



CSIRO Submission 10/375

Inquiry into Australia's international research collaboration

House of Representatives Standing Committee on Industry,
Science and Innovation

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CSIRO welcomes the opportunity to provide input to the House of Representatives Industry, Science and Innovation Committee inquiry into Australia's international research engagement.

CSIRO has responded to the Terms of Reference below in areas where the organisation has appropriate knowledge and expertise. CSIRO would be pleased to provide further information to the Committee as required.

CSIRO is Australia's national research organisation and fulfils a unique and differentiated role in Australia's national innovation system. It conducts large-scale multidisciplinary research across a wide range of scientific fields and uses the outcomes to deliver impact and innovative solutions for industry, society and the environment. In doing so, CSIRO seeks to advance Australia's national and international objectives.

This is also captured in CSIRO's enabling legislation, the *Science and Industry Research Act 1949*.¹ Section 9 of the Act prescribes CSIRO's primary functions as the conduct of scientific research for the following purposes:

- (1) assisting Australian industry;
- (2) furthering the interests of the Australian community;
- (3) contributing to the achievement of Australian national objectives or the performance of the national and international responsibilities of the Commonwealth.

This section of the Act also sets out additional functions of the organisation, which include: facilitating the application of the results of research; to train research workers and to cooperate with tertiary education institutions; to disseminate and publish information relating to scientific matters; and to act as a means of liaison between Australia and other countries.

General introduction on the global economy and innovation system

Australia with its small population, open economy and distance from major trading partners relies heavily on international flows of trade and investment to maintain our economic development.² This is also true for Australia's involvement in the global innovation system.

It is by now a truism that science is international by nature. Many of the science challenges facing Australia are of global significance and involve understanding of the earth's systems, the drivers of those systems and their effects on Australia, our region and the globe. The science of climate, oceans and the atmosphere is inherently global. We cannot develop effective knowledge or solutions for Australia with out international engagement in these fields.

Australia plays a significant role in international science and the global innovation system; publishing approximately 3% of total scientific papers and producing approximately 0.7% of world patents. International organisations such as the OECD have noted that science has become increasingly globalised, at the same time as it has become central to responses to the major challenges facing nations, which are also global in nature. This has recently led to calls for new modes of governance of science and innovation, to improve coordination and multilateralism, and to recognise the importance of innovation in sustainable economic development.³ In recent years, science has also become an increasingly important tool in international diplomacy in addressing major international issues and in developing productive relationships with government and non-government organisations.

¹ See

[http://www.comlaw.gov.au/ComLaw/Legislation/ActCompilation1.nsf/0/58334A9907686DECCA256F71004DEEDB/\\$file/SciIndRes1949.pdf](http://www.comlaw.gov.au/ComLaw/Legislation/ActCompilation1.nsf/0/58334A9907686DECCA256F71004DEEDB/$file/SciIndRes1949.pdf)

² [Combating the GFC. Speech by Lindsay Tanner to American Chamber of Commerce in Sydney, 15 Oct 2009](#)

³ See for example http://www.oecd.org/document/36/0,3343,en_2649_34269_42711844_1_1_1_37417,00.html

Some countries, notably China, Brazil, India, Turkey and Korea, have dramatically and deliberately increased public and private expenditure on R&D recently, in spite of (and in some cases in response to) the Global Financial Crisis (GFC).

Within this fast-moving global system, Australia needs to continue to strengthen its international research and innovation linkages. No one research organisation in Australia has the competence or facilities to address major, complex challenges in isolation. Maintaining and strengthening international connectedness will help ensure that Australian research remains competitive, ensure access to new knowledge and technologies developed overseas, ensure that we can address the major challenges facing the nation and play a constructive role internationally.

While it is vital for Australia to stay connected to our global research partners in established research nodes, it is also important to acknowledge that, there may be opportunities for Australia to forge major new strategic international partnerships in this region. CSIRO's proven expertise in addressing major challenges common to the biogeophysical zones of the southern hemisphere (water resource constraints, fisheries management, climate adaptation, dry land agriculture, zoonotic disease research, and resource extraction) suggests that there may be at least equal value in exploring new opportunities for global leadership and partnering with countries experiencing similar challenges (Brazil, Southern Africa, Chile, New Zealand, Indonesia). Furthermore, the nature of international collaboration is evolving to include more virtual research collaboration, where "e-research" and data diffusion processes will facilitate new opportunities for geographically isolated regions to participate in the analysis of large, globally significant data sets.

1. The nature and extent of existing international research collaborations

CSIRO is actively engaged in international science collaboration and the global innovation system, and has been since its inception. As per its legislation, CSIRO engages with international partners in a wide variety of ways – an indicative list is provided below.

There are therefore a number of ways to measure the extent of CSIRO's international engagement – to take but three simple measures:

- approximately 45% of CSIRO's peer-reviewed scientific publications in 2008 were co-authored with partners and collaborators overseas;
- CSIRO had 73 relationship agreements such as memoranda of understanding with partners in 19 countries in 2008-09
- the organisation was engaged in approximately 700 collaborative activities in 2008-09 covered by contracts (not including publications) with partners in 66 countries.

Further detail is provided at Appendix 1 about key partner countries for collaborative publications and projects under contract. The majority of CSIRO's international engagements are with the major centres for research and innovation – North America, Europe and East Asia. CSIRO also has significant involvement in developing countries, however, and with partners in Australia's near-neighbour region including New Zealand and Indo-Pacific Island states.

CSIRO has a clear strategy for enhancing international engagement, as part of the organisation's Strategic Plan 2007-11 (see further detail in section 5 below). This international strategy seeks to provide a coherent framework for the full range of CSIRO's international activity, and to identify areas of particular focus and investment across the organisation. This strategy encompasses attracting, retaining and developing world-class talent; further developing international scientific networks; and increasing the global impact of CSIRO's science in line with national priorities.

CSIRO's international activities include the following forms of collaboration, most of which are supported directly from the organisation's own annual funding:

- 1. Research collaborations** - Where CSIRO staff engage in collaborative research with counterparts in overseas research institutes (in both the public and private sectors), often leading to the production of scientific papers and reports (see Appendix for CSIRO joint

international publications). A key example is the collaborative relationship between CSIRO's Food Futures Flagship and Limagrain⁴ and associated publications detailing advances in wheat breeding for value added traits.

2. Bilateral and multilateral co-investment - Collaborations on significant research issues where the risks, costs and benefits are all shared by the different organisations. Examples include CSIRO's involvement in the Intergovernmental Panel on Climate Change (IPCC), Square Kilometre Array project (SKA), International Energy Agency and others.

3. Exchange of knowledge and technology. Examples of transfer of technology to and from overseas organisations include licensing CSIRO's UltraBattery technology to Furukawa Battery Company in Japan and East Penn Manufacturing Co. in the USA. The transfer of knowledge includes sharing of observational data and models. For example CSIRO obtains observational data of immense value from the satellite programs of other countries (e.g., USA, Japan, Germany, and the European Union) and from international earth observation programs; licensing to use atmospheric models from the UK Hadley Centre in developing a new generation climate and weather prediction system for Australia – the Australian Community Climate and Earth System Simulator (ACCESS)⁵; and use of international models in developing ocean forecasting models for our region e.g., BLUElink⁶. CSIRO's Atlantis model for marine resource management is being used by research and natural resource managers in many other countries and carries Food and Agriculture Organisation endorsement as one of the world's leading ecosystem modelling environments.

4. Contract Research - Where CSIRO researchers are contracted to provide technical solutions to clients in international markets. An example is the development of a flotation model for a Canadian resources company by CSIRO's Process Science and Engineering division.

5. Research for Development - Where CSIRO uses its expertise to deliver solutions to our regional neighbours, or build capacity in developing countries as part of Australia's international aid program (e.g., the Pacific Climate Change Science Program, CSIRO contributions to efforts after the 2006 Tsunami).

6. Strategic Relationships - Where CSIRO has long-term partnerships with a number of major international organisations where both organisations provide significant resources into multiple projects and make rapid advances due to the scale of the investment. Examples include The Boeing Company⁷, PETRONAS⁸ Research in Malaysia and Bayer CropScience⁹.

7. Research Training – CSIRO trains a large number of international Postdoctoral and Higher Degree by Research students each year, enabling CSIRO to access talent, fill skills gaps, and build long term international relationships with students and overseas supervisors beyond their time at CSIRO.

2. The benefits to Australia from engaging in international research collaborations

CSIRO gains many benefits from international collaboration and these have had economic, social and environmental flow-on benefits to Australia. Through its research management and investment processes, CSIRO ensures that international engagement demonstrates a clear link back to CSIRO's objectives and the national interest.

⁴ www.Limagrain.com

⁵ <http://www.accessimulator.org.au/>

⁶ <http://www.marine.csiro.au/bluelink/>

⁷ <http://www.boeing.com/>

⁸ http://www.petronas.com/internet/corp/centralrep2.nsf/frameset_home?OpenFrameset

⁹ <http://www.bayercropscience.com/>

The benefits to Australia and CSIRO from international collaboration include:

- Attracting and retaining top quality researchers to Australia. In 2008 over 20% of CSIRO's staff were born overseas. Many brought new ideas and expertise to CSIRO, which has added greatly to our knowledge base. Anecdotal evidence suggests these researchers were often attracted to CSIRO as a result of the international links that we had with organisations in those countries.
- Extending CSIRO's research expertise in priority areas for Australia through international collaboration – an example of this is research undertaken with Chinese and Indian partners that has improved the use of water in agriculture and resulted in new knowledge that has had major benefits for Australian agriculture.¹⁰
- Enhancing the skills of Australian researchers and retaining our workforce. The skills and knowledge of CSIRO staff as individuals and as a science workforce in Australia are enhanced through developing international collaborations both formally between organisations and informally between individuals. International exchange of researchers between Australia and other nations exposes our researchers to new ideas and innovations and develops our ability to understand and provide solutions to the science challenges facing Australia.
- The ability to undertake research that is not possible in Australia due to lack of availability of equipment or possible contamination concerns. An example is the work underway by researchers in CSIRO, BSES¹¹ and in China to develop new sugarcane hybrids with resistance to diseases not present in Australia but that may severely affect the crop if introduced into Australia¹². CSIRO has also maintained research facilities in Europe and Latin America in order to conduct research on biological control agents not yet in Australia. Access to the research vessels of other countries (e.g. France, Germany, Japan and the USA) to undertake science voyages in our region addressing issues for Australia is another example.
- Involvement in major international projects, with multiple research organisations, such as those concerned with global climate change, biodiversity, fisheries management etc. has provided Australia with access to scientific data and facilities which require international funding support that cannot be undertaken by a single organisation or a single country. An example is CSIRO's involvement in the ARGO project (see box 1).

Box 1. CSIRO involvement in Argo

Argo¹³ is a major international collaborative program initiated in the late 1990s to gather temperature and salinity information from the upper ocean using robotic floats. The information from the program was and is used in ocean and climate analysis and forecasting. The original participants in the program were from the northern hemisphere and included organisations in the USA, France, UK and Japan. Australia was invited to be a participant at the commencement of the program. A special grant enabled CSIRO to get involved and to deploy 10 floats off NW Australia. CSIRO's involvement ensured an increased emphasis on the Indian and Southern oceans rather than the northern areas of the Pacific and Atlantic oceans. This long term study has had major benefits to Australia in increasing our understanding of the impact of Indian ocean temperatures on Australia's climate and weather patterns. It has also assisted the development of improved international climate models.

- Attracting investment from other countries (both public and private sector). For example Australian projects such ACCESS and BLUElink have direct international engagement and

¹⁰ [Overseas aid program is saving billions of litres of water in Australia](#)

¹¹ http://www.bses.org.au/bses_01_home.asp?page_id=0

¹² [Australia-China sugarcane collaboration](#)

¹³ <http://imos.org.au/argo.html>

facilities such as the Cape Grim Baseline Air Pollution Station operated by the Bureau of Meteorology with joint management with CSIRO attracts significant international collaboration in Australian projects.

- Access to knowledge, intellectual property and expertise not available in Australia. This is becoming increasingly important in some areas as value chains themselves become global and competition increases for products and services. Without international links Australian access to this information will be delayed or may be limited, which may have serious implications for the Australian innovation system. For example, Australia's international engagement in research is a key platform of ongoing access to satellite remote sensing data from multiple countries that we could neither provide ourselves nor afford to purchase but which is central to many aspects of weather, climate, land use, and Natural Resource Management research & development.
- Contributing to the delivery of Australian foreign policy objectives and enhancing Australia's bilateral and multilateral relationships through participation in international forums (e.g. climate change, fisheries management, the Antarctic Treaty agenda) and through collaborative projects with organisations in various countries.

CSIRO's work in partnership with AusAID and ACIAR benefits Australia through improved regional security, economic development and enhanced research capability in countries in our region. An example is research involving the Malaysian Department of Veterinary Services, the Center for Disease Control in the USA and CSIRO to address an outbreak of the Nipah virus in Malaysia. The Nipah virus is very similar to the Hendra virus and the research led to the identification of a potential human vaccine to provide protection against both viruses.¹⁴

3. The key drivers of international research collaboration at the government, institutional and researcher levels

A long-standing fundamental driver for international research collaboration at all levels is to ensure participation in the international processes for the peer review and communication of research and recognition of the quality of Australian research against international benchmarks. Many research problems are now global in nature (such as climate change) or present impending global challenges to health and trade (such as Foot and Mouth Disease).

Box 2. Foot and Mouth Disease – the Global Alliance

After the successful eradication of rinderpest from the world, international organisations such as the World Organisation for Animal Health (OIE) and Food and Agriculture Organisation (FAO) are focusing their attention on the global control of foot and mouth disease (FMD). It has long been realised that basic and applied research is needed to support efforts to control this animal disease that is seen as the biggest threat to international trade in livestock and livestock products. CSIRO (through its Division of Livestock Industries and the Australian Animal Health Laboratory national facility) is a founding member of the Global Foot and Mouth Disease Research Alliance (GFRA). This unique global research alliance started off with 5 of the world's leading high-containment laboratories working on FMD but now includes 13 members and has assisted with improved collaboration, sharing of resources and data as well as more focused research projects.

The collaborations formed within the alliance have assisted in attracting significant research funding. A recent GFRA meeting held at the Pirbright Laboratories UK, clearly demonstrated the significant research being undertaken under the GFRA umbrella and highlighted some important new concepts both in the pathogenesis of the disease as well as alternative control options. The complexity of research into diseases such as FMD can only be addressed through effective international collaboration and GFRA is a unique example of how this can be achieved.

¹⁴ [Fighting the Nipah virus](#)

In addition to this, shifts and changes in the nature of research and the make-up of the global research and innovation systems over recent years have altered the drivers for international collaboration. These include:

- The advances in information and communication technologies (ICT) that have enabled the rapid access to, and manipulation of, large data sets and shared information by multiple users in multiple sites. In addition, the convergence of the computing, biotechnology and nanotechnology disciplines is transforming the nature of scientific research and accelerating the rate of innovation in a number of areas.
- The increasing mobility of talent has resulted in researchers being willing to move to the centres with the best research capacity, infrastructure and funding, and to deliberate and significant investments by a range of countries and regions, particularly the European Union.
- Strong investment in research and innovation in other countries resulting in the “rise” of new scientific powers outside the traditional centres of North America and Europe. As a small contributor by international standards, Australia must work to stay connected with the production of new knowledge and technologies overseas.
- International connectedness also raises the possibility of attracting funding and foreign investment to further research and collaboration.
- Regional and international approaches to research infrastructure and the growth of international “mega-science” projects which require sustained commitment across the national innovation system. See Box 2 below on the SKA – other examples include Australian involvement in the sequencing of human, bovine and rice genome programs.

Box 3. Australian involvement in the Square Kilometre Array

The Square Kilometre Array (SKA) will be a new generation radio telescope with 50 times the sensitivity of any existing telescope and with a total collecting area of one square kilometre. Work on the SKA brings together a consortium of 19 countries, including Australia, which will revolutionize our understanding of the universe by providing answers to fundamental questions in astrophysics, fundamental physics, and particle astrophysics.

The SKA will be built either in Australia or South Africa and will cost over \$2.5 billion. Construction is scheduled to begin in 2013 and be fully operational by 2022. An international process is underway to determine the site for the SKA, with broad recognition of the benefits that hosting the SKA will bring, ranging from business opportunities and industry development, boosting local research and innovation as well as enhancing Australia's global standing. CSIRO is working closely with research partners and the Australian and State Governments to further Australia's bid for the SKA.

- Science plays a key role in the Australian Government's response to complex challenges such as energy, food security and climate change, that have global impact and require facilities, information and expertise beyond the scope of any one country. Currently 18 of the 19 Australian Government departments have dedicated international branches.¹⁵ A number of these departments regularly seek CSIRO input and support in their international policy development and/or relationship development roles.
- A growing sense of the role of “science diplomacy” and the links between science, trade, aid and broader international relations.

¹⁵ [Australia's Diplomatic Deficit, Lowy Institute \(2009\) p.18](#)

4. The impediments faced by Australian researchers when initiating and participating in international research collaborations and practical measures for addressing them

CSIRO seeks to make maximum use of its internal funds and of various Australian Government and international programs to support its international engagement. These substantial government programs with which CSIRO is well aligned include the International Science Linkages (ISL) program, the ISL Science Academies Program and the special funds for bilateral collaboration with China, France and India which are administered by the Department of Innovation, Industry, Science and Research. CSIRO also participates in programs administered by other departments, such as the Asia-Pacific Partnership on Clean Development and Climate (APP) as well as receiving significant AusAID and ACIAR project funding.

Nonetheless, Australian researchers face a number of hurdles in enhancing their international collaboration, including:

- Distance – as a country geographically removed from the major international research and innovation centres, Australia may have to consider investing proportionally more on researcher mobility than other countries. Distance also increases the time and cost commitment required by Australian researchers to effect international engagement.
- Funding programs – internationally there is a huge array of programs to support international research collaboration, but many of these offer small amounts with very tight timeframes and restrictions on what funds can be used for (for example, for only certain kinds of travel, for only certain countries, not for contracting research staff, etc.). This can be very hard to navigate for individual researchers, with a high opportunity cost. There are regular problems with collaborators in different countries not being able to align applications, both in terms of timing and the support available. In addition, many Australian government funding programs explicitly do not provide any funds international travel.
- Sustained support – support for international collaboration is often intended to facilitate a short-term engagement to 'seed' new relationships rather than contribute to the longer-term building of relationships or the participation of researchers in international working groups and fora over a number of years. There is also limited support within institutions or across funding programs for longer term secondments (6-24 months) overseas. These longer-term arrangements enable researchers to develop new networks and a comprehensive understanding of new techniques which benefit the Australian innovation system on their return. It also reduces the need for researchers to move overseas (the brain drain) as the researchers can set up sustained collaborative projects in those laboratories.
- Coordination within Australia – more could be done to improve coordination across Australian research institutions to allow for international engagement at scale in national priority areas. Similarly, there could be greater coordination across governments about the role of science in supporting international policy objectives. As an example of success, CSIRO's Flagship Collaboration Fund has been extremely beneficial in cross national coordination and in encouraging international participation in major Australian efforts.
- Competitive and collaborative tension – recognising that research institutions such as CSIRO operate at once in both national and global systems, some science relationships require close planning and monitoring to ensure that the tension between national benefit and effective international collaborators is well managed.
- Achieving investment at the level necessary to provide world-leading infrastructure in Australia with the capability to attract international collaboration and address complex global science issues that affect Australia. For example international researchers are developing climate and earth system models which require significant super computing facilities and are moving beyond the current capacity in Australia. The emerging science of integrated earth system and economic modelling also will be constrained by Australia's current super computing capability.

- International engagement requires reciprocal benefits in both knowledge transfer and infrastructure support. Australia, with a relatively small investment in R&D, has difficulty providing matching R&D funds and infrastructure for major international initiatives. For example, Australia has only two blue water research vessels despite having the world's 3rd largest marine estate and Australian supercomputing capacity has failed to keep pace with international advances in recent decades. Significant R&D infrastructure investments in recent budgets will help keep Australia in touch with international research contributions but the rate of R&D investment and need for ongoing operational funding remains a challenge in this area given Australia's relative small GNP base.
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5. Principles and strategies for supporting international research engagement

CSIRO has a key role in Australia's national innovation system, and is well placed among international research institutions. CSIRO is focused on bringing together large, interdisciplinary teams from across its broad research capabilities to address issues of national priority and international significance. Partnering effectively within Australia and with the international science and innovation system, including industrial collaborations, is crucial to the delivery of impact from CSIRO's science.

CSIRO believes that a clear and coherent international strategy is an important part of being able to deliver upon this broader mission. This strategy respects the diversity of CSIRO's international engagement and the broad spread of collaboration (working with partners in approximately 70 countries each year), but also seeks to identify cross-cutting areas of priority and particular importance for the organisation. For the 2007-11 period, these are strengthening institutional partnerships in China and India; clarifying and focusing on key opportunities for more strategic engagement with partners in the US and EU; and enhancing CSIRO's "research for development" role, particularly in the Asia-Pacific region and Africa. CSIRO's international strategy is included at appendix two.

CSIRO's international research collaborations have provided immense value to Australian research. CSIRO's experience with these activities indicates that their continuation and expansion will be of great benefit to Australia's future research capability and impact. There are a number of potential mechanisms that could be used to enhance international collaborations in future years which are listed below:

- It is the experience of CSIRO that the removal of recurrent barriers for the full range of research collaboration and improvement of coordination across programs and agencies would be of great benefit. For example, in 2008 CSIRO obtained government approval to open up the guidelines for the Flagship Collaboration Fund to allow increased international participation. The Fund provides over \$100 million for Australian and overseas research partners to join in the work of the National Research Flagships, where their research capabilities can enhance the delivery of impact in ten areas of national priority.
- Based on their very positive impact upon CSIRO's research outcomes to date, the continuation and expansion of collaborative research projects and two-way researcher mobility into the future will be hugely advantageous for Australian science. CSIRO's experience is that flexible funding timelines and rules will further enhance the impact of these activities. Simple researcher exchange programs can have significant long-term benefits, as illustrated in Box 4 below.

Box 4. International Exchange Program

As part of an international exchange program Dr Xu Shisen, Deputy Chief Engineer of the Thermal Power Research Institute¹⁶(TPRI) of Xian, China was hosted by CSIRO in 2006. Dr Xu gained a good understanding of CSIRO technology and good contacts with CSIRO researchers from the exchange. He was subsequently promoted to be the Chief Engineer of TPRI and was heavily involved in the development of an APP-funded project involving TPRI and CSIRO for a pilot post combustion carbon (PCC) dioxide capture plant in Beijing. In April 2008, the Prime Minister Kevin Rudd and the Minister for Climate Change Penny Wong inspected the pilot plant that was commissioned before the Beijing Olympics. TPRI was involved in the design and installation of the pilot plant where Dr Xu was the key engineer. TPRI is now designing a PCC plant with ten times the capacity of the Beijing plant which is to be installed in Shanghai before the upcoming Shanghai Expo. Again Dr Xu is working very closely with CSIRO on scaling up the project. The project was supported under the APP program and would not have occurred without the relationships developed in the 2006 international exchange program.

¹⁶ <http://www.tpri.com.cn/en/enindex.htm>

- CSIRO's experience is that having appropriate and well-resourced infrastructure is vital to sustaining international R&D engagement. Examples include: supercomputing to support effective international collaboration and enable the application of international developments in Australia in key areas such as earth system science and climate science; and blue water research capabilities to allow reciprocal contributions to international research on the oceans and to underpin understanding, conservation, exploitation and effective management of the world's third largest marine estate consistent with our obligations under the International Law of the Sea.
- Australian representation and participation in international science and technology committees has proven to be highly beneficial. Examples include the OECD and other multilateral bodies that are active in promoting research collaboration, new models of international governance and new initiatives in innovation policy.
- Improving the coordination, collection and dissemination of data across the Australian innovation system on international research and innovation performance and trends will help inform strategy decisions by institutions and highlight cross-cutting opportunities and issues.
- CSIRO's engagement experience with various areas of the Department of Foreign Affairs, particularly with respect to the contribution of knowledge and technical transfer to aid missions and Free Trade Agreements, has shown that the alignment of science with foreign policy can be hugely effective in enhancing international collaborations. This could also provide a secondment opportunity for researchers to broaden their skills and awareness.
- Improving the coordinated promotion of Australia as a strong research and innovation performer offshore, through marketing and information campaigns, alumni networks and research and innovation counsellor positions at select overseas posts, will also likely be of great benefit.
- The promotion and long-term support of select strategic partnerships at both the institutional and national levels is a priority for CSIRO which is committing its resources to a number of such partnerships, both within Australia and bilaterally and multilaterally overseas. See for example Box 4 on the CSIRO-AusAID Alliance below. CSIRO is also a founding member of the Global Research Alliance, which brings together the combined expertise and resources of nine applied research organisations worldwide to focus on opportunities to contribute to the Millennium Development Goals.

At the national level, it may be possible to identify a small number of large-scale initiatives (such as the SKA) where Australia can genuinely play a leading and coordinating role globally in the medium to long-term. One such opportunity may be the development of a research alliance within the southern hemisphere that is based on shared socioeconomic, and geographical characteristics and shared challenges (food security, arid agriculture, water resources, ocean fisheries, mineral resources and energy) facing countries in Africa, the Asia-Pacific and Latin America. Based on CSIRO's experiences to date, such an alliance would likely have major scientific, economic and political benefits for Australia and the other countries across the region, and would enable Australia to play a regional leadership role. Having some of the largest research capability and capacity in the southern hemisphere, Australia could then work with its alliance partners to leverage more strategic and coordinated collaboration with northern hemisphere leaders such as the US, EU, China, Japan and India.

Box 5. The CSIRO-AusAID Alliance

This strategic partnership aims to improve the impact of aid and Australia's foreign policy objectives through tailored, science-based solutions to the range of environmental pressures that threaten economic growth, security and poverty reduction. Foremost of these challenges are managing the adverse impacts of development, escalating demand for natural resources, and climate change. Many of these challenges are issues where applied research can play a significant role, both in addressing urgent issues around supporting the delivery of aid and in ensuring that longer-term needs can also be met through informed strategic investments.

This CSIRO-AusAID partnership provides an opportunity to introduce approaches to international aid delivery that better respond to the relationship between poverty and the environment. Alliance projects will achieve impact through influencing AusAID's development policies, investments and projects, as well as informing international stakeholder policies and decisions. Importantly, CSIRO and Australia are also exposed to a wide range of research partners and multilateral agencies through their activities in Research for Development.

Appendix 1

Table 1. Breakdown by CSIRO's top 20 partner countries of international collaboration (not including publications) over the last four years

	<i>05/06</i>	<i>06/07</i>	<i>07/08</i>	<i>08/09</i>
USA	193	193	190	268
NZ	44	51	45	116
China	57	49	64	88
France	50	34	37	55
UK	64	62	45	54
Japan	55	43	37	49
India	26	12	17	43
Hong Kong	5	2	2	39
Canada	27	39	34	38
Malaysia	16	9	13	33
Netherlands	20	17	24	29
Germany	50	34	42	24
South Africa	43	31	27	22
Vietnam	20	20	18	22
Switzerland	17	18	14	21
Indonesia	46	32	28	19
Chile	6	6	14	15
Italy	31	13	10	13
South Korea	10	9	12	13
Belgium	11	4	3	10
Total projects / yr	881	737	733	1033

Table 2. CSIRO's scientific publications co-authored with collaborators in CSIRO's top 12 international partner countries over the last 4 years

	<i>05/06</i>	<i>06/07</i>	<i>07/08</i>	<i>08/09</i>
USA	253	266	276	245
UK	125	128	133	125
China	65	83	116	109
Germany	66	74	89	77
France	72	76	78	75
Canada	70	79	81	65
Japan	45	48	53	46
NZ	43	44	52	40
Netherlands	30	34	41	42
Italy	26	28	29	31
India	21	19	23	22
Spain	18	19	22	21

Appendix 2 – CSIRO's International Strategy - attached as a separate document