shown in figure 4 above, a possible real option might be to plant deciduous trees on the northern side of the house (in the southern hemisphere) as an interim measure. The trees would be relatively inexpensive and would cool the house until temperatures rose to levels where an air conditioner was considered necessary. It is assumed here that the trees would be kept even if air conditioners are later installed because they would reduce the amount of air conditioning used, and hence its expense. There is an initial cost of planting the trees and some maintenance (e.g. trimming, watering) is required throughout their life. The cost of planting and maintaining the trees in net present values is incorporated in the supply curve in figure 5 as part of the generalised cost of adaptation to temperatures above 20˚C.

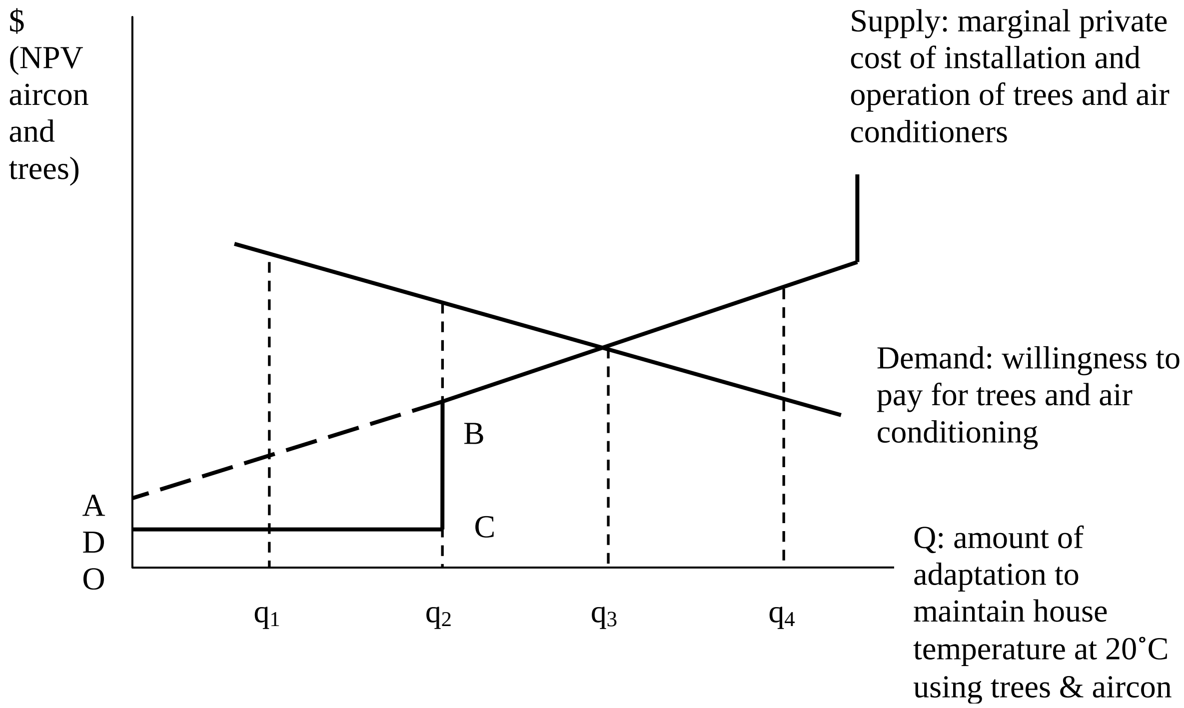
By delaying the investment outlay of an air conditioner until better information about climate change and ambient temperatures becomes available, the net present cost of adaptation is effectively lower. The reduced cost is the value of the real option.

Figure 5 illustrates the concept of a real option. A householder wishes to maintain internal temperatures at about 20˚C. Rather than purchasing an air conditioner (q1, as in figure 4) immediately, however, they plant deciduous trees around the house at a lower cost in net present value terms than installing and operating an air conditioner. When the trees prove inadequate for maintaining internal temperature at 20˚C, two air conditioners are installed (q_2). As ambient external temperatures rise over time due to climate change, the option remains to purchase further air conditioners, but the household would only purchase the equivalent of three because that is the optimal level.

Because the householder is able to delay the full investment of installing air conditioners, there is a gain in producer surplus: the irregular area ABCD in figure 5. The gain in producer surplus is the value of the ‘real option’ of first planting trees, and then, if these are insufficient, installing air conditioners.

It is worth noting that the supply curve in figure 5 shows marginal private cost. In a cost-benefit analysis conducted from the perspective of society as a whole, a marginal social cost curve would be more appropriate. One outcome of using a marginal social cost curve might be that, in the presence of positive externalities it would shift downwards relative to the marginal private cost curve. Examples of positive externalities associated with tree planting might include a reduction in urban heat islands, or sequestration of carbon dioxide. The gain in (social) producer surplus would then be commensurately larger.

Figure 5: Illustration of use of a real option for a householder



8.3 The demand curve and social preferences and priorities

Despite misconceptions on the part of some non-economists, an economic perspective is not limited to market or commercial transactions. A social cost-benefit analysis, for example, would in fact be as concerned to take into account individuals' preferences for leisure activities (e.g. playing golf on green grass) as with production (e.g. agriculture, tourism) and environmental issues (biodiversity).

Society's well-being, the ultimate focus of economics, cannot be addressed comprehensively through the narrow prism of science, industry, or building codes. The focus of economic analysis is on identifying and evaluating overall social preferences, based on the priorities and preferences of all the individuals that make up society. This approach contrasts strongly with the paternalistically 'top down', 'social planning' approach that has been adopted by many 'expert' interest groups such as Engineers Australia.

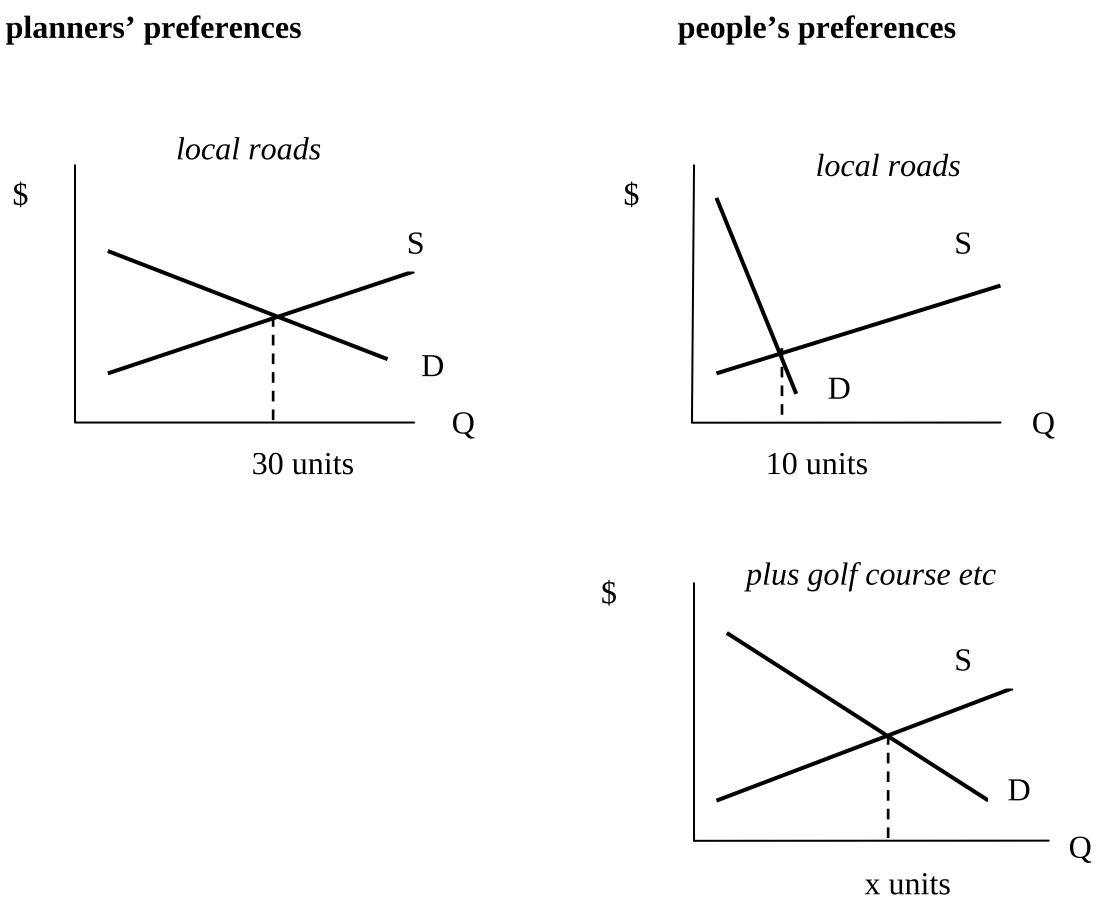
Individual citizens and communities may have preferences that attach relatively lower priority to high-level issues such as infrastructure or community health. Unlikely as it may be, a community may prefer to install a large number of bird baths (to provide water to save native bird species), even in the face of an increased risk of encouraging the breeding of mosquitoes that carry malaria or dengue fever. By implication, such altruistic communities would be prepared to incur the costs of ill-health in order to reap the benefits of continued ecological diversity. They might incidentally also impose the negative externality of malaria on nearby communities that have different preferences.

Another example of potential differences in preferences and priorities between experts and individuals might be found in a settlement on a river that occasionally floods and cuts road and rail links. Well-meaning government officials and transport experts may consider the construction of ‘flood-proof’ roads to be a top priority, perhaps to ensure continued provision of food supplies. Or continued road access may be considered to be a top priority for its own sake, with no specific derived needs identified.

However, a significant number of local citizens may grow their own food in backyard gardens. These gardeners may be more concerned that their gardens are not destroyed by floods, co-incidentally fostering some continuity of food supply, as well as providing gardening pleasure. They may prefer that limited resources be used to limit flooding of private properties, rather than the maintenance of road connections to nearby towns.

Figure 6 illustrates a hypothetical set of preferences held by planners and local residents regarding the potential for increased flooding due to climate change. Planners are shown as preferring to acquire 30 units of adaptation (say raising roads by 1 metre to ensure full accessibility 95 per cent of the time) in terms of local roads. Residents, on the other hand, may well be content to use a smaller quantity of the community’s resources to ensure accessibility (say 60 per cent of the time) but wish to also protect the golf course and other communal facilities which they also value.

Figure 6: Hypothetical planners’ and people’s preferences compared



Comprehensive public policy on adaptation to climate change requires that it be informed by the preferences of individuals, not merely the more specific but narrower concerns of ‘experts’. Exclusive reliance on the opinions and perspectives of a limited number of experts and specialists risks distorting policy actions and will not necessarily yield results that produce the greatest benefit for society as a whole. In the example above, ‘flood proofing’ a road would most benefit those who use it regularly or who rely on it for supplies of goods and services. More self-sufficient or sedentary residents will bear only the costs, without reaping much of the benefit.

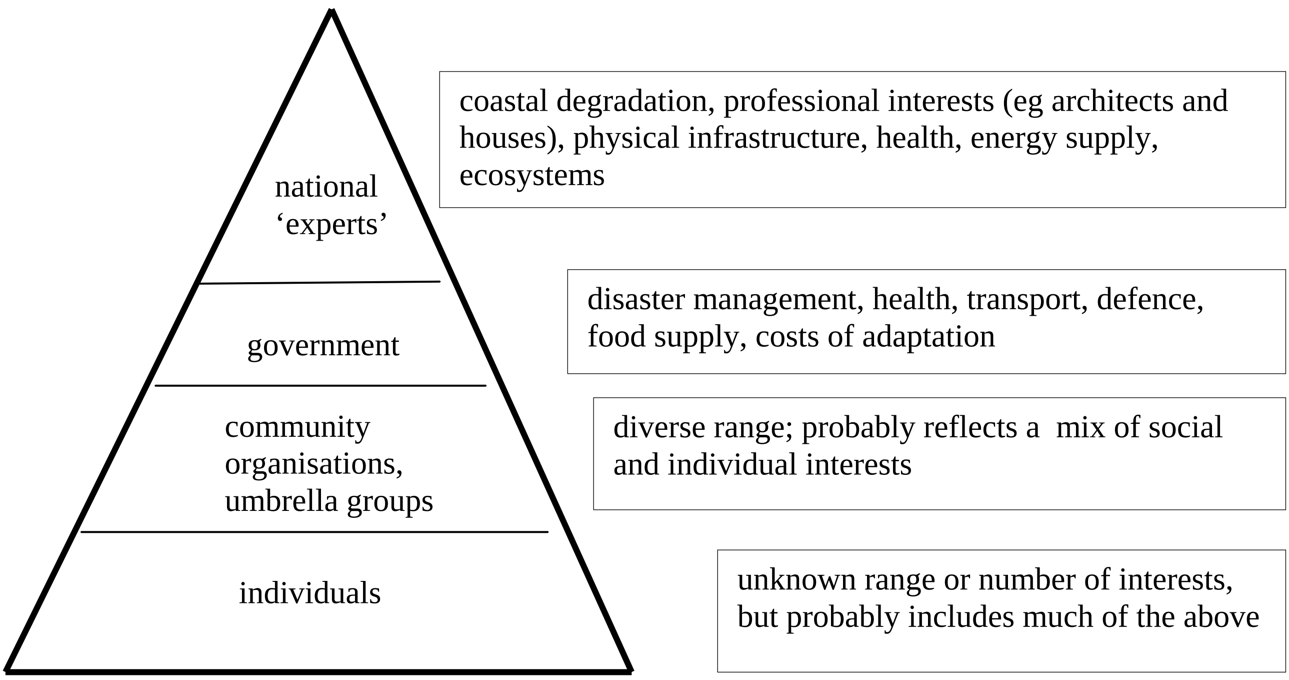
Unfortunately, little or no work at all has been done in Australia on estimating the benefits (in terms of willingness to pay) of adaptation measures. It is therefore a key objective of this project to undertake the preliminary work necessary to generate information about individuals’ preferences that can be used to develop ‘stated preference’ studies of their willingness to pay for adaptation measures.

9.0 IDENTIFYING PEOPLE’S PREFERENCES AND PRIORITIES

Identifying the complete set of community or individual preferences and priorities with respect to adaptation measures is not an immediately viable option. Although it would in theory be possible to survey all 21.7 million Australians to ascertain their priorities and preferences over a large range of possible adaptation issues, the practical difficulties would make the exercise expensive and difficult.

In particular, there is little or no information at a local level about the likely areas of concern and preferences of individuals in terms of climate change. It is necessary to first identify the range of possibilities to make a broader stated preference survey feasible. Figure 7 illustrates the range of potential adaptation concerns at different levels of society.

Figure 7: Illustrative schema of levels of hypothetical perception and concern about adaptation to climate change



As a first step, therefore, it is proposed to identify as many as possible of the potential priorities and preferences that individuals may have, using a three-step process:

1. a desktop review of priorities and preferences held by subject-matter experts and officials at all three levels of government. While they will not be identical in scope to those of individuals, it is highly likely that individuals will also consider some proportion of them to be relevant, although probably not to the same extent as planners.
2. consultation with a range of community organisations and umbrella groups on the assumption that, being closer to individual citizens, they will reflect concerns at the grass-roots level better than national experts and government officials.
3. focus groups of residents in each local area that is to be used for surveys intended to measure willingness to pay through stated preference methods.

Identifying potential preferences and priorities of individual citizens is critical to the subsequent design of a stated preference questionnaire. While this may seem a straightforward task, it would be unrealistic to think that the entire set of individual preferences can be completely and perfectly identified[3]. The very uncertainty that characterises future climate change means that a large proportion of likely effects will fall into the 'unknown unknowns' category and cannot therefore be completely identified, even by the individuals themselves.

Even if there were a reasonable degree of likelihood of identifying most of the major preferences of individuals in terms of desired adaptation measures, a number of complications are likely to affect any analysis.

> For various reasons, individuals may be in a state of denial, or seek to suppress discussion of adaptation measures. This appears to be the case in at least one Sydney beachside suburb where local government officials wish to explore possible contingencies associated with expected climate-induced flooding, but face opposition from residents who fear reductions in house prices if the increased risk of flooding comes to be associated with their suburb.
>
> People's priorities can also change over time through habituation. For example, deaths of older people due to heat waves may in future come to be seen as commonplace, and measures to reduce mortality levels will receive lower preference values than today. Similarly, in a choice experiment of responses to interruptions to water services, Hensher et al (2005) found that the mean willingness to pay to reduce the frequency of interruptions declined as the number of interruptions per year increased. This result was attributed to two factors. Firstly, people were likely to adapt to more frequent interruptions through actions such as storing water. Secondly, 'from a psychological perspective, a reduction from 12 [interruptions] to, say, 11 seems less important than a reduction from 2 to 1' (Hensher et al, 2005, p. 522). In

[3] I am grateful to Richard Mulgan for raising this issue in his comments on an early draft of this paper, and for drawing my attention to the critique by Lindblom (1959) of the 'rational-comprehensive' approach to analysis and decision-making.

other words, habituation may well reduce the marginal disutility of climate change impacts.

While sophisticated framing of questionnaires may help people better imagine the future, it is difficult to identify or even to envisage the full range of systems effects. For example, farmers may identify as a preference the need to maintain road access to specific crops at specific times of the year for planting and harvesting, but climate change may well result in a change in crop type, change in planting and harvesting season, or even the unsuitability of the district for any crops.

10.0 SUMMARY OF PROPOSED RESEARCH PROJECT

The overall objective of the proposed project is to identify and value individuals' preferences and priorities for measures to adapt to climate change. Information about individuals' willingness to pay is essential to assessing the benefits that can be expected from implementing adaptation measures. Because such information does not appear to have yet been developed, it should prove to be of considerable utility to researchers and policy makers.

As a first step, it is proposed to identify, but not value, the priorities and preferences of

- planners and experts, as well as their perceptions of the priorities and preferences of individuals in their sphere of work; and
- community organisations, as well as their perceptions of the priorities and preferences of individuals in their sphere of activity.

Information about the range of priorities and preferences of planners and experts, community groups and organisations, as well as their perspectives on individuals' priorities and preferences will enable comparisons to be made to better inform research.

Most importantly, however, the qualitative information gained will provide a solid foundation for the second stage of the project, that of conducting a stated preference survey to estimate the mean willingness to pay for adaptation measures on the part of individuals in different geographic areas of Australia. By scaling up these estimates, it will be possible to obtain nation-wide estimates.

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