Australian agronomy abroad

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Abstract

Australian agronomists work internationally in many different situations and roles. The contribution of Australians to international agricultural research, whether from an international or an Australian base, does appear to be greater than that expected on the basis of history, politics and investment. Australian investment and participation in the International Fund for Agricultural development (IFAD), the Consultative Group on International Agricultural Research (CGIAR) and the Australian Centre for International Agricultural Research (ACIAR) are used as examples of public investment in international agriculture. Then, the homology between the agroecosystems in Australia and in the developing world is assessed. As important as any similarity between Australian/international agroecosystems and farming systems are likely to be are factors such as a detailed understanding of collaborative processes, the quality of agricultural research and educational institutions, and the experience of linking between farmers, researchers and industry at an international level. Past, present, and future challenges in international agricultural research for development are discussed within the context of the contributions that Australia can make in the future. It is concluded that there is much to be gained, in agricultural development and by Australia, through increased involvement in international agricultural research.

Key Words

Rural development, Foreign aid, CGIAR, ACIAR

Introduction – Australia and Australians abroad in agriculture

Australian agronomists, and agriculturalists in general, work internationally in a wide range of situations. They operate through Australian and international consulting firms, as individual consultants or project employees based overseas or in Australia; through the commercial sector, whether in agriculture or in agricultural or environmental aspects of engineering or mining operations; as employees of global and regional organizations for disaster relief or development of the UN or of development agencies such as the World Bank, the Asian Development Bank, and the International Fund for Agricultural Development; through International Non-Government Organizations, both with or without Australian bases and connections; through the research for development (R4D) institutions of the CGIAR network; and as researchers who participate in overseas activities while working from a base at an Australian institution. This paper will not attempt a comprehensive coverage of all these areas of employment nor of the impact achieved, but it will cover some examples and issues, consider whether there are some special features of Australian involvement, and then discuss the potential for Australia and for Australian agriculturalists to contribute further to global agricultural development within the context of the current and emerging challenges.

What drives Australian involvement in international agriculture?

There are many reasons why Australians are involved in agriculture abroad and these are related to a broad suite of historic, political, economic, cultural, and biophysical aspects of Australia as a place and as a people.

History, membership, and funding

To some degree, the involvement of Australians in the various modes of working internationally is related to history, to the status of Australia in the organisations, and to the level of financial contributions from Australia.

Because of previous political, commercial, and research and development involvement, Australians continue to play a comparatively large role in Papua New Guinea and, to a lesser extent, the Pacific. These historical connections, however, are relatively minor compared to the former political and economic colonisers of many other countries and compared to the other political criteria that direct the international aid budget of Australia today. Involvement in international organisations is based, at least in part, on nationality quotas for member countries. On this basis, Australia can never expect to have a large involvement in these aspects of international development, although there are many examples of Australians in productive and influential positions in the agricultural, development, and relief sectors of the UN. Interestingly, there can be strange interactions between disciplines in deciding who will be employed. For instance, employment into the Programme on Nuclear Techniques in Food and Agriculture, a joint programme of the Food and Agriculture Organisation (FAO) and the International Atomic Energy Agency (IAEA) of the United Nations, which is involved in basic and applied agriculturally-related research linked to the use of isotopes, is reputed to have been affected by the need for some countries to keep their quota "free" for any critical nuclear proliferation monitoring positions that may arise within the IAEA.

An analysis of how Australia and other countries spend their aid budget more broadly gives further insights into how, why, and where Australians are involved in international agricultural R4D. The total ODA of the 20 countries that make up the main Development Assistance Committee (DAC) of the OECD in 2006 was US$105 billion. This investment was equal to about 0.3% of the Gross National Income (GNI) of these countries (Table 1). This was significantly less than the target stated by the UN of 0.7%, a target that was exceeded by only five of these countries: Sweden, Luxembourg, Norway, the Netherlands, and Denmark. Australian ODA was equivalent to 0.29% of GNI.

Of this total ODA, only about 2.8%, or US$3 billion, was spent on agricultural ODA (AgODA). Australia directed above the average of ODA towards agriculture, at 4.5%, which ranked behind Canada, Denmark, Switzerland, Japan, and Belgium. Of the contributions to AgODA, an average of 8.8% was spent on the institutions that make up the CGIAR. Again, Australia contributed slightly above the average, at 11.6% of AgODA, but well below the total contributions of the USA, the UK, Canada, the Netherlands, Switzerland, Germany, Sweden, and Norway, as well as the World Bank and some non-member institutions, such as the Bill & Melinda Gates Foundation.

Thus, in terms of financial contributions, Australia would be expected to play a moderately important role in international agricultural development, albeit much smaller than many. Of course, it is hard to quantify the role of Australians in such activities. Clearly, much of the money spent on development assistance, whether directly through AusAID, through NGOs, through other agencies, or from the Australian commercial sector, goes through Australian consulting companies or involves Australian staff. Deregulation in this sector, however, means that more non-Australians are involved in implementing Australian aid and more Australians are implementing aid funded by other countries and agencies.

International Fund for Agricultural Development (IFAD)

A strong example of involvement by membership is Australian participation in the activities of the International Fund for Agricultural Development (IFAD), which is a Rome-based international financial institution established in 1977 as an outcome of the 1974 World Food Conference. IFAD, a specialised agency of the United Nations, was originally intended as a way of channelling funds from the Organisation of Petroleum Exporting Countries (OPEC) into development assistance, at a time when OPEC financial stakes were high as a result of the first oil crisis. OPEC interest in IFAD has diminished sharply from 43% of total contributions at IFAD's establishment to about 5% recently. However, many OPEC members remain major contributors and OPEC's Fund for International Development may return as a donor.

The mandate of IFAD is to combat rural hunger and poverty in developing countries through loan and grant programmes, which have totalled US$10 billion since it was founded (IFAD, 2007). Australia was a founding member and it committed a total of A$50.3 million between 1977 and the end of 2003-04, which represented only 0.13% of Australia's Official Development Assistance (ODA) during this period. In July 2007, Australia withdrew from the 164 member IFAD, with the reasons for withdrawing stated as:

- Limited relevance to the Australian aid programme's priority countries in South-East Asia and the Pacific – despite the fact that 30% of approved financing in 2007 was in Asia and the Pacific;
- A lack of comparative advantage and focus compared to other organisations that are more strongly involved in rural development in the regions of Australian interest – a reason that is also difficult to understand as IFAD works in a similar mode to many development agencies and works increasingly closely with the Asian Development Bank; and
- A failure (of IFAD?) to respond to (what?) concerns that the Australian Government raised with IFAD senior management (AusAID, 2004).

As a result of the withdrawal decision, it appears that Australians will lose their employment opportunities directly within IFAD and, perhaps of greater impact, IFAD will not be able to use the many Australians it has used in the past to review and implement projects.

CGIAR Centres

One area in which the involvement of Australians can be estimated with some accuracy is in the CGIAR. Establishment of the first of the 15 R4D institutions that constitute the CGIAR started some 50 years ago, once the threat of global food shortages was recognised. The CGIAR is a strategic partnership of R4D institutions and donors that is dedicated to mobilising agricultural science to reduce poverty, promote agricultural growth and protect the environment. In 2006, the 15 centres, 13 of which have their headquarters in the developing world, employed more than 1,100 internationally recruited staff and over 7,000 staff of the various host countries. They worked out of more than 185 offices in 100 countries. The total budget in 2006 was US$426 million, with US$265 million from the DAC countries listed in Table 1, US$28 million from other member countries (in total, there are 64 member countries), US$74 million from the 11 international and regional organisation members, $14 million from six foundations that are members, and US$44.8 million from an array of non-members.

Table 1. Contributions of Official Development Assistance by the 20 main OECD Development Assistance Committee countries and how this is spent on agriculture and on the CGIAR

	ODA US$billion	ODA as % of GNI	AgODA US$million	AgODA as % of ODA	CGIAR US$million	CGIAR as % of AgODA
USA[1]	23.9	0.18	610	2.6	60.7	10.0
UK	12.7	0.52	200	1.6	44.1	22.1
Canada	3.8	0.29	200	5.5	26.9	13.4
Netherlands	5.6	0.81	65	1.2	20.1	30.8
Switzerland	1.7	0.39	75	4.7	16.7	21.6
Germany	10.6	0.36	400	3.8	15.3	3.8
Sweden	4.0	1.03	150	3.8	14.4	9.6
Norway	3.0	0.89	110	4.0	13.4	11.4
Australia	2.1	0.29	85	4.1	10.1	11.6
Japan	11.4	0.25	500	4.5	9.1	1.8
Belgium	2.0	0.50	85	4.5	7.4	8.4
France	10.8	0.47	180	1.7	7.1	3.9
Denmark	2.3	0.80	120	5.3	6.7	5.7
Italy	3.7	0.20	40	1.2	4.8	11.0
Spain	3.9	0.32	120	3.2	2.1	1.8
Austria	1.5	0.47	15	0.9	2.1	15.8
Finland	0.9	0.40	30	4.1	2.1	6.0
New Zealand	0.3	0.27	10	3.0	1	12.4
Luxembourg	0.3	0.89	10	2.9	0.5	6.5
Portugal	0.4	0.21	0	0.7	0	0.0
	105		3,005		264.6	

[1]Ranked in order of contributions to the CGIAR.

Source: CGIAR, 2007

On the basis of providing 2.4% of total funding to the CGIAR and 3.4% of the total funding from member countries, as well as being the ninth largest donor country, Australia could expect to be quite well represented in the staff. In fact, Australia is one of ten countries contributing the most research staff, which puts it ahead of several larger donors. Explanations for the presence of the other countries in the top ten staff list fall into four categories. Firstly, Colombia, Nigeria, Peru, and Syria are included as they host centre headquarters and thus contribute a large number of national research staff at these headquarters. Secondly, India is a host of one centre and a significant contributor of staff to other centres. Thirdly, France and Japan are important donors and, particularly for France, they also second staff to the CGIAR centres from their national research institutes, namely the French Institute de Recherche pour le Développement (IRD) and Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), and the Japan International Research Center for Agricultural Science (JIRCAS). And fourthly, the USA and the UK are the two biggest donors, and the USA is host to one (IFPRI, the International Food Policy Research Institute, Washington) of the two centres (the other being Biodiversity International, in Rome) not located in developing countries. In addition to good representation as research scientists, Australia has had good representation in management of CGIAR centres. Currently, an Australian Colin Chartres) is the Director General of of the 15 institutions (the International Water management Institute in Sri Lanka), and he follows a number of Australian Directors General (including Tim Reeves CIMMYT 1997-2001), and Tony Fischer as head of the wheat breeding program at CIMMYT 1988-1995. Also, three of the 15 Boards of Trustees are chaired by Australians, and there are another three Australian board members, again with many Australian predecessors. All of these personnel linkages further enhance Australia's involvement with the CGIAR. So it does appear that Australia is represented in the CGIAR beyond the level of Australian funding.

Australian Centre for International Agricultural Research (ACIAR)
A further model through which Australian agriculturalists work abroad is with support from the Australian Centre for International Agricultural Research (ACIAR). A minor role of ACIAR is to manage Australia's contribution to the CGIAR and a number of other international institutions, but the major task is that of developing and funding collaborative research projects with institutions in Australia and abroad.

ACIAR was established in 1982 to encourage Australian scientists and institutions to use their skills to develop solutions to agricultural problems in developing countries. Since establishment, at which time it operated with funding from AIDAB (now AusAID), ACIAR has been an important vehicle for linking Australian researchers, many for the first time, to challenges in international agricultural development. ACIAR has grown into an institution with an annual budget of approximately A$60 million, with an active portfolio at any one time of over 300 projects and about 100 associated postgraduate scholarships, across more than 20 countries. The current budget represents just 2% of Australia's ODA, although about 70% of aid in agriculture, and includes the annual contributions to the CGIAR of at least A$10 million.

In addition to changes in the organisational structure and funding sources, now with a separate budget to that of AusAID, ACIAR has undergone changes in the balance of the country and thematic foci, and has shifted to a greater interest in impacts, with projects now organised 40:40:20 for near-term, medium-term, and long-term impact, respectively. This shift has in part answered the criticism during earlier reviews that the gap between ACIAR-funded research and AusAID-funded development was too large. Currently, there is a move to reduce the number and increase the average size of projects, which may have increase the potential for real impact.

Another link to international agricultural development by Australia and Australians that deserves a mention is the Crawford Fund. The *ATSE* Crawford Fund was established in 1987 by the Australian Academy of Technological Sciences and Engineering to increase Australians' engagement in international agricultural research, development and education for the benefit of developing countries and Australia. The major impacts of the fund have been to support a wide array of training courses and events and to promote the work of Australian in international agriculture, particularly the work of ACIAR, AusAID, and the CGIAR centres.

The biophysical and technical nature of Australia and Australians
At a simplistic level, Australia's comparative proximity to the Pacific and southeast Asia is a factor in continued involvement in development in these regions rather than other developing countries in Latin America, central Asia, and north and west Africa. Proximity alone does not explain, however, the involvement in the Pacific and Southeast Asia, let alone the involvement further afield, in south Asia, east Asia, or southern Africa.

Many of the biophysical constraints that have occupied the minds of Australian farmers and researchers, such as poor soils and low rainfall, are not dissimilar to those experienced by poor farmers in many parts of the developing world, especially in the dry and sub-humid tropics. Does this similarity translate into a strong homology between Australia and the developing world so far as agriculture is concerned?

In terms of soils, Australia does have many problem soils and has much experience in identifying and managing soils constraints. If we look at the soil resources of the world analysed by both the areas of soils with particular constraints or the proportion of soils with particular constraints (FAO AGL, 2000) there are only a couple of factors that stand out. Australia has larger areas relative to its size of soils with:

- A low cation exchange capacity (as an indicator of low soil fertility), along with Brazil and much of Sub-Saharan Africa;
- vertic (shrink-swell) properties, along with India, Sudan, and Mexico;
- Sodic subsoils, along with Kazakhstan, Russia, and Argentina; and
- Saline soils, along with China, Argentina, Mongolia and Iran.

While Australia has R4D links in several of these countries, particularly India and China, it would appear that the homology between where these soil-related problems exist and where Australia and Australians work is not that high. At the same time, some of the major problems that are widespread in the agriculture of developing countries, such as aluminium toxicity and high phosphorus fixation, by world standards, are not great problems in Australia on an area basis.

Of course, such analyses, based on the whole land area of Australia and on the whole land area of the developing countries are not totally appropriate, as Australia's research expertise is very much focussed on specific agroecosystems and the critical areas for research abroad will be in similarly specific agroecosystems. When climate, topography, geo-position, soil, etc. are combined another level of homology can be assessed. The recent development by the International Center for Tropical Agriculture (Centro Internacional de Agricultura Tropical, CIAT) and partners of the software Homologue (Jones et al., 2004) provides an opportunity to test this idea. Unfortunately, Homologue is not populated with data from the higher latitudes of Australia were much research has been focussed, but in analysing the tropical north of Australia with all of these factors, it does appear that there is more homology than might have been expected, particularly in South Asia, in equatorial and Southeast Africa, and in small pockets of Latin America. It will be interesting to assess homology between the higher latitudes of Australia and the developing world once the data are available. The question is whether such analyses of homology as shown in Figure 1 help in analysing both where and why Australians do work abroad and what they have to offer?

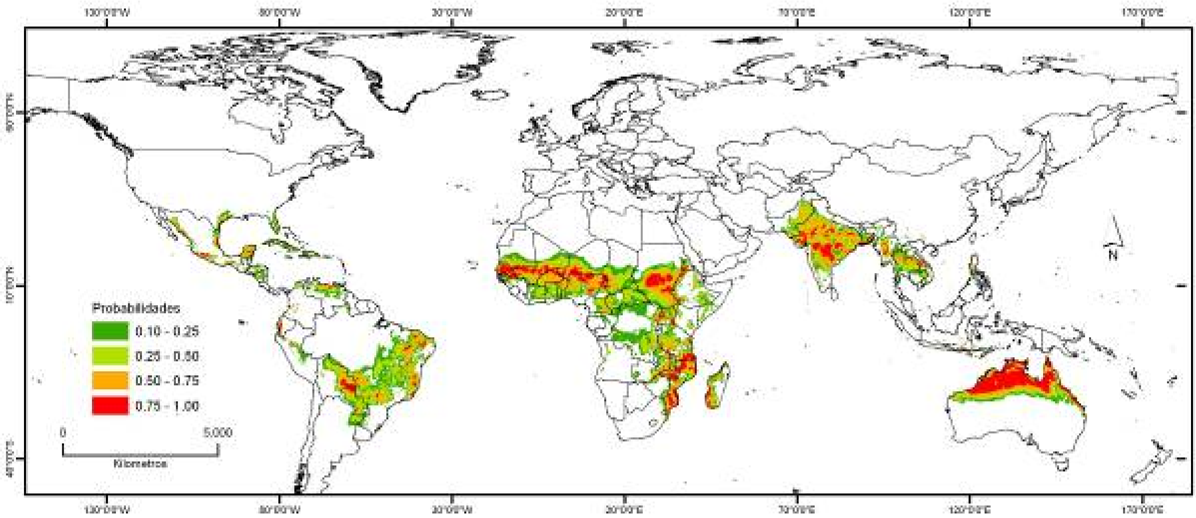

Figure 1. Probabilities of homology between sites in northern Australia, based on climate, topography, geoposition, and soils, derived using the Homologue software

What can Australian agronomists working abroad contribute?

Australia has a long history of excellence in biological research and in agricultural research in particular. A difficult climate and comparatively poor soils, combined with a relatively short agricultural history meant that the agricultural industry emerged under rather different pressures than in other parts of the world, particularly in Europe, where the science of agriculture emerged into well established agricultural systems.

The harsh biophysical resources of Australia, combined with the large distances to both internal and external markets, have imposed pressures on the agricultural systems, often at an earlier stage than in other countries. This has resulted in the development relatively low-input, low-cost systems with efficiencies in nutrient and water use and labour. Whilst these *particular* biophysical and economic constraints may be very different, these same forces that fashioned and continue to fashion Australian agriculture and agricultural research are similar to the problems that plague many farmers in developing countries, especially those on more marginal lands.

However, it is perhaps more the general nature of agriculture and of agricultural research in Australia, with a strong link between pure research, applied research, and practical application by farmers, have been hallmarks of Australian agricultural research. When coupled with a strong education sector, in a favourable environment for international students, there is a strong potential for innovative and productive research, with direct impact potential, and with critical capacity building potential.

Setting the international rural development scene
Having discussed what Australian agriculture and agriculturalists have to offer abroad, it is necessary to assess the current status and challenges of international rural development.

Agricultural research has been at the heart of enormous advances in global agricultural productivity and has underpinned the general industrial development that has occurred in the first world over the last 150-200 years. The large increases in production and productivity per unit labour have freed people for non-agricultural activities while maintaining an affordable food supply.

The establishment in the 1960s of the research institutions that later became the CGIAR, particularly those institutions with a focus on the major staple crops, such as rice (the International Rice Research Institute, IRRI) and maize and wheat (Centro Internacional de Mejoramiento de Maíz y Trigo, CIMMYT – the International Maize and Wheat Improvement Center), resulted in the breeding successes that heralded the Green Revolution. Through these advances, world food production increased substantially, averting much of the worst of the extremely serious food shortages that were predicted, and providing cheap food that has been at least one important factor in the comparative political stability in many developing countries, particularly in Asia. The production of cereals increased by a factor of about 2.6 from 1960 to 2006, in the same period that population increased by a factor of about 2.1, resulting in a 21% increase in per capita production of cereals (FAO, 2008).

In a recent assessment of the impact of the Green Revolution and of the CGIAR system, it was concluded that in the absence of CGIAR centres and their work done with partners in the developing world, the area planted to crops would be higher (for instance 4% for wheat and 2% for maize), crop yields in developing countries would have been 19.5-23.5% lower, prices for food crops 35-66% higher, imports 27-30% higher, calorie intake 13.3-14.4% lower, and 32-42 million more children would have been malnourished (Evenson and Gollin, 2003).

While the main research outputs that initiated these increases in yield were in plant breeding, the subsequent improvements in agronomy through increased use of fertilisers to overcome nutrient deficiencies and agricultural chemicals for pest, disease and weed management, and mechanisation were an integral part of the successes..When these developments were coupled with public investment in seed supplies, irrigation systems, transport and general infrastructure, world food production was lifted.

From 1962 to 2006, when cereal production increased by a factor of 2.4, the total use of N, P, and K fertilisers (expressed as N, P_2O_5, and K_2O) for all agriculture increased by a factor of nearly 4.9 (FAO, 2008). The increase in the use of nitrogen, by a factor of 7.9, was far greater than for phosphorus (3.3 times) or potassium (2.9 times). When the production and fertiliser use statistics are disaggregated into different regions for the period from 1965 to 1998, when some of the largest changes occurred, the very dramatic impact of increased fertiliser use on net food production in Asia, particularly in China can be seen (Figure 2). This is in stark contrast with the decline in food production and fertiliser use in Sub-Saharan Africa, as well as in the former Soviet Union, although declines in fertiliser use and production following the collapse of the USSR were from a much higher base.

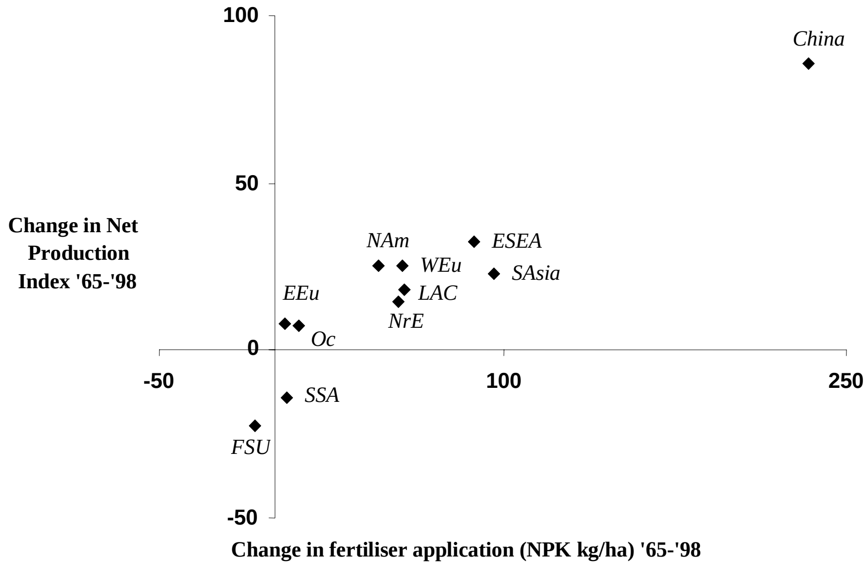

Figure 2. The impact of changes in fertiliser use on net production indices (corrected to 1989-91 base prices) from 1965 to 1995, for different regions. Source: FAO (2000) (Regions: China = China; ESEA = East and Southeast Asia, other than China; SAsia = South Asia; WEu = Western Europe; LAC = Latin America and the Caribbean; NAm = North America; NrE = Near East; Oc = Oceania; EEu = Eastern Europe; SSA = Sub Saharan Africa; FSU = Former Soviet Union)

The main focus of research during this era of rapid food production increase were the more favourable agricultural lands. In general, these lands are more homogeneous, and suitable for a "technology package" approach to extension.. They were areas where the returns to investment were high. Many areas either did not benefit from the Green Revolution because they did not have access to the required inputs – seeds, fertiliser, other agrochemicals, and irrigation water – or they did not reap the full benefit because the genetic improvements were not targeted at their agricultural systems and/or balanced by congruent improvements in agronomy. In fact, some people argue that the full benefit of the first *genetic* Green Revolution can only be reached through a second *agronomic* Green Revolution, which so far has been impossible in many places.

Many of the benefits of the first genetic Green Revolution were practically immediate. For example, after a poor harvest in 1966, India imported 18,000 tons of seed of the new semi-dwarf wheats bred at the forerunner of CIMMYT in Mexico. The Indian wheat harvest in 1968 was 16.5 million tons, compared with 11.3 million tons in 1967. Thus, under the then current farming practices, the *genetic* revolution had been a major contributor to a more than 40% immediate increase in yield.

Recently, Peter Jennings, who founded the breeding programme at IRRI in the Philippines and discovered the semi-dwarf gene of rice that led to the landmark IR8 variety, commented in a similar fashion for rice in Latin America (Jennings, 2007). The introduction of semi-dwarf rice varieties in favourable environments in Latin America resulted in a one-off increase in yield of about two tonnes per hectare. Average yields continued to increase, but only until all of the irrigated and favourable upland ecologies were converted to these varieties – on individual farms the genetic revolution took one season. There was no additional major increase in *yield* with the release of a further 400 semi-dwarf varieties and that same yield barrier persisted for about 30 years. Realising there was an agronomic limitation, Jennings' colleagues at the Latin America Fund for Irrigated Rice (Fondo Latinoamericano para Arroz de Riego, FLAR), based at CIAT headquarters in Colombia, worked to identify the major agronomic limitations and then addressed them systematically, as multiple farm constraints rather than individual problems. These included (i) inappropriate seeding dates missing peaks of solar radiation after panicle initiation; (ii) heavy seeding densities causing lodging, disease, and pest attacks; (iii) repeated aerial spraying rather than seed treatment to control insects; (iv) deficient weed control; (v) poor fertilisation practices, including the application of urea into water; and (vi) late establishment of permanent irrigation. Within three years, the second revolution, an *agronomic* revolution, had resulted in an impact in Latin American rice production similar to the genetic revolution, namely an increase in yield of about two tonnes per hectare.

The question is ‘why weren’t the impressive impacts of the Green Revolution seen more broadly? Was the science wrong? In part, perhaps yes, as the importance of the agronomic component of the Green Revolution was either under emphasised or lost in the attempts to achieve broad adaptation through an overly simplistic technology package approach. Perhaps even the breeding can be criticised a little, as none of this effort was targeted at the more marginal biophysical environments, an understandable tactical and practical decision. Probably, the biggest fault was the lack of consideration of socio-political components. The poor, be they marginalised as a result of whatever combination of ethnicity, class, caste, gender, religion, conflict or politics, or simply because of their limited access to biophysical resources, did not have access to all, lacked the components for significant improvements in production. Thus, they lacked the full combination of improved germplasm, agronomic knowledge, the necessary inputs for improved agronomy, and access to input and product markets.

A different development environment
Many things have changed since agricultural research first started to have major impacts on rural communities in the developing world in the 1960s. The total world population has increased by a massive 2.14 times from 1960 to 2005, and the urban populations have grown even faster, by a factor of 3.18. The result is not only many more people to feed, but since 2005 less than half of the world population are rural dwellers, down from 67% in 1960. These global trends were driven by rapid population growth and rapid urbanisation in much of the developing world.

The amount of land used for agriculture (arable crops + permanent crops + permanent pastures) increased by about 10% from 1965 to 2005, with arable crops and permanent pastures increasing by about 9.5% and the much smaller area of permanent crops increasing by nearly 60%, to 2.8% of total agricultural land. Since food production more than doubled over this period, it is clear that increased production did not come from an increase in the area of land under agriculture but from yield increases resulting due to improved varieties, more intensive cropping, and improved agronomy.

In 2005 38% of total land area was used for agriculture, up from 34.5% in 1965. This increase suggests that additional land reserves remained. However, this is not now the case, as increasing amounts of land are being used for urban use, industrial purposes, biodiversity, timber production and environmental services. In addition, any remaining land reserves are generally of marginal quality compared to the productive lands that have been in use for generations, and these land reserves are restricted to a small number of countries, primarily Brazil and the Democratic Republic of Congo. Furthermore, the threat of land degradation is likely to increase as more pressure is put on current agricultural land.

In terms of land utilisation, three great challenges remain: (i) how to make inherently marginal lands more productive, (ii) how to stop the degradation of the agricultural land that is in use currently, and (iii) how to restore the already degraded lands. Central to all of these issues is the efficient management of water, carbon, and nutrients, all of which have been key elements in understanding and adapting agriculture in the Australian environment, and especially so with the additional threats and uncertainties of climate change.

For decades, the relative price of food has fallen. During the last four decades of the 20th Century, as the average food supply per person increased by 24%, the price of food decreased by 40% (UNDP *et al.*, 2000). Seen against this decline, the recent increase in prices can be seen in part as a correction of this trend in food prices, albeit driven in part as a response to the price of fuel, the biofuel policies of Europe and North America, trade restrictions, speculation, and food subsidies. It is also driven by low world food stocks. Despite improvements in the capacity of agriculture to supply adequate nutrition and provide well being for much of the world population, the distribution of benefits is far from uniform, resulting in levels of poverty, household food security and nutrition that are unacceptably low for many people. The current food crisis only exacerbates these problems.

Where to in agricultural R4D?
The great successes of the Green Revolution were in producing more food for a starving world. Many countries were able to achieve, or at least get closer to, acceptable levels of national food security, which then enabled the supply of relatively cheap food to increasingly urban and industrialising societies. Thus agriculture allowed for the advancement of economic development. As the focus moved, or is moving, from national food security to household livelihood security so there was and is a need to disaggregate the

communities below the level of the nation. This need will involve tackling the problems that arise from the great disparities that exist in the resource-base of individuals or communities, the differences in accessibility to a wide range of services and markets, and the inequalities of rights metered out on the basis of ethnicity, religion, politics, gender and more.

Thus, the challenges become not just producing more food at the national level, or delivering more food to the hungry, but delivering improved livelihoods to the poor and particularly the marginalised poor. In short, the challenge has shifted from developing fairly broad prescriptive technology packages with limited site-specificity, to the development of adaptive strategies with a high-degree of site-specificity that allow adaptation by farmers to suit their particular suite of biophysical, economic, social, cultural, and political conditions. Even in the more favourable agroecosystems that were the home to Green Revolution successes, far greater degrees of site specificity in both germplasm and agronomy are reaping great benefits. The need for more adaptive strategies, with high levels of site-specificity in more than just germplasm and agronomy is far greater for the more heterogeneous and broadly marginal agroecosystems that are the home for the majority of the poorest of today and that have received less research and development focus to date.

These challenges can be separated into three specific areas. Firstly, there is the need for far greater targeting of research and extension efforts. This requires understanding the broad set of biophysical, social, and economic characteristics of the peoples and their place. Secondly, there is the capacity to develop broad technical solutions to these specific domains, with much of this development involving close collaboration between farmers, advisers and researchers. Thirdly, there is the capacity to deliver these outcomes to farming communities as adaptive strategies with which they can work to innovate strategies that will be adopted broadly, with continuous adaptation by their fellow farmers.

Most of the specific technical solutions, and the majority of the methods for farmer adaptation and adoption, will bear very little resemblance to issues that are faced by agricultural researchers in Australia. However, given the success of Australia's contribution to world agricultural development, there remains a place for Australian agronomists abroad now, more than ever.

Implementing change in the name of the developing world

The recent World Development Report of the World Bank (2007) focuses, for the first time in many years, on agriculture. The message was clear that there is a need for greater support for and investment in agriculture, and for increased agricultural R&D to support agriculture, so as to increase agricultural production and to provide an engine for economic development. The current food crisis has helped focus the concerns even more. With current ODA funding being well below the UN stated target of 0.7% of GNI for all but a handful of countries, there is room for increased aid funding. Even without an increase in overall aid, the current average of less than 3% of ODA being spent on agriculture is very hard to justify in the current situation.

The institutions of the CGIAR are not in the pre-eminent situation they once were in international agricultural R4D, however, they still have an extremely important role to play. Many national agricultural research institutions from the developed countries are operating as International Agricultural Research Centres (IARCs) and make major contributions to international agricultural R4D. In Australia, much of this work is funded through ACIAR projects. In addition, the National Agricultural Research Systems (NARS) in the developing countries are increasingly important contributors to important research outputs at both the national and international levels, and for some, such as China, Brazil, and India, they are working increasingly at an international, rather than just a national level.

In this environment, there are several major roles for the CGIAR institutions in helping to form and maintain productive international partnerships. Firstly, the gene banks of the CGIAR are invaluable international resources that need to be well characterised and utilised freely and widely – and well beyond the CGIAR institutions. Whereas the CGIAR institutions were world leaders in breeding, they are but part, albeit a very vital part, of a larger group that includes NARS and IARCs and in which the CGIAR institutions gene banks are core. Secondly, the partnerships that have been established by the CGIAR institutions working in over 100 countries are invaluable in undertaking truly collaborative research, in facilitating South-South and North-South communications, and in ensuring the appropriate scaling-out of improved technologies and systems. Thirdly, the decades of work in developing agriculture has resulted in new approaches and tools for targeting interventions, facilitating the adaptive process of farming systems development with farmers, and achieving the greatest level of impact reaching the greatest number of farming households as outcomes of R4D become international public goods.

Currently, the CGIAR system is undergoing a process of change, although it remains unclear if and how the structure of the CGIAR institutions will change. There may be a small or even a large reduction in the number of centres, but whatever the structure, it is hoped that the outcome will be a more integrated and financially and technically sound institution, or group of institutions, that continue to play a pivotal role in agricultural R4D. With such changes should come an increase in the budget and calls have been made from both within and outside the CGIAR that the budget should be doubled. This could be achieved through relatively small changes in either the percentage of AgODA that goes to the CGIAR or, more logically, to an increase in the AgODA as a percentage of ODA or an increase in the total ODA. If AgODA is increased then other recipients of AgODA would benefit. In the case of Australia, this benefit could be through increased funds, presumably through ACIAR, for Australian research institutions to work internationally, to build the capacity of developing country research staff through scholarships, and enhanced linkages with the CGIAR through joint projects, secondment of staff, and by increased employment opportunities for Australian within the CGIAR institutions. Justification for increased support of, and involvement with, the CGIAR by Australia can be supported on purely financial returns. Several studies (NSW DPI, 2006) suggest that the direct annual benefits that flow to Australia from just three of the CGIAR centres, the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India, and CIMMYT in Mexico, in terms of improved germplasm is equivalent to about A$50 million, i.e. about five times the funding Australia provides annually to the whole CGIAR system.

The innovative and progressive development of Cooperative Research Centres (CRCs) in Australia, that started in 1991, which formed linkages between a wide range of research, education, and industry partners, has equivalency in the CGIAR system. Initially, the CGIAR established so-called system-wide and ecoregional programmes that worked across centres and included NARS, of which 17 have been established since 1992. Subsequently, in 2003 the CGIAR moved to establish the larger, more independent, and broader partnerships, the Challenge Programmes, which involve CGIAR institutions, IARCs, NARS, and the private sector. There are four Challenge Programs running currently: on water and food, on biotechnology in genetics, on enhancing the nutritional value of foods, and on agricultural development in Sub-Saharan Africa. Australian institutions play important roles in the first three. In addition, three more are being developed: on climate change and agriculture and food security, on high-value crops, and on combating desertification. The involvement of industry in these developments is important and Australia has much to offer by way of the example of an end-user focus, developed through linkages that have been forged by both industry levies and the involvement of industry in the CRCs and other research initiatives.

What next for Australian agronomy abroad?

With much remaining to be done in improving agricultural production in the developing world, both as a direct source of food and improved livelihood for the rural poor, and as a catalyst for economic development and in some cases political stability, there is a need for the development of new partnerships and strengthening of existing partnerships to achieve these goals. Australia can play a significant role in these developments.

Strengthening the CGIAR system is one important task in which Australia and Australians can play an important role. Increasing collaboration between national and international research partners, from the developed and developing world is another activity in which Australia can and should participate, through continued and expanded financial support, the implementation of projects in partnerships, the training of agricultural graduates, postgraduates, and postdocs, and perhaps through increased secondments from and to Australian institutions.

While building on some important close similarities between agricultural systems in Australian and agricultural systems in the developing world, the greatest contribution to developing world agriculture from Australia will be the quality, not the specific outputs, of Australian research. This quality has come from high quality training and a research tradition forged through industry funding, close collaboration with farmers and farmer groups, and experience with the Landcare approach. In Australia, there is a balance between science, practical application, and the critical social and economic components of agriculture.

There are many incentives for greater involvement in international agriculture. At a time when domestic student numbers in agriculture and natural resource sciences are falling, there are increased employment opportunities in Australian and international agriculture for agricultural graduates. Increased scholarships for international students will provide a welcome boost to university teaching and research. Broadening the base for Australian agricultural research, beyond the conditions experienced in Australia has and will continue to strengthen the quality of research, bringing benefit to both Australia and the world, especially when we face an uncertain future with climate change. In the same way that Australians abroad have provided a new view for developing world agriculture, their experience abroad will provide a new and challenging perspective to Australian agriculture, in biophysical, economic, and social terms.

The direct and indirect economic benefits to Australia of increased funding for international agricultural research for development, and specifically for increased Australian involvement, should be sufficient justification for even the most economic rationalist of politicians. It can be hoped, however, that these benefits are seen as only secondary considerations to the benefits for humankind that can reduce hunger and suffering and initiate and then maintain the process of moving the marginalised millions towards a situation of adequate food, shelter, and livelihood, and towards a situation where they can enjoy the political and social rights, freedoms, and dignity that should be the accepted norm for all.

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