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Our Ref: 08/312

Committee Secretary
Senate Education, Employment and Workplace Relations Committee
Department of the Senate
PO Box 6100
Parliament House
Canberra ACT 2600

27 August 2008

The Committee Secretary

RE: CSIRO's Submission to the Inquiry into the Effects of Climate Change on Training and Employment Needs

We thank you for the opportunity to comment on the capacity of universities and other research and training institutions to meet current and future demand for climate change professionals, and possible measures to assist understanding of climate change in the Asia-Pacific region, including provision of training and skills assistance. Our attached comments are written with an understanding that CSIRO is actively undertaking research on issues of climate change and its impacts.

CSIRO scientists in a range of fields of research have been engaged with colleagues at other climate and environmental research centres in Australia and internationally, and CSIRO plays a number of roles in education related to climate change.

CSIRO believes there are generic needs for professionals making decisions affected by climate change, including systems thinking and an understanding of uncertainty. Key generic skills and complementary investments are identified in the attached submission. CSIRO also identifies eight domains that require specific skills to address Australia's response to climate change.

Should you require any further information regarding our submission, please do not hesitate to contact me or Dr Katherine Harle (the main submission contact).

Yours sincerely

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CSIRO Submission

Senate enquiry climate change, skills and employment

August 2008

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Table of contents

Executive Summary

CSIRO has responded to the Terms of Reference for the Senate Enquiry into climate change, skills and employment. In order for Australia as a country to remain ahead of the game in dealing with climate change, the nation needs to build certain skills and ways of thinking in almost all professional training, as well as augmenting specific areas of scientific endeavour. These are also needed in the Asia Pacific, but with a bias towards locally relevant aspects of the problem.

With regard to the ability of universities and other training institutions to meet current and future demand for climate change professionals, CSIRO believes there are generic needs for professionals making decisions affected by climate change. These include systems thinking and an understanding of uncertainty. To date, only a few university curriculums provide students with this way of thinking or involve discussion of uncertainty and the tools for addressing it. Whilst organisations such as CSIRO include such training in their support of early career scientists and in some areas of participatory research with managers, there is limited systematic building of such skills.

Key generic skills and complementary investments are identified. There will be continued strong demand for scientists and researchers with excellent quantitative skills and continued demand for software engineers and other IT professionals. Management skills to deliver major research outputs will also need to be enhanced. In addition, there is an urgent need to invest in infrastructure such as supercomputing and research platforms to attract and retain the best researchers.

CSIRO identifies eight domains that require specific skills to address Australia's response to climate change:

- socio-economic integration,
- earth systems and climate science,
- urban systems,
- natural environment,
- primary industries and fisheries,
- water,
- energy, and
- mining.

A list of specific skill shortfalls within each of these domains is provided in Table 1.

Many of the skill requirements identified for Australia, also apply to our near neighbours in the Asia-Pacific (Term of Reference B). There is a diversity of countries within the Asia-Pacific region; some already have very high capacity. However, countries in the region that have a low capacity to understand the impacts of climate change need to make decisions about priorities for investment in training. There is no strong rationale for these countries to invest in underlying technologies (e.g. global climate models), or to develop new frameworks for climate impact assessment. Rather, these countries could utilise global scientific knowledge, through avenues such as IPCC, and focus on creating local capacity to apply this information to address mitigation and adaptation concerns for their particular country or local region.

As a major per-capita emitter of greenhouse gases, Australia can play a role in assisting our near neighbours with understanding climate change and its impacts. Assisting our neighbours to develop capacity to address local issues will provide benefits to Australia. It is likely to decrease the need for direct financial support from Australia to fund large scale adaptation projects, it may create new markets for our goods and services, and it will reduce the likelihood of environmental refugee movements in the region as a result of climate change.

Introduction

The challenge and characteristics of climate change

It is now widely acknowledged that human activities are causing climate change (IPCC 2007; Garnaut 2008), leading to the twin needs to *mitigate* – reduce our greenhouse gas emissions – and *adapt* – cope with the changes to which we are now committed. The global environmental changes that we face today, including climate change, ocean acidification and other major modifications to the earth system, are creating challenges that are qualitatively different to the sustainability challenges of the past. To a degree not seen previously, these changes and their impacts are *systemic*, *global*, and *uncertain*:

- they are *systemic*, in that every sector and field of human endeavour at every scale is affected by them, and there is an immense complexity in the feedbacks and interactions among these effects;
- they are *global* in nature, in that they are driven by and affect human activities everywhere in the world; their *global systemic* nature requires systems thinking, to help identify solutions that do not cause further problems; and
- they are *uncertain*, in that, even with better science, there will always be irreducible uncertainty in how humans will respond in the future, and in new complex interactions in the global system that catch us by surprise (e.g. Carter *et al.* 2007). This demands skills, tools and ways of thinking that provide confidence in the face of uncertainty, rather than old ways of assuming that uncertainty will eventually go away.

This submission argues that, as a consequence of these characteristics, and in order for Australia as a country to remain ahead of the game in dealing with climate change, the nation needs to build certain skills and ways of thinking in almost all professional training, as well as augmenting specific areas of scientific endeavour. These are also needed in the Asia Pacific, but with a bias towards locally relevant aspects of the problem.

CSIRO's Capability

CSIRO carries out scientific research in areas including energy, the environment, information technology, health, mining, manufacturing, agriculture, and natural resources. We seek to make a difference and generate impact by focusing on the nation's big challenges and opportunities. Our research delivers:

- integrated solutions to help meet major national challenges;
- technologies to transform or create new markets for Australian industry;
- innovative technologies to improve the competitiveness of existing industries;
- advice, information and research to meet specific community needs; and,
- knowledge-based services to governments and businesses.

CSIRO scientists in a range of fields of research have been engaged with colleagues at other climate and environmental research centres in Australia and internationally. These scientists progress the global understanding of climate change through the peer-review process, a system in which scientists anonymously review and test research prior to its acceptance for publication in recognised science journals. These peer-reviewed journals include *Nature*, *Science*, and *Geophysical Research Letters*.

They use CSIRO computer-modelling expertise to project forward to understand future climate change. This research informs decision-makers and the community about changes occurring in regional climate, and increases understanding of the way shifts in future climate will impact on Australia.

Figure 1 shows CSIRO response to climate change. The *Energy Transformed* National Research Flagship is addressing research questions relating to mitigation of climate change through energy and transport solutions. The *Agricultural Sustainability Initiative* is addressing agriculture, forestry and soils. Fundamental Climate Science is explored through CSIRO's *Climate and Atmosphere Theme* and its collaboration with the Bureau of Meteorology known as the *Centre for Australian Weather and Climate Research* (CAWCR). The *Climate Adaptation* and *Water for a Healthy Country* National Research Flagships focus on adaptation strategies required as a result of climate change.

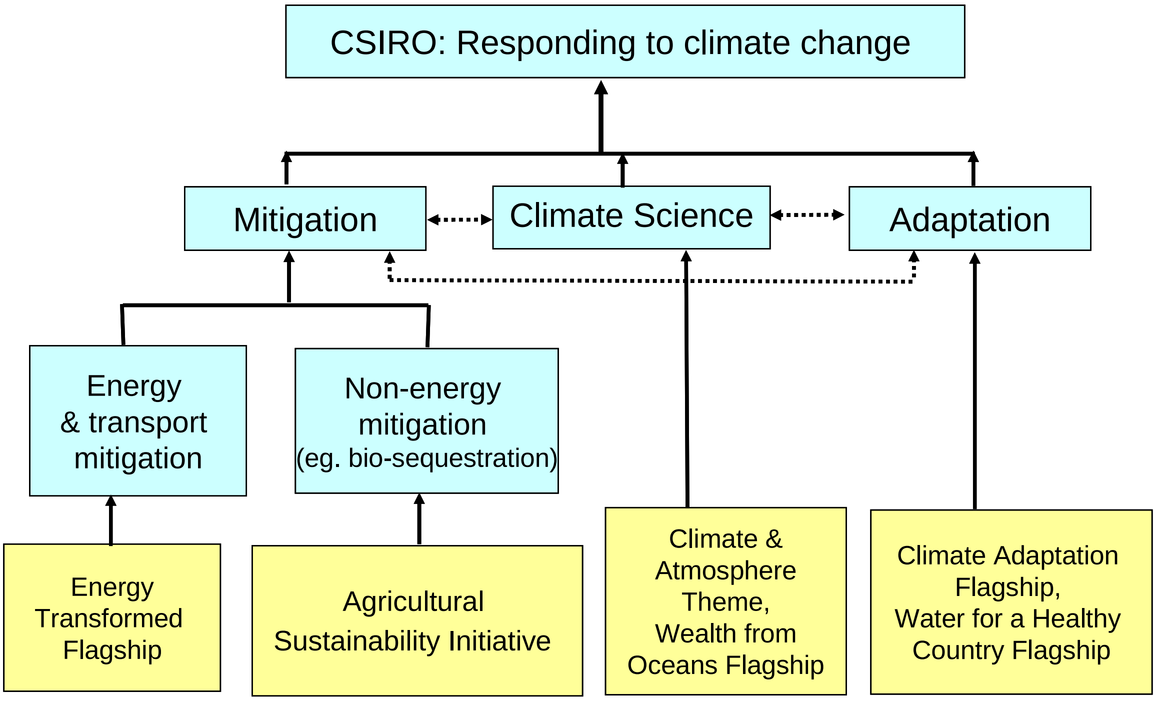

Figure 1: CSIRO's key responses to the challenge of climate change, through National Research Flagships, CAWCR and the Agricultural Sustainability Initiative

CSIRO plays a number of roles in education related to climate change. CSIRO sponsors and supports a number of PhD students, post doctoral fellows and early career scientists working on a variety of issues surrounding climate change; in many cases such training includes systems thinking and handling uncertainty. In addition to formal education, some areas of CSIRO use systems thinking and uncertainty theory in participatory research with managers (e.g. through the Sustainable Communities Initiative [*http://www.csiro.au/science/SCI.html*], and its precursors); however, this effort is modest compared with the systematic scale of the need for these skills in all education and training.

Terms of Reference A: the ability of universities and other research and training institutions to meet current and future demand for climate change professionals

Generic needs for professionals making decisions affected by climate change

As noted in the introduction, climate change issues are systemic, global and uncertain, yet decisions can and must be made. As the Allen Report (2005) said, “An adaptation strategy, to be effective, must result in climate risk being considered as a normal part of decision-making”. All management and policy decision makers thus need the appropriate skills to do this. Generic skills about ways of thinking and tools to assist with decision-making under these circumstances include systems thinking approaches, and the use of tools to assist with decision-making under uncertainty.

Systems thinking exposes people to recognising that aspects of life are linked (e.g. Tilbury and Wortman 2004). As examples, using more energy will, in the absence of a dramatic reduction in carbon intensity of that energy, release more greenhouse gases, that will increase the probability of harmful climate change; hence there are hard decisions to be made about fuel prices. Australia could wait for others to act on CO_2 emissions, but stands to lose more than most from climate change globally; hence there are hard decisions to be made about emissions trading.

Understanding uncertainty enables people to overcome any potential paralysis by indecision, through having comfort with well-structured approaches to making decisions in the face of irreducible uncertainty. There are many tools available to assist such decision-making (e.g. Allen Report 2005), and the skills to use these tools need to be widespread. Risk management approaches, increasingly widely adopted by business, enable people to deal with alternative futures, and risk hedge against them; scenario building assists this process. Flexible institutions, using principles of adaptive management and adaptive governance (e.g. Walters 1986, Dietz *et al.* 2003, Olsson *et al.* 2004, Brunner *et al*. 2005), are able to respond better to uncertainty and future change than rigid structures, but people need to have the skills to operate within such institutions. People in general need to have the skills to be comfortable with the language of uncertainty, knowing that, rather than creating an incentive for inaction, it requires action using particular tools.

In the absence of a strong majority of the population having a reasonable understanding of systems, uncertainty and the global complex nature of the challenges we face, policy making on these issues will be contentious.

As a generic requirement, Australia should support schools, universities and in-career training activities to embed skills in systems thinking and with tools to deal with uncertainty in every day life of all Australians, particularly all professionals. The goal should be to create an Australia which is a flexible, adaptive learning society at all levels. This would be a worthy goal in the face of current sustainable development challenges, but is greatly amplified in the face of global climate change. At present organisations such as CSIRO struggle to find sufficient numbers of people with such skills, and there is a significant dearth of these skills nationally. Although there is an increasing emphasis on building systems thinking and sustainability into curricula (e.g. Australian Government’s 2000 ‘National Action Plan - Environmental Education for a Sustainable Future’, and work such as that of the Australian Research Institute in Education for Sustainability [http://www.aries.mq.edu.au/]), the demand for these skills will continue to rise and outstrip supply if sufficient numbers are not educated in systems thinking.

Specific skills and needs in scientific research

Whilst all professionals require the skills noted above, including scientific professionals, there are additional skills requirements in a research response to the climate change challenge. CSIRO has reviewed skills and needs in scientific research in eight domains: socio-economic integration, earth systems and climate science, urban systems, natural environment, primary industries and fisheries, water, energy, and mining. The following discussion outlines some issues in each domain, as well as some more generic concerns, then lists (Table 1) specific skills needs by domain.

Demand for current skills in particular disciplines will probably not change radically. However, the research emphasis and deployment of those analytical and engineering skills will continue to take new directions. An overarching message that emerges is of the importance of interdisciplinarity. The most effective people will be those who can deploy their skills across disciplinary boundaries in non-traditional ways, as well as those who can understand and analyse systems in the presence of uncertain risk.

Not everyone needs to operate across disciplines, but Australia would significantly benefit by building a much stronger core of research professionals who can. The key problem in the domain of climate change is the shortage of people with the ability to focus disciplinary expertise on the science most likely to support mitigation and adaptation, and to embed these skills in the decision making, policy and social processes necessary to induce action.

Few educational pathways in Australia create disciplinary expertise focused on societal outcomes, nor train boundary-spanning individuals capable of bridging the gulf between disciplines and institutions. The link between multi-disciplinary integration and sustainability outcomes is rarely used to set education agendas. Such transformational educational models do exist, for example in the Arizona State University's sustainability program, which might provide lessons for the Australian context (http://sustainability.asu.edu/giosmain/education/index.htm).

Socio-economic integration: a variety of social and economic science skills are needed in ways that are integrated with all domains, to help with understanding the processes of achieving behaviour changes and adaptation in management and policy. The need is especially for skills in bridging between these sciences and biophysical sciences, and in engaging with policy demands.

Earth systems and climate science: this area of science is moving towards a more holistic view of 'earth systems science' by including biogeochemical feedbacks and interactions in the modelling of the coupled land-ocean-atmosphere environmental system, and then building human/societal processes in as a major driver or forcing agent within these coupled systems.

Urban systems: urban systems probably are behind the agricultural sector in adaptive integrative research approaches, yet the domain represents where most humans live and where most demand for energy and resources ultimately derives from, and where adaptation and mitigation will be critical issues.

Natural environment: the natural environment and biodiversity is recognised widely as the sector with most sensitivity to climate change globally and in Australia (e.g. *Strategic Assessment of the Vulnerability of Australia's Biodiversity to Climate Change*, 2008 forthcoming [Department of Climate Change]). Profound changes in the conceptualisation of conservation policy and management are needed to deal with the reality that different species will respond to climate change at different rates, so that today's assemblages and ecosystems will change in uncertain ways in the future. Management actions being implemented today with very long-term implications for biodiversity require a particularly sophisticated response to uncertainty about possible futures. Novel research addressing whole of ecosystem responses but with a close understanding of management and policy needs is required.

***Primary industries and fisheries*:** Australia's primary industries on land and in the sea are recognised as the third sector with high exposure but also great potential to adapt to climate change, as well as being major emitter of greenhouse gases (Stokes and Howden 2008).

Water: a combination of rising demand and uncertain supply of water in southern Australia makes this another critical sector for Australia's future.

Energy: the energy sector is fundamental to Australia's efforts to mitigate climate change. The skills required by the energy sector will be affected by uncertainties associated with the carbon price that will be controlled by the introduction of an Emission Trading Scheme and mandated government targets – choices about long and short term greenhouse gas emission reductions and renewable energy mandates will alter the balance of future industry needs. Notwithstanding this, key skills that provide resilience against any future are required.

Mining: automation and remote control is a major thrust in the minerals industry to address foreseeable future skills shortages. With automation comes the potential both for additional energy requirements and (conversely) for intelligent and efficient use of equipment.

In addition there are some more generic issues:

Key generic skills: notwithstanding the above there will be continued strong demand for scientists and researchers with excellent quantitative skills (irrespective of discipline) and continued demand for software engineers and other IT professionals. There is no doubt that Australia is part of the 'talent war' globally. Better harmonisation between government research organisations (such as CSIRO and the Bureau of Meteorology) and the Australian University system will be important if Australia is going to successfully produce the skills it requires. In the present environment it is clear that there is a shortage of suitably qualified people who have come through the Australian system. CSIRO and the Bureau have always recruited internationally, but as countries such as China and India develop we are seeing recruitment from non-traditional sources. Thus the climate science workforce is drawing from a widening set of cultural backgrounds; developing processes to ensure that the full potential of all scientists is engaged, including those with leadership potential, will be a significant challenge.

Continuous career-long improvement: more attention needs to be paid to within-career and continuous learning processes. Similarly, rapid technological change requires continued development of technical skills.

Management skills: management skills required to deliver major research outputs such as a major earth system model, or an observational and data system or harnessing resources from disparate organisations from a variety of programs in order to undertake a major piece of research, are *de rigueur* in the present environment, yet relatively few working scientists are trained at university in this aspect of their professional life.

Complementary investments: It is also worth noting that, while skills and training are a very significant dimension of the climate science challenge, investing in human capital alone is not sufficient. There is an urgent requirement in Australia to invest in infrastructure such as supercomputing, research vessels, satellite data acquisition and processing systems to complement investments in skills, and to attract and retain the best researchers.

Table 1: Specific skills required in each domain.

Domain	***Skills required in each domain***
Socio-economic integration	• Skills for decision making: the ability to focus disciplinary expertise on the science most likely to support mitigation and adaptation, and to embed these skills in the decision making, policy and social processes necessary to induce action and derive its maximum impact and value. • Disciplinary expertise should be focused on societal outcomes, or boundary-spanning individuals capable of bridging the gulf between disciplines and institutions • Socio-economic skills engaged with other domains below • Skills with stakeholder engagement
Earth systems and climate science	• Climate scientists that can respond to and incorporate human adjustments to a changing climate into their research, through adaptive processes
Urban systems	• Specialists in transport, urban agriculture, urbanisation and health, industrial ecology of materials, buildings, urban developments and indoor environment quality, energy efficiency in buildings, • Researchers who can integrate approaches to urban-regional informatics and spatial analysis • Economists to assist in the prioritisation of urban infrastructure asset management and climate adaptation investment

Natural environment	• Researchers with excellent ecological knowledge, outstanding statistical and modelling skills and the ability to communicate effectively with policy-makers and ecosystem managers • Increased capability in qualitative modelling and Bayesian networks will assist making recommendations on how to deal with complex ecological and social processes given imperfect knowledge
Primary industries and fisheries	• The capability to translate climate and atmospheric changes into biophysical, economic and social impacts so as to deliver decision-relevant and policy-relevant information. • Specific capabilities include plant and animal production science, fisheries and forestry management science, oceanography, soil biology, remote sensing, risk analysis, farming systems, social and economic research, simulation modelling, scenario building and integration science, institutional and policy analysis, value chain modelling and regional integrated analysis
Water	• Specific domain knowledge required in: rainfall/runoff relationships, soil water vegetation interactions and feedbacks, arid zone hydrology, flood forecasting, remote sensing of water variables and hydrological data, technology development for generation of field based real time data handling and capture, flow-ecology relationships • Systems level knowledge required in: spatial modelling of regional hydrological variables and processes in a) atmosphere, b) landscape systems and c) river networks. Risk and uncertainty analysis, error frameworks, probability analysis, as well as conceptual structures and platforms to enable and incorporate synthesis of all of the above • Computer modelling knowledge required in: modelling architecture for handling large complex dynamic spatial data sets, integration of real time and historic data, integrating remotely sensed with ground based data, hardware platforms and algorithms to handle/process large quantity data loads
Energy	• Coal fired plants will increasingly become more like chemical plants as they will have to capture CO_2 (and store it) and this will generate an increasing demand for chemical engineers that are willing to work in the power sector • There will also be a growing demand for people to work in the renewable energy sector - particularly solar thermal technology applications
Mining	• Mining-related skills needs: process water treatment and recovery expertise; combined metallurgy/engineering skills to develop low energy, GHG and water options for the processing of minerals; and interdisciplinary skills to support a systems approach to managing water and energy use and environmental impact at mining and processing operations

Terms of Reference B: measures to assist understanding of climate change in the Asia-Pacific region, including provision of training and skills assistance

Many of the skills identified for Australia in the first section of this submission are also relevant to our near neighbours in the Asia-Pacific. In this regard, CSIRO is engaging strongly in the provision of research results and research capacity building in the Asia Pacific region, including through the development of a new Alliance between CSIRO and AusAid to contribute strategic support to the aid programmes in the region.

Among the countries of the Asia-Pacific region there is a great deal of diversity in population, GDP, and capacity to understand climate change and its impacts. Countries such as Thailand and China have greater resources and capacity to engage with challenges associated with climate change and its impacts. Other countries, including our nearer neighbours such as East Timor, Papua New Guinea and many small island nations, have lower capacity to understand the impact of climate change.

For countries with lower capacity, there are decisions to be made about priorities in investment in research and training. There is no strong rationale for these countries to invest in underlying technologies (e.g. global climate models or basic energy technologies like solar cells), or to develop new frameworks for climate impact assessment. Rather, these countries could utilise global scientific knowledge on these topics, through avenues such as IPCC; they may then concentrate their scarce resources on creating local capacity to apply this information to address the mitigation and adaptation issues and concerns for their particular country or local region.

It is likely to be in Australia's interest to assist our neighbours to develop capacity to address local issues. Supporting knowledge building so that nations can develop local management strategies is likely to decrease the need for direct financial support from Australia to fund large scale adaptation projects, particularly if the local management strategies are adopted early. In addition, it will reduce the likelihood of environmental refugees arriving in Australia in years to come. It may also open up new markets for Australian goods and services.

Australia should adopt measures to assist our neighbours to develop capacity to address local issues caused by climate change. These could be through sabbaticals to Australian institutes for foreign scientists, by providing training to planners and policy makers, and by providing assistance to foreign students at local universities. Overseas aid projects can provide a context within which training occurs at the same time, and allow better engagement of regional scientists with their Australian counterparts. Assistance (financial, material and personnel) to help countries determine their strategic needs through generalised assessment of regional vulnerability and adaptation options could be contributed by Australia immediately.

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