The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982 by an Act of the Australian Parliament. Its mandate is to help identify agricultural problems in developing countries and to commission collaborative research between Australian and developing country researchers in fields where Australia has special research competence.

Where trade names are used this does not constitute endorsement of nor discrimination against any product by the Centre.

ACIAR MONOGRAPH SERIES

This peer-reviewed series contains the results of original research supported by ACIAR, or material deemed relevant to ACIAR's research objectives. The series is distributed internationally, with an emphasis on developing countries.

CRAWFORD FUND

The Crawford Fund for International Agricultural Research is an initiative of the Australian Academy of Technological Sciences and Engineering. The Fund's mandate is to publicise throughout Australia the benefits of international agricultural research and encourage greater support and participation from both government and non-government organisations.

Lawrence, Janet, ed. 1994. A profit in our own country. Record of a seminar conducted by the Crawford Fund for International Agricultural Research, Parliament House, Canberra, May 17 1994. ACIAR Monograph No. 30, 139 p.

ISBN 1 86320 119 X

Design and art production: BPD Graphic Associates, Canberra, Australia
Printed by: Goanna Print Pty Ltd, Canberra

A Profit in Our Own Country

RECORD OF A SEMINAR CONDUCTED BY THE CRAWFORD FUND FOR INTERNATIONAL AGRICULTURAL RESEARCH, PARLIAMENT HOUSE, CANBERRA, MAY 17 1994

EDITOR: JANET LAWRENCE

COSPONSORS:

Australian Centre for International Agricultural Research
Australian International Development Assistance Bureau
Department of Primary Industries and Energy

Canberra 1994

Acronyms and Abbreviations

ABARE Australian Bureau of Agricultural and Resource Economics
ACIAR Australian Centre for International Agricultural Research
AIDAB Australian International Development Assistance Bureau
ASEAN Association of Southeast Asian Nations
CGIAR Consultative Group on International Agricultural Research
CIAT International Centre for Tropical Agriculture
CIMMYT International Centre for Maize and Wheat Improvement
CSIRO Commonwealth Scientific and Industrial Research Organisation
GATT General Agreement on Tariffs and Trade
IAEA International Atomic Energy Agency
IARC International Agricultural Research Centres
IBSRAM International Board for Soil Research and Management
ICARDA International Centre for Agricultural Research in the Dry Areas
ICRAF International Centre for Research in Agroforestry
ICRISAT International Crops Research Institute for the Semi-Arid Tropics
IFPRI International Food Policy Research Institute
IIMI International Irrigation Management Institute
ILCA International Livestock Centre for Africa
IPGRI International Plant Genetic Resources Institute
IRRI International Rice Research Institute
NARS National Agricultural Research System
OECD Organisation for Economic Cooperation and Development
QDPI Queensland Department of Primary Industries
TAC Technical Advisory Committee (of the CGIAR)
UNCED United Nations Conference on Environment and Development
UNEP United Nations Environmental Programme
UPOV Union Internationale pour la Protection des Obtentions Végétales
WTO World Trade Organisation

Contents

Introduction

RT HON. J.D. ANTHONY

CHAIRMAN, CRAWFORD FUND FOR INTERNATIONAL AGRICULTURAL RESEARCH

This Crawford Fund Seminar will discuss the benefits which flow to Australia from this country's participation in international agricultural research.

However, at the outset, I want to say loudly and clearly that the main aim of Australia's overseas aid program is the support of countries and communities in the developing world. All Australians recognise that countries such as our own have an obligation to provide whatever assistance we can to improve the standards of living of those in the world who are today suffering the miseries of abject poverty and hunger.

The Australian aid program offers assistance of various sorts but today we are concentrating on a mere three per cent of the total aid program. However, although small in cost, it is, in the view of many of us, the most effective of all our aid activities.

Overarching the immense problems of Third World development is the basic issue of poverty. According to the world poverty report of the World Bank, the poorest people in the world 'are overwhelmingly in the rural areas' and they are poor because they are unemployed and landless. The best, and perhaps only, hope for the future of these most unfortunate people rests with the development of their agricultural industries. This development will create job opportunities, both on farms and in the rural industries supplying farmers with their inputs and transporting, storing and processing their outputs.

The recognition of agricultural development as the essential base on which broader national development can be built is not new. Improved agriculture provided the primary basis for industrial development in Britain, Western Europe, the USA, Canada and, of course, Australia. We can see the same process today in, for example, Malaysia, Indonesia, Thailand and China.

Agricultural research and development merit the highest priority in our aid program because it is farming improvements that will alleviate rural poverty. There are therefore excellent reasons for maintaining, indeed increasing, Australia's participation in international agricultural research and development.

While our primary purpose is to assist the progress of poor communities overseas, certain benefits also accrue to Australia.

While our primary purpose is to assist the progress of poor communities overseas, it is in the nature of these activities that certain benefits also accrue to Australia. We should not shy away from this, in fact we should continue to publicise it, particularly because if this was better understood (especially in Treasury and Finance) there would be greater enthusiasm to expand these aid activities.

International agricultural research and development is genuinely a win–win activity. It brings enormous and long-term benefits to Third World countries, while at the same time it is inevitably helpful to Australia's agricultural and trading activities and to the ongoing care of its environment.

Keynote Addresses

THE HON. GORDON BILNEY is the Minister for Development Cooperation and Pacific Island Affairs. He was previously Minister for Defence, Science and Personnel. Mr Bilney has stated his firm support for international agricultural research as one of the most effective ways in which a country like Australia can assist development efforts, and that it is a major factor in achieving food security and sustainable development.

Benefits to Australia from International Agricultural Research

THE HON. GORDON BILNEY
MINISTER FOR DEVELOPMENT COOPERATION AND PACIFIC ISLAND AFFAIRS, AUSTRALIA

It is my pleasure to present this keynote address to the Crawford Fund Seminar. In April last year I spoke at the Australia-IRRI day seminar arranged by the Crawford Fund which was provocatively titled, 'The Food Time-bomb in Asia'. I am delighted to participate again this year and would like to commend the Crawford Fund for continuing its campaign to increase public understanding in Australia of the importance of international agricultural research.

The theme of this year's seminar is the benefits that accrue to Australia from our participation in international agricultural research. Another provocative title—a dreadful pun, but I hope it attracts attention. The benefits are many—for Australia's agriculture and trade and for the Australian environment.

Other speakers today are going to explore the range and nature of those benefits in far greater detail than I. What I want to do is to provide an overview of those benefits, both real and potential.

The overriding objective of Australia's Aid Program is to improve the lives of people in developing countries in ways that are ecologically sustainable and socially equitable. This is primarily driven by humanitarian concerns, but also reflects our commercial and foreign policy interests.

Long-term, sustained poverty reduction is intrinsic to the aid program and it is a very complex task. It requires action at both the macro and micro levels. In the macro sense, the aid program tackles poverty by promoting sustainable economic growth and the development of human resources through education, health and capacity building. At the micro level, the aid program fights poverty through activities directly targeted at the poor, to meet basic needs and provide emergency relief.

We have seen how generously the Australian public responds to appeals to raise money for the victims of famines and disasters. The humanitarian ethic and a commitment to social justice are fundamental to our culture. But it doesn't require much of a leap in imagination to see that poverty reduction is also very much in Australia's interests.

The end of the cold war has brought both opportunities and challenges. In particular, it has forced us to define more broadly the concept of security. Much greater emphasis is now being placed on non-military threats to security arising from continuing poverty, disease and environmental degradation.

Development assistance programs aimed at reducing poverty and improving health and resource management thus have a key role in strategies for peace building, peace keeping and peace restoration. In this sense, overseas aid is patently not charity. Rather, it is an investment in global and regional security and prosperity. It is also an investment in the future with all the intra-generational benefits that implies.

All this is well summed up in the title and contents of Professor Derek Tribe's book, *Doing Well By Doing Good,* in which he argued compellingly that the best way to improve returns to Australian farmers is to increase the demand for the food they produce. The aid program plays an important role in stimulating that demand, by reducing poverty and increasing the purchasing power of people in developing countries.

The aid program is a matter both of humanitarian obligation and enlightened self-interest.

Where I seek your help today is in getting the message across in the community—particularly the rural community —that the aid program is a matter both of humanitarian obligation and enlightened self-interest.

Unfortunately we still have some way to go in convincing everyone that is the case. Last year I received more letters from rural communities questioning the value of the aid program than from any other group. Now it is not surprising that, when faced with unemployment, low incomes and the repossession of farms, people ask whether aid money would not be better spent at home. I say two things in reply. First, I say without equivocation that a country as relatively wealthy as Australia has a duty to spend what is, after all, a very small proportion of our national income on helping people with far fewer opportunities than we have. But the second thing I do is to make the point that in doing so we are also laying the foundations for continued prosperity in this country—not least in rural communities which often depend heavily on exports, and therefore economic development overseas.

The Government's approach to maximising both the development impact of our aid and the commercial returns to

Australia is activist and strategic. The principle driving the country programming process is to respond to the needs and priorities of developing countries in sectors where Australia has internationally competitive goods and services to offer. Agriculture is clearly one of those sectors and Australia's expertise in agricultural research is second to none.

It follows, therefore, that a key feature of our aid program is to showcase Australian goods and services. Over 90 per cent of the aid budget is spent on goods and services made in Australia. That this has immediate benefits for the Australian economy by increasing production and jobs is indisputable, but it also has significant additional spin-off effects through demonstrating what we do best.

In this way, the aid program provides long-term benefits for Australia, helping to create an internationally competitive export culture. It does this by providing firms with, in many cases, their first opportunity to gain access to overseas markets. The experience gained is invaluable.

This year's aid budget outcome—a $51 million real increase, $82 million in dollar terms over last year—reflects government understanding of the dual role that aid plays.

Agricultural research has proved one of the most effective forms of aid. It has brought improved living standards in developing countries and substantial benefits for Australian agriculture—and therefore the Australian community. It has helped deliver better productivity, pest and disease control, and lifted demand for Australian agricultural exports.

Agricultural research has brought improved living standards in developing countries and substantial benefits for the Australian community.

There is no doubt that the pressure is now on to increase agricultural production to feed the world's growing population. This means finding new and better ways to lift crop and livestock yields, and to manage fisheries, forests, land and water in sustainable ways. For a country such as Australia, this is both a challenge and an opportunity.

One document I've seen recently gives some very up-to-date perspectives on these challenges and opportunities. The Independent Inquiry Report into Population and Development—released by the Australian Government in April—reported that one of its most sobering findings is that rapid population growth will make the problem of growing sufficient food to feed the world's population much more difficult. The world's population is likely to reach 11 billion by the middle of next century and 90 per cent of that increase will take place in developing countries.

Global crop yields will need to increase to about 6000 tonnes per hectare if the world's population is to be adequately

fed in the year 2050. Most of this increased production will need to be accommodated without increases in land devoted to agriculture—it must come predominantly from increased yields.

The exception is in aquaculture where higher output, at least initially, can be achieved by utilising more of the sea. Marine resources will become much more important as the pressure builds on land resources. Ocean fisheries are poised to become the farms of the future. As such, agricultural scientists will play a vital role in ensuring they are not over-exploited.

That same Independent Inquiry Report into Population and Development concluded that increased investments in agricultural research will be essential to boost agricultural productivity. Efforts to build agricultural research capacity in developing countries must also be intensified. The report finds that more private-sector resources will be needed, and points out that an increasing share of the new knowledge generated by research is likely to come to producers in the form of proprietary products or services.

The increases in agricultural productivity that are so urgently needed will, however, place heavy strains on the environment—especially with respect to soil erosion, forest cover, water quality and residual chemicals. Reconciling production and environment considerations is thus a critical area for agricultural research.

Even if world population growth slows significantly, it will be many years before the growth in demand for food will stabilise. It therefore falls to the farmers of the world and the agricultural research scientists to find ways of providing food at affordable prices for the extra 100 million people added to the global population every year. The task is not an easy one. The International Food Policy Research Institute estimates a 100 million tonne shortfall between annual production and demand for food grains in Asia alone by the year 2005, unless productivity of existing lands is increased significantly.

A vast amount of food will have to come from both increased productivity on farms in Asia, and from imports from countries like Australia.

Such a vast amount of food will have to come from both increased productivity on farms in Asia, where land is in short supply, and from imports from countries like Australia. The capacity of the Asian countries to pay for these imports will depend on their economic growth and participation in global trade—opportunities for which are greatly expanded with the successful completion of the Uruguay round of the GATT.

According to some assessments, net food-importing developing countries will be worse off in the short term as a result of the Uruguay round agreement. These countries will need additional food aid to tide them over the adjustment period.

Clearly the impact of the Uruguay round agreement will depend on the circumstances of individual developing countries. But the fact is that many developing countries now have the opportunity to increase their own food production and incomes in response to a fairer market place.

I know that some farmers fear that increased food production in developing countries resulting from agricultural research could end up reducing the demand for Australian exports. However, the evidence is to the contrary. In the 1980s, the Asia region, with the highest growth rates of per capita agricultural production, also increased imports of agricultural products at a rapid pace.

As standards of living increase in developing countries, so does the purchasing power of consumers as well as the proportion of family income spent on food. As their incomes increase, people want a more diversified and sophisticated diet. The excellent economic performance of a number of the east Asian countries in particular has increased per capita income by 3–6 per cent per annum, and created a strong growth in demand for Australian beef, lamb, dairy products and grain.

Increased agricultural production is a major factor in economic growth in developing countries. The majority of the world's poor still live in rural areas. Agriculture is truly the 'primary' industry and engine of growth in most developing countries.

Gains in agricultural productivity depend heavily on the continuing stream of improved technologies that flow from research. Most of these technologies are in the public domain and available to farmers all over the world. Australian support for international agricultural research therefore creates a win–win situation by benefiting Australian farmers as well as farmers in developing countries.

Gains in agricultural productivity depend heavily on the continuing stream of improved technologies that flow from research.

Examples of the benefits from international agricultural research are numerous. For instance, in 1991, independent assessments of 12 projects run by the Australian Centre for International Agricultural Research showed a startling 31:1 average benefit to cost ratio. More recently, ACIAR's economic evaluation unit estimated that of the total benefits of $236 million from six ACIAR postharvest research programs on tropical fruits, $46 million will accrue to Australia.

Our most quoted example of benefits from Australian contributions to the international agricultural research centres concerns wheat. I understand that a study to be reported on later today has shown that Australia's use of wheat varieties derived from CIMMYT (the International Maize and Wheat Improvement Centre) in Mexico has led to annual returns of

over 150 times our annual contribution to this organisation. That in itself should convince even the most hardened sceptic that our aid contributions can pay big dividends.

Better protection of Australia's livestock industries from exotic diseases and pests is a further major benefit of international agricultural research.

Better protection of Australia's livestock industries from exotic diseases and pests is a further major benefit of international agricultural research. It strengthens our capacity to diagnose and control pests and diseases of cattle, sheep, poultry, even bees. Almost as importantly, it helps the quarantine service do its job better.

In that regard, my colleague Bob Collins, Minister for Primary Industries, recently announced the creation of a new hot line on exotic livestock diseases, which brought to mind an example of benefits from research on foot-and-mouth disease. I am pleased to tell you that as a result of funding through the aid program, research collaboration between Australian and Thai scientists has produced a safe reliable test for this disease. This test was used in a recent suspected outbreak in Queensland. The negative result obtained within 12 hours saved many animals in the area from the slaughter that would have been necessary if, as in the past, tests were sent to England for processing.

International research collaboration in forestry research is also delivering dividends. ACIAR-funded research by CSIRO and Chinese scientists uncovered the high potential of an acacia species for providing pulp for high quality paper. This has stimulated interest by commercial growers in Australia and China.

Research on ecological sustainability is another key area of mutual benefit. For example, studies of soil management techniques that protect steep lands from soil erosion while increasing their productivity are benefiting farmers in southeast Queensland as well as poor upland farmers in Southeast Asia. In Queensland, the application of these techniques will reduce erosion and lower the amount of fertiliser used, both of which will help minimise off-site impacts on rivers and coastal tourist areas.

Finally, I want to comment on research in the pipeline. As a South Australian horticulturalist—in fact a tomato grower—I am very much aware of the problems that fruit flies cause to our industry. I was therefore very encouraged to learn that ACIAR-supported research is under way in Australia and Malaysia to find effective means of fruit fly control in the Asia–Pacific region. Australia will benefit in two ways—firstly, fruit fly infestation will be reduced in Australia, and secondly, the threat of fruit fly introduction from outside the country will decline.

To sum up, then, there is no disputing the range of the benefits to Australia from participation in international agricultural research. It is a catalyst for economic growth in developing countries leading to increased demand for Australian exports.

It helps reduce poverty and hunger in developing countries, and that's critical for international peace and prosperity. So is developing and utilising methods of agricultural production that are ecologically sustainable. In all these ventures, international agricultural research is the key.

Participation in international agricultural research helps reduce poverty and hunger in developing countries, and that's critical for international peace and prosperity.

For this reason, ACIAR's funding was increased in last week's budget by $2 million in real terms to a total of $36.6 million. This increase is almost twice the proportional increase secured for the program as a whole. And it's on top of successive real increases for agricultural research in each of the past three budgets.

Australia's funding for international agricultural research will support the work undertaken by ACIAR, the Crawford Fund and the International Agricultural Research Centres. Australia provides funding to some 20 of these, including IRRI (the International Rice Research Institute) in the Philippines; CIMMYT in Mexico; and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India. Several Australians occupy senior research positions in these centres and serve on their boards of management, thus spreading further the contribution of Australian research to the development of global agriculture for the Third World.

I am pleased to announce that within the ACIAR allocation is a significant increase for the Crawford Fund. The Australian Government will provide a total of $500 000 for the fund in 1994–95—and for each of the subsequent four financial years—a total of $2.5 million over five years. This will give the Crawford Fund some certainty in its financial planning for the next five years and additional resources which I know it will employ very effectively.

I am delighted that the Australian Government has been able to support not only additional high-quality training for overseas agricultural scientists and technicians, for which the Crawford Fund has become justifiably famous internationally, but also its exciting master classes in molecular biology.

Finally, may I appeal to the private sector to match the Government's commitment by increasing its own investment in our common future through international agricultural research. I am confident that today's seminar will convince you that this will be one of the best investments you could make.

PROFESSOR JOHN DILLON is Professor of Farm Management at the Department of Agricultural and Resource Economics of the University of New England with more than 30 years' experience in the field of international agriculture. Professor Dillon has been actively involved in both ACIAR and the CGIAR. He has also served in various capacities at a number of centres including ICRISAT, ISNAR, CIAT, ILCA and ICLARM.

The Range of Benefits

JOHN L. DILLON

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS
UNIVERSITY OF NEW ENGLAND, ARMIDALE NSW

The eminent speakers that follow me will provide you with hard evidence of the benefits to Australia's agriculture, trade and environment that flow from our investment in international agricultural research. Suffice for me to note that these benefits are shared by all Australians and that they far, far exceed the cost of our investment in international agricultural research.

First I will explain what international agricultural research is and who the major players are. Then I will briefly refer to the benefits beyond the areas of agriculture, trade and the environment that we gain from investing in international agricultural research. Finally, I plan to tell you of the fantastic but little-publicised job that Australia has done over recent years to position itself so as to benefit from international agricultural research.

What is International Agricultural Research?

International agricultural research encompasses research in the areas of agriculture, fisheries, forestry and natural resources which is supported by developed country donors (largely government agencies) and which aims to assist developing countries through the provision of sustainable improved production and resource management systems. Its target beneficiaries are the poor, whether producers or consumers, and future generations. Typically it is more strategic than applied or location-specific, and is generally of a nature beyond the capacity of developing countries to do on their own.

International agricultural research is funded and carried out both bilaterally and multilaterally. Under the bilateral

mechanism, developed countries provide support for their national agricultural research institutions to undertake work in or on behalf of developing countries. Major players in this game are Canada, France, Germany, Japan, UK and USA. Multilaterally, the major mechanism is through core budget support to the 18 international agricultural research centres sponsored by the Consultative Group on International Agricultural Research (CGIAR) and to a number of other international research institutes not under the wing of the CGIAR. Currently the CGIAR System has an annual core budget of some US$220 million plus complementary funding of some US$70 million. This is provided by nearly 40 donor countries (including six developing countries), foundations and international organisations.

Australia has always played a significant part in the CGIAR System since its founding in 1970.

Australia has always played a significant part in the CGIAR System since its founding in 1970. The late Sir John Crawford, that great Australian public servant and internationalist who is commemorated by the Crawford Fund for International Agricultural Research, was influential in its inception and structuring under cosponsorship by the World Bank, FAO and UNDP, and we are more than proportionately represented in the governance of the system (each of the 18 centres is autonomous with its own Board of Trustees—of some 274 current Trustees, 14 are Australian). Not least, two of the 18 CGIAR centres are currently directed by Australians—Dr James Ryan of the International Crops Reasearch Institute for the Semi-Arid Tropics and Dr Meryl Williams (the CGIAR's first female Director-General) of the International Centre for Living Aquatic Resources Management. Also our scientists have always contributed significantly, both as members of the centres' international staffing and as participants in the System's advisory and peer review mechanisms.

Benefits beyond Agriculture, Trade and the Environment

While the benefits Australia gains from international agricultural research—in terms of improved agricultural technology, enhanced trade and better methods of managing our environment and natural resources—can all be assessed in financial terms, there are other benefits of a less direct and more long-term nature that are not so easily measured in dollars and cents.

The first of these additional benefits comes from the complementarity we gain for our science by participating in international agricultural research. Though only a small part of the total global scientific effort, this research is at the

cutting edge of science for agriculture and the environment, particularly in the areas of (1) germplasm conservation and manipulation, (2) crop and animal husbandry and disease control, (3) research management, priority setting and evaluation, (4) agricultural information systems and (5) the nexus between agriculture, resources and the environment.

Without their connections to the international agricultural research system with its partnerships and networks of scientists spanning the developed and developing world, our scientists would have to continually reinvent the wheel. Our involvement in international agricultural research gives us a jump start. To give just one example: without access to the cereal germplasm made available through our involvement in international agricultural research over the past 30 years, our cereal breeders would be greatly disadvantaged and our cereal productivity would be far below its present level.

Of course our membership of this international agricultural research community implies a two-way flow of knowledge—we receive and we contribute knowledge, and both we and our international partners benefit. It's a positive sum game that not only gives us immediate benefits but positions our science to serve us better in the long term.

The second additional benefit of our involvement in international agricultural research is more diffuse and pragmatic. I refer to the benefits we gain in the international political arena. Doubtless these political benefits are sometimes more at the margin and longer term. Like other overseas development assistance, aid through agricultural research is a sign of friendship, interest and willingness to help, especially in the context of developing countries where agriculture is usually the major sector and most people live in rural areas. Support for research, just as other less effective forms of aid, earns us brownie points that we can spend to help achieve our international political agenda.

Aid through agricultural research is a sign of friendship, interest and willingness to help.

There is no doubt, for example, that—thanks to ACIAR—our agricultural research partnership with the People's Republic of China has helped to open doors there that would otherwise have opened more slowly, if at all, for us. Other political gains from international agricultural research are more direct. For example, without food security in the countries to our north, these countries are unlikely to maintain political stability, and without international agricultural research, given their growing population pressure, they will not achieve food security. It is in our political interest to help ensure their food security and thus contribute to their political stability by playing our part to ensure the necessary research gets done.

Our good relations with scientists in other countries can translate into goodwill for Australia in their domestic political environments.

Less directly, but not least, there are the political gains to us of having international linkages with scientists in other countries. Particularly in developing countries scientists are influential. Our good relations with them can translate into goodwill for Australia in their domestic political environments. Moreover, when nations argue, as we have sometimes done with some of our northern neighbours, scientific and research linkages are typically among the last to be disrupted, if they are at all, and can provide a bridge back to normalcy in relationships.

The third additional benefit to us of our participation in international agricultural research is a moral and psychic one. Though we could and should contribute more, nonetheless we can hold our heads high in the international arena knowing that we are contributing, albeit not without benefit to ourselves and, in a small but highly effective way, to the amelioration of the world's problems of poverty, food supply and environmental degradation. Being as lucky as we are to be Australians, this humanitarian contribution is important for the good of our national psyche.

ACIAR: its Uniqueness and Success

Now let me tell you how Australia has so successfully positioned itself to ensure that we do indeed reap profit for ourselves from our investment in international agricultural research—profit, moreover, that in no way diminishes our contribution to helping solve the global problems of poverty, food security and environmental degradation.

The institutional mechanism is the Australian Centre for International Agricultural Research (ACIAR). Largely the brainchild of Sir John Crawford, who served as its first Chairman (and whose shoes I found it very difficult to fit), ACIAR was established as a Commonwealth statutory authority in 1982 with a small Australian-based Board of Management and a joint Australian–partner country Policy Advisory Council which meets approximately annually to provide relevant advice to the responsible federal Minister. The major element of ACIAR's mandate is to promote research partnerships between Australia and developing countries. As well, since 1992, ACIAR's budget ($35 million for 1993–94) has included provision for the funding of some training and development activities (about $1 million in 1993–94) related to its research programs (budgeted at $20 million in 1993–94) and for it to serve as the official channel through which Australia provides support ($8 million in 1993–94) for the international agricultural research centres (chiefly those sponsored by the CGIAR). As an aside, reflecting ACIAR's

managerial efficiency, let me note that only about 13 per cent of ACIAR's budget goes to administration—a feat unmatched by any analogous aid agency in the donor world.

ACIAR was envisaged as, and has remained, a small entity with a dozen or so highly qualified professional staff experienced in agricultural research who act as program coordinators across the major areas of agricultural research (including fisheries, forestry and natural resources). In essence, ACIAR is a research broker. Its modus operandi is to commission research groups in Australian universities, the CSIRO, state agriculture, forestry and fishery departments and, if appropriate, industry, to carry out research projects in joint partnership with analogous public agencies in developing countries.

Beyond the professionalism, enthusiasm and dedication of its staff, the essence of ACIAR's success has lain in the ground rules which it follows. First and foremost, ACIAR-sponsored research must be conducted on a partnership basis between the commissioned parties in Australia and overseas. The developing countries are equal partners. They are not clients; they contribute their fair share both intellectually and financially to the research. Worldwide, ACIAR has led the way in fostering such a partnership approach to agricultural research for development. Second, ACIAR only considers research topics that are proposed at the official request of a developing country as a priority need. Third, the proposed research must be in an area of agricultural research for which Australia has competence and comparative advantage. Fourth, the research must involve problems whose solution will provide benefits to both Australia and the partner country, and preferably will also provide spillover benefits to other developing countries. Fifth, the research topic must be such as to attract the participation of relevant Australian institutions on generally no more than a marginal cost basis so that they too, just as the developing country partner institutions, contribute not just intellectually but also financially to the research.

Worldwide, ACIAR has led the way in fostering a partnership approach to agricultural research for development; the research must involve problems whose solution will provide benefits to both Australia and the partner country.

In consequence, because of the financial contributions of its commissioned research agents in Australia and in partner countries, ACIAR has been able to leverage at least an extra dollar if not two dollars of research investment for every dollar of its own outlay on research. Sixth and lastly, the research projects must fit ACIAR's own priorities and guidelines in terms of research priority (based on expected payoffs), research-portfolio balance both geographically and scientifically, and environmental and gender impact considerations.

To ensure all these considerations are met in the choice of commissioned research projects, ACIAR has established a set

of four complementary mechanisms: country consultations which are held every three years or so with the partner countries in Asia, the South Pacific and Africa to determine country priorities; world state-of-the-art procedures for in-house priority setting and ex-ante evaluation of benefits; strict project-cycle procedures running from the ideas stage to completion of the final report with ongoing monitoring and regular peer review; and, lastly, regular reporting to (and, as need be, approval by) ACIAR's Board of Management at its quarterly meetings on all projects through all stages of their project cycle.

So it is no wonder that ACIAR has continuously had a portfolio of research projects that are well managed, tightly focused on priority problems and balanced across both its geographic regions of interest and across program areas. Nor is it any wonder that ACIAR received high praise when it was reviewed by the Joint Committee on Foreign Affairs, Defence and Trade in 1992. Among the many complimentary remarks made about the Centre from all sides of the House following the tabling of the report was that of the committee's chairman, Senator Chris Schacht, who said: 'In my view ACIAR is one of those good news stories that does not get the coverage in the Australian media that organisations like it should get' and the committee's deputy chairman, Hon. Michael Mackellar, who said: '[ACIAR's] work has great benefit and should be more widely publicised. Furthermore, the high level of ACIAR's performance sets an example for other statutory bodies to try to match'.

The Minister for Foreign Affairs, Senator Gareth Evans, described it as a 'lean professional organisation with an excellent approach to its task'. These remarks were reiterated, along with other complimentary comments, by Minister Gordon Bilney and Mr Andrew Peacock when ACIAR's Annual Report for 1992–93 was tabled in the House of Representatives on 3 February 1994.

Without doubt ACIAR has generated a very handsome return both to Australia and to its partner countries.

Since its establishment in 1982, ACIAR has commissioned some 250 research projects, usually of three years' duration, some 180 of which have been completed. Without doubt ACIAR has generated a very handsome return both to Australia and to its partner countries on the taxpayers' funds invested in its bilateral research activity. This is specifically evidenced by the two substantial benefit to cost ratio studies measuring returns to Australia which have so far been carried out on ACIAR's commissioned research.

The first, finalised in 1991, was of a diverse subset of five projects covering crops, livestock and fisheries (Menz 1991).

The total research cost to ACIAR of those five projects was $12.5 million in 1990 dollars. Their estimated payoff in terms of 1990 dollars was $132 million, of which nearly $14 million was estimated to accrue to Australia, indicating a benefit to cost ratio of 10:1 overall and of 1.1:1 for Australia itself. Though not well justified statistically because of the small sample size, extrapolation from this analysis of five projects to all of ACIAR's projects suggested that, as compared to a total appropriation to ACIAR of $198 million (in 1990 dollars) from 1981–82 to 1990–91, Australia would receive benefits of $270 million (in 1990 dollars).

The second substantial benefit to cost study was conducted in 1993 (Davis and Lubulwa 1994). It covered six tropical fruit postharvest research projects that had been commissioned by ACIAR. In 1991 dollars, these projects had a total research cost of $6 million and a total estimated benefit of $230 million, of which $46 million accrued to Australia, again indicating very favourable benefit to cost ratios of 30:1 for ACIAR's partner countries and nearly 8:1 for Australia.

From these two studies it is clear that the expected benefits of ACIAR's commissioned research far exceed the cost of ACIAR. Whether considered globally or merely in terms of profit to Australia, ACIAR pays a handsome dividend on taypayers' investment in it. Indeed there must be few such attractive investments available to the Government—and that is without any consideration of the very substantial benefits we receive from our investment in the CGIAR and other multilateral international agricultural research.

It is clear that the expected benefits of ACIAR's commissioned research far exceed the cost of ACIAR.

Finally, to give you some feeling for the type and variety of projects commissioned by ACIAR, let me list a few that have clear and significant benefit to Australia as well as to the partner country for which they were a priority need.

Of benefit to our agriculture:

- Canola/rapeseed genetic improvement
- Sulfur soil-test development
- Genetic engineering for resistance to Barley Yellow Dwarf disease
- Banana improvement to overcome Black Sigatoka disease.

Of benefit to our trade:

- Foot-and-mouth disease and blue tongue virus tests for rapid diagnosis and control
- Banana skipper control
- Honey bee mite control
- Postharvest technology for grains and fruit

- Wool quality improvement
- Bee pollination of forest plantations
- Control measures for Newcastle disease of poultry and nematode worms leading to commercial joint ventures.

Of benefit to our environment:

- Trees for salty land
- Biological control of *Mimosa pigra*
- Soil erosion management
- Integrated pest management of fruit fly.

Detailed information on these and other projects is available from ACIAR.

ACIAR is a stand-out success in international agricultural research and as an investment for our taxpayers' funds.

Let me conclude by emphasising again that ACIAR is a stand-out success in international agricultural research and as an investment for our taxpayers' funds. It is highly cost-efficient, well led, totally professional. It provides a substantial profit to Australia in both financial and scientific terms. Not least, it has substantially enhanced Australia's image among both developed and developing countries and is providing the model that others are attempting to follow. In the words of Derek Tribe, Executive Director of the Crawford Fund, ACIAR—through both its bilateral and multilateral activities—does well for us by doing good (Tribe 1991).

References

Davis, J. and Lubulwa, A.S.G. 1994. Evaluation of Postharvest Research: Results for an Application to Tropical Fruit Research Projects and Some Further Methodological Issues. (Paper presented at the 38th Australian Agricultural Economics Society Conference, Wellington, N.Z., Feb 8–10.) ACIAR, Canberra.

Menz, K.M. 1991. Overview of Economic Assessments. ACIAR, Canberra.

Tribe, D.E. 1991. Doing Well by Doing Good. Pluto Press, Sydney.

Agriculture

Dr Tony Fischer is the Director of Wheat Research at the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico and has worked in aspects of crops physiology as applied to wheat agronomy and breeding for much of his working life. There are very few aspects of the field physiology of wheat which Fischer's research has not touched. He also has extensive experience in working with scientists from developing countries and is very familiar with wheat science globally.

A Bountiful Harvest

R.A. Fischer

International Maize and Wheat Improvement Centre (CIMMYT), Mexico

The Consultative Group on International Agricultural Research (CGIAR or simply CG) upon which I will focus this talk consists of 18 international agricultural research centres whose mission is to contribute to sustainable increases in productivity in agriculture, forestry and fisheries in poor countries through international research in partnership with national agricultural research systems (NARS). The centres are publically funded, non-profit and usually located in developing countries. IRRI, the International Rice Research Institute, and CIMMYT, the International Maize and Wheat Improvement Centre, are the oldest and best known centres of this system.

As an agricultural scientist sandwiched between economists and urged to give an economic analysis of the benefits to Australia's grain industries of the money Australia invests in the CG system, I feel rather uneasy. Thus I am not going to attempt to prove that a dollar invested in grains research in the CG system yields even more for Australian farmers than one invested in Australia. However, I do hope to present arguments that suggest to us noneconomists that this could well be the case. For if you have, as I am sure you do, more than a passing interest in the ideas of Charles Darwin, Gregor Mendel and William Farrer, I believe we have sufficient common ground upon which to build a more interesting, if less quantitative, story.

Lessons from Evolution

Let's start in the Galapagos off the coast of Ecuador. Charles Darwin noticed small differences in finches and tortoises indigenous to each of the adjacent islands. He concluded that these differences were inherited and conferred adaptive advantage to the subtle environmental differences between

apparently similar islands. The notion that in nature evolutionary processes based on heritable traits, or genetics, drive animals and plants to become adapted to small environmental differences—the concept of specific adaptation—has now of course become widely recognised. One need only contemplate the diversity of form and adaptation amongst the numerous species of Australian eucalypts. This is paralleled by the widely recognised efforts of farmers from the dawn of agriculture to select adapted and diverse land races from amongst the natural variants in their crops. And beginning some 100 years ago, plant breeders began to deliberately breed for adaptation to their environments. With the case of wheat in Australia, selection by farmers, for earliness and disease resistance and later by William Farrer and successive wheat breeders, was fundamental to improved performance and establishment of a strong wheat industry here. Throughout, specific adaptation seems to be the key to success. It might therefore be hard to see how crop varieties from the far-flung institutes of the CG system can be of any use in the distinctive agricultural environments of Australia.

Experience of Recent Plant Breeding

The overwhelming experience has reinforced the importance of global genetic exchange.

Whilst specific adaptation dominated thinking for a long time, even Farrer realised the importance of obtaining parental material from other countries. And the overwhelming experience of the last 40 years or so in plant breeding has both reinforced the importance of global genetic exchange, and introduced the concept of broad adaptation. This implies that certain crop varieties can show superior performance in many locations around the globe with seemingly distinctive environments. I am proud to say that Norman Borlaug at CIMMYT was one who pioneered this concept of broad adaptation in wheat breeding, and it was successfully taken up by my earlier colleagues at Wagga Wagga, wheat breeders Albert Pugsley and Jim Syme. Why is it therefore that foreign germplasm bringing not only specific desirable traits but also broad adaptation can be so valuable to Australia and what does the CG system have to do with its availability anyhow?

Agricultural environments Modern crops are grown in agronomically managed systems in which the management compensates for some of the vagaries of the natural environment. Thus cropping environments around the world are not as different as adjacent natural ones. For example, Australia's natural vegetation has generally evolved adaptation to low P levels in our native soils: in cropping it pays to get around this by adding P fertiliser.

Broadly desirable traits There are traits in crop plants which appear to be desirable in many environments and clearly contribute to broad adaptation. One example in wheat would be the famous Norin 10 dwarfing genes almost always associated with higher yields. These genes have been spread over the last 30 years via CIMMYT germplasm to spring wheat varieties grown on over 50 million hectares in the developing world and on more than 85% of the wheat area in Australia. Another such trait which helps confer adaptation to CIMMYT wheats, including immediate fitness to Australia, is daylength insensitivity. A further example in wheat would be broadly based durable resistance to rust in which CIMMYT germplasm has excelled.

Climatic similarities The fact that the CG crop research programs target developing-country agroclimatic zones of low to intermediate latitude, some of which are the same, broadly speaking, as those of Australian agriculture, adds greatly to the general usefulness of their germplasm in Australia. And incidentally, few other developed countries have this good fortune. Let's look at the most relevant centres:

The fact that the CG crop research programs target developing-country agroclimatic zones of low to intermediate latitude adds greatly to the general usefulness of their germplasm in Australia.

- ICARDA—winter rainfall dominant environments of intermediate latitude, which correspond with the cereal belt of western and southern Australia
- CIMMYT—All wheat and maize environments of intermediate and low latitude, which equate to all cropping environments of Australia but especially higher rainfall and irrigated ones
- ICRISAT—semi-arid tropics, the climatic zone of north eastern and northern Australia
- CIAT, IRRI, IITA—humid and sub-humid tropics, the climatic zone of coastal north eastern Australia.

I have outlined some general issues which make foreign germplasm, and in particular CG centre germplasm, well suited to Australia. Let's look at some more specific ones:

New crops The whole history of agricultural expansion is tied up with the introduction by man of plants to new cropping environments, often environments far removed from that in which the plants evolved in nature. This is not an easy process as Australia has learnt through its major role in the domestication and adaptation of narrow-leafed lupins (*Lupinus angustifolius*), which now after 30 years of effort occupies almost one million hectares of our crop lands. Hence the establishment of other new crops in Australia such as chickpea, lentil, faba bean, triticale, pigeon pea and millet has and will continue to benefit greatly from already adapted germplasm coming from well-established breeding programs in CG centres. To this list could

be added CG centre germplasm adapted to ecological or market niches which are too small to warrant special attention in Australia, e.g. wheats adapted to acid soils or to cold tableland conditions, or durum wheats for dry winter rainfall environments, all available from CIMMYT, or hull-less barleys from ICARDA.

CG centre germplasm often carries genetic resistance which can be extremely valuable to Australia.

New diseases and pests Australia still lacks a number of important pests and diseases of its crops because of its isolation and strict quarantines. However, there will inevitably be new arrivals from time to time. CG centre germplasm, having being exposed to all pests and diseases, often carries genetic resistance which can be extremely valuable to Australia in such cases. A good example was provided by the chance arrival of stripe rust of wheat in 1979. Quite a bit of genetic resistance was already present in Australian varieties unwittingly introduced via the use of resistant CIMMYT parental material. Losses were thus mitigated substantially, while the quick introduction of more resistance varieties was facilitated. Australia does not yet have Russian wheat aphid or Karnal bunt but CIMMYT has resistance to both in adapted wheats. Australia similarly does not yet have stripe rust of barley or ascochyta of chick peas—ICARDA has resistant germplasm for both.

The CIMMYT Wheat Program makes three to four times more crosses and grows more area of segregating populations annually than all Australian programs put together.

Comparative advantages of scale Breeding programs in CG crop centres tend to have comparative advantages relative to programs in Australia, which means that even when programs have the same objectives, the CG ones can make more rapid progress. This is exemplified by the CIMMYT Wheat Program. The program makes three to four times more crosses and grows more area of segregating populations annually than all Australian programs put together. The program runs two generations in the field a year, taking advantage of Mexico's unique environments, potentially doubling the annual rate of progress. Besides, the program has access to several distinctive screening environments in Mexico and many through its collaborators in the developing world. While yield-testing opportunities in Mexico may not match those across Australia, international testing more than makes up the difference. Thus CIMMYT screening nurseries and yield trials go to more than 100 global sites each year. Finally, the breeding program has a strong backup of support disciplines in particular plant pathology. I do not wish to sound boastful but it is a wheat breeding machine without equal and it is no surprise that its germplasm products are to be found behind over 75% of the varieties currently being released each year, and occupy over 40 million ha in the developing world outside of China. Since breeding is a numbers game, in which creating and identifying the rare superior gene recombinations is crucial, size does

count, along of course with skill. CIMMYT's Maize Program is about equal in size to its wheat one, as is the IRRI rice breeding program. Other crop programs in the centres are smaller but still very large by any standards.

Ready access to germplasm A feature of the CG crop centres, which is likely to be even more important in the future, has been their strict adherence to a policy of free availability of germplasm to all breeders, whether public or private, developing country or developed country. This policy arises largely because we believe it best serves our ultimate clients, namely the grain farmers and consumers. The policy also applies to the extensive collections of germplasm in our gene banks. Australia's access to germplasm of CG mandated crops is facilitated by this policy, as it will be by efficient computerised crop databases presently being developed in the Centres. Despite recent moves towards restricting use of certain germplasm in gene banks, the CG system will strive to maintain open access for greatest public benefit.

Australia's access to germplasm of CG mandated crops is facilitated by a policy of free availability of germplasm to all breeders, whether public or private, developing country or developed country.

Current and Future Impacts of CG Activities

Having introduced the general reasons why CG grain crop germplasm is so useful to Australian plant breeders and farmers, let us look briefly at the specific commodities involved.

Winter grain legume Eastern Australia's rapidly expanding production of chickpeas (200 000 tons in 1993) is in the words of one local specialist 'almost entirely based on germplasm from ICRISAT and ICARDA'. Material from these two centres is being used extensively in the breeding programs at Tamworth and Horsham. Chickpeas are now on the upsurge in West Australia and again CG material is being widely tested. Australia produced a record 140 000 tons of faba beans in 1993 based on a Waite Institute variety selected out of Greek material. However, the second faba bean release was a disease-resistant variety selected directly from material from ICARDA, which holds an extensive germplasm collection of faba beans. With respect to lentils, the Grains Research and Development Corporation has already adopted a policy that lentil breeding be left to ICARDA, and that Australia with its program based in Horsham concentrate upon evaluation of introductions. Currently production is small but the new red and green seeded varieties recently released from ICARDA materials and the taller types in the pipeline promise to change this. Both world market and Australian wheat cropping systems need more grain legumes and these new crops, along with other possible ones from ICARDA (*Lathyrus, Vicia,*

In the national navy bean breeding program based in Hermitage, Queensland, CIAT germplasm is used extensively to bring in yield, disease resistance and eating quality.

Development of new techniques pioneered in Australia could speed up the breeding of drought-resistant peanuts.

Pisum spp.), will no doubt play an important future role in Australia.

Summer grain legumes There is an acute need for better summer grain legumes in Australia's warmer cropping regions, primarily in Queensland and northern NSW. Australia collaborates with ICRISAT on two such crops, namely peanut and pigeon pea, and with CIAT on navy bean. Soybean, the other significant summer grain legume in Australia, has only recently been taken up by a CG centre, namely IITA in Nigeria. The collaboration on pigeon pea led to the development of the first varieties ever suited to short-cycle cropping and mechanical harvesting for the Queensland environment—for lack of market, however, the crop is not yet grown widely in Queensland. In the national navy bean breeding program based in Hermitage, Qld, CIAT germplasm is used extensively to bring in yield, disease resistance and eating quality. A new rust-resistant variety released in 1993 is a direct introduction from CIAT. In the case of peanuts, undoubtedly the most important of this trio of tropical grain legumes, with annual production of around 30 000 tonnes, germplasm exchange has been less important than research collaboration between Queensland Department of Primary Industries, ICRISAT and (through ICRISAT) the Indian national program. Development of new techniques, pioneered in Australia but now being further developed and tested in ICRISAT, could speed up the breeding of drought-resistant peanuts. This ACIAR-funded project reaps several advantages by being based at ICRISAT, namely the availability of diverse germplasm, reliable selection environments and low field labour costs.

Summer cereals Here we are talking about maize, sorghum and millet. In the first two crops there has been germplasm exchange with CIMMYT and ICRISAT, respectively. However, the general use of hybrid material in Australia, commonly supplied by private companies, has meant less utilisation of CG germplasm which has in the past been non-hybrid. CIMMYT and ICRISAT are nowadays producing inbred lines of maize, and sorghum and millet, respectively, for hybrid performance in the tropics and subtropics. They are becoming a major source of inbreds for private and public seed companies in these regions. At both centres special emphasis is being placed on drought-resistant material. I anticipate spillover benefits to Australian farmers will increase, especially in the case of millet, which presently is almost unheard of in Australia.

Winter cereals Wheat and triticale fall in the mandate of CIMMYT, while barley is handled by ICARDA. By any

standards the impact of CIMMYT wheats in Australia has been huge: I have cited several examples already and will leave the quantification of this impact to the following speaker. I would like, however, to touch on the following advances which are in the pipeline and are of special interest to Australia:

(i) We are beginning projects with Grains Research and Development Corporation (GRDC) support to incorporate resistance to Russian wheat aphid (RWA) and improved preharvest sprouting resistance into Australia-adapted germplasm. We can do this efficiently because of suitable natural screening environments in Mexico. Since RWA has yet to reach Australia, the RWA work is precautionary and complements recent testing of Australian material in Colorado. The sprouting work is part of a longstanding effort at Narrabri to reduce expensive losses in grain quality due to rain at harvest.

(ii) In a project of clear mutual benefit we are taking unique barley yellow dwarf virus (BYDV) resistant germplasm developed at CSIRO in Canberra and incorporating it into improved high-yield materials. This step of incorporating resistance into a suitable plant type is not a trivial one and was therefore given relatively low priority by Australian breeders. Nevertheless, improved resistant material from CIMMYT will be beneficial to these breeders because BYDV does cause significant yield losses in Australia.

(iii) In an effort to expand the germplasm base of wheat and incorporate new sources of disease resistance, CIMMYT has been repeating the interspecific cross which in nature produced bread wheat as we know it some 7000 years ago. Interspecific crosses are not so easy to make but nevertheless, almost 500 new (so-called synthetic) bread wheats have been produced over the last five years. We are finding that not only do we have new sources of disease resistance but also it appears there could be sources for increased vigour and yield. This is very exciting and, taken along with the likely occurrence of unique grain protein and starch qualities, makes the material of considerable interest to Australia.

We are finding that not only do we have new sources of disease resistance but also it appears there could be sources for increased vigour and yield.

This mention of interspecific crosses brings me to the Cinderella of CIMMYT's suite of crops, namely triticale. Triticale is the result of a man-made cross between rye and wheat, and has the potential to combine the best qualities of each. Some 2 million ha are grown globally with around 100 000 ha in Australia. Nowadays almost all the base germplasm for spring type triticale, the type grown in Australia and

the developing world, comes from CIMMYT's triticale program, as do the varieties released by the Waite Institute and Sydney University. Triticale is a crop with considerable potential as a feed grain for poultry and pigs because of its nutritional advantages and adaptation to a whole range of marginal conditions (nutrient-deficient, acid, light-textured drought-prone soils, and disease-prone environments).

However, the area of triticale in the developing world is still minor (about 160 000 ha), largely because of the new crop syndrome and distortions in marketing. Indeed continued research on triticale at CIMMYT is now under threat because of budget cuts. This is something which ought to alarm those who have expressed so much concern about the lack of diversity in agricultural crops. For more pragmatic reasons it ought also to concern Australia, which has been a major beneficiary of the triticale program to date.

With respect to barley, germplasm from ICARDA has only recently started to have an impact in Australia with the release as varieties of three direct introductions from ICARDA's Mexico-based breeding program. Two of these incorporate the hull-less trait which gives the barley a special advantage in certain feed and food markets. No Australian barley breeding program works with this trait. In the future it is to be expected that special drought-resistant barley from ICARDA's Syria-based program will also be of value to Australia's breeders.

Balancing Investment in Australia and the CG

So there seem to be many reasons for Australia to be taking advantage of CG system germplasm. Nevertheless, there are likely to be some doubts and concerns regarding the implications of this proposition.

Why breed in Australia?

In our major crops we need the capacity to run crossing programs in which introduced germplasm might be used and from which varieties even better tailored to our needs are expected to arise.

Lest I am misunderstood, let me deal at the onset with the idea I expect some are now harbouring that if germplasm from the CG centres performs so well in Australia, why should we invest in local breeding at all? This is not a difficult question to answer: without a national breeding capacity in a given crop, a capacity which will always include the ability to select, screen and test introduced germplasm, little progress would be made with the crop. Besides, there is no doubt that in our major crops we also need the capacity to run crossing programs in which introduced germplasm might be used and from which varieties even better tailored to our needs are expected to arise.

Why not freeload?

If Australia also freeloads on the system, benefits may still flow passively as in the past, but bigger opportunities will be missed. If instead Australia's grain industry invests in CG commodity research, it can ensure rapid access to products more likely to be of use to Australia. CG centres do not have as their mission assistance to developed countries like Australia, but quite often projects can be devised which permit the Centres to get on with meeting their goals while Australia specifically benefits as a spin-off.

Projects can be devised which permit the Centres to get on with meeting their goals while Australia specifically benefits as a spin-off.

Interchange of breeders between Australia and the Centres is one very obvious mutual benefit and is often supported by such projects. Indeed, without these person-to-person contacts on a frequent basis, many other benefits are missed by Australia. Plant breeding is still very much an art and seeing is an important way for it to be appreciated and the way advances are transmitted. Beyond enhanced linkages between scientists lie the possibilities of executing projects of mutual benefit which can clearly be done more efficiently at or with the Centres. Screening germplasm adapted to Australia for pests and diseases not yet present is an obvious example. Besides, it is often cheaper to do a piece of research at a CG centre than to do the same research in Australia.

In all cases direct project investment in CG centres and rapid access to results have the potential to give Australian grain growers the jump on their competitors. Getting there first is the name of the game in the export business, and to the extent that Australian researchers can also quickly adapt CG advances to their country's conditions and transfer them to its farmers, Australia will come out ahead. To miss out on links with what are probably the strongest and most successful breeding programs in the world in each particular CG commodity would seem very shortsighted.

Relative levels of investment A related question is the appropriate level of investment in breeding in Australia compared to that which Australia might fund in a CG centre. Here the ground is much shakier—the arena of uncertain biology, assumption-ridden economics, and ever-present local politics. But let's try by looking at the present balance of Australia's investment in wheat improvement (Table 1). For every $19 dollars the Australia taxpayer invests in wheat improvement in Australia, only $1 is invested in CIMMYT wheat improvement (and of course this investment in CIMMYT has several objectives besides producing better germplasm for Australia, objectives about which we will learn from other speakers today).

Table 1. Investment by Australia in wheat improvement in Australia and at CIMMYT ($A'000 p.a.).[d]

Source	Australia[a] 1991–92	CIMMYT 1994
Public sector	7723[a]	415[b]
GRDC	5777	45[c]
Non-Australian sources	–	10,341[d]
Total	13500	10,800[d]

a. Total wheat improvement cost (breeding plus breeding support) as reported in Clements, Roseille and Hilton (1992).
b. Australia's grant to CIMMYT's core multiplied by Wheat Program costs as a percentage of CIMMYT's core (40%) plus Special Purpose Grant from ACIAR for Genetic Resource Information Project (wheat) of $A55 000.
c. GRDC-approved funding of wheat breeding activities at CIMMYT (Probe genotypes, Russian Wheat Aphid and grain sprouting resistance, Brennan study on impact of CIMMYT wheats).
d. Wheat improvement in core plus special project estimated at 70% of total.

The marginal return on an extra dollar invested at CIMMYT could well exceed that on an extra dollar invested in Australia.

The GRDC, however, has a narrower set of objectives. It has just started to invest in CIMMYT, and currently only invests about $1 in CIMMYT for every $128 in Australia (Table 1). Given this wide disparity and the serious shrinkage in CIMMYT's wheat budget, amounting to a 40% real cut in the last five years, it seems that the marginal return on an extra dollar invested at CIMMYT could well exceed that on an extra dollar invested in Australia. But the question of returns on dollars invested in CIMMYT will be dealt with in detail by the next speaker.

Similar calculations could be made for winter pulse breeding at ICARDA, an activity of measurable benefit to Australia and one in which Australian grain growers have begun to invest. I suspect there is a closer balance than is the case with wheat between what they invest for this purpose in ICARDA and what they invest at home—there ought to be, since the winter pulses involved are new and still minor crops in Australia. Indeed, considerations of critical mass and of likely returns to local crossing and selecting versus reliance upon spillover benefits of exotic germplasm may mean we should never invest in a fully-fledged local breeding program for these minor crops, since such a program is generally not profitable unless the target crop is worth at least $200 million (Brennan 1991).

Won't others freeload?

Since CG germplasm is freely available to all it is obvious not only does Australia benefit but so also can grain growers in other countries. To a large extent this includes poor food-importing nations. I believe other speakers will present the overwhelming case that their freeloading is to our advantage. That leaves rich countries and/or exporters. Other than Australia most rich countries are in the North and will not benefit so immediately or to such a large extent because their environments are different from those targeted by CG centres. Indeed, some don't even grow CG mandated grain crops.

Saudi Arabia is an interesting exception as a freeloading beneficiary but this situation is not likely to last. Poor grain-exporting nations on the other hand—Argentina and Turkey come to mind—do freeload on the CG system and do receive immediate benefits. However, for a number of reasons—largely related to weak infrastructure, variable grain quality and poor marketing skills—they are not yet significant competitors with Australia. But the real answer to their freeloading is not to freeload ourselves but rather, as explained earlier, to invest wisely in CG centres.

Dependency and genetic vulnerability

It has often been argued that CG centres, by the very success of their germplasm, engender a dangerous dependency in their client countries, besides increasing the genetic vulnerability of their crops. Emotional stuff for which there are sound answers, in the case both of developing countries and of Australia. Suffice to say here that Australia is clearly in control of its destiny in this respect, and has chosen to restrict the use of CG germplasm where it has deemed it desirable. For example, the strict quarantine laws have never been questioned as a result of the increase of opportunities for germplasm import, and otherwise desirable CG-derived varieties have been quickly rejected if they don't meet all of the industry's requirement (e.g. the repeated rejection of CIMMYT-derived high-yielding 1B/1R wheat varieties because of a grain quality risk).

Otherwise desirable CG-derived varieties have been quickly rejected if they don't meet all of the industry's requirement.

Conflict with plant variety rights

Australia has moved towards protection of plant breeders' rights along the lines of the UPOV convention. It should be pointed out that in no way does the CG policy of free access to its germplasm conflict with the operation of plant variety rights (PVR) in client nations. Centres are prepared to grant permission for germplasm in which they have an equity to be

registered under PVR in a country. They may, however, restrict registration (provisional or otherwise) in other countries so that the material is freely available outside Australia. Where a variety is derived under a joint project between, for example, a CG centre and the GRDC, it seems both reasonable and feasible that rights to the variety in at least Australia belong to the GRDC.

Conclusions

CG centres deal with all the major grain crops grown in Australia, with the exception of lupins, canola, and until recently, soybeans.

1. CG centres deal with all the major grain crops grown in Australia, with the exception of lupins, canola, and until recently, soybeans.
2. Despite the centres' geographic distances and apparent environmental differences from Australia, germplasm carrying either special traits or broad adaptation has been and continues to be of value to Australian breeders and farmers. Australia amongst developed countries has a unique advantage in this respect because of the latitudinal and climatic correspondence between our cropping areas and those which CG centres target.
3. Australia should not simply freeload on the CG system but must work closely with the centres' crop programs in order to reap the greatest advantages for itself and relative to its export competitors. This requires investment in specific projects of mutual benefit. Many opportunities exist.
4. The nature of Australian collaboration will differ depending on the strength of local breeding. Thus an obvious case exists for collaboration with new and currently minor crops like chickpea, lentils and triticale. But our multimillion-tonne crops with strong local breeding programs, namely wheat and barley, should not be overlooked in the push for more collaboration, as the huge gains from the past use of CIMMYT germplasm attest.

Benefits from collaboration will continue and even grow as long as the CG centres run world-class breeding programs and germplasm exchange remains relatively free.

5. Breeding and breeding research is an ongoing activity and I see no reason why the benefits from collaboration will not continue and even grow, as long as the CG centres run world-class breeding programs and germplasm exchange remains relatively free.

Acknowledgments

Data and information were generously provided for the paper by J. Brennan, R.G. Henzell, J. Bronwer, K.H.M. Siddique, E.J. Knights, H. Marcellos, R. Redden and G. Wright in Australia, besides W. Erskine, H. Vivar (ICARDA) and D. Byth (ICRISAT). I thank D.L. Winkelmann, A. Acosta and D. Byerlee for their comments on the manuscript.

References

Brennan, J. 1989. Spillover effects of international agricultural research: CIMMYT-based semi-dwarf wheats in Australia. Agricultural Economics, 3: 323-332.

Brennan, J. 1991. Economic criteria for establishing plant breeding programs. CIMMYT Economics Working Paper 92-01, Mexico, D.F., CIMMYT.

Clements, R.J., Roseille, A.A., and Hilton, R.D. 1992. National review of crop improvement in the Australian Grains Industry. Report to GRDC, June 1992.

Dr John Brennan is a Special Economist at the Agricultural Research Institute at NSW Agriculture in Wagga Wagga, NSW. He works closely with agricultural scientists in assessing and evaluating their research and in determining where the greatest pay-offs occur. His main research interests have been the economic issues related to plant breeding and new varieties.

A Windfall for Australian Wheat Farmers

JOHN P. BRENNAN

NSW AGRICULTURE, AGRICULTURAL RESEARCH INSTITUTE, WAGGA WAGGA NSW

It is apparent that Australia has made widespread use of germplasm developed by the international agricultural research system, particularly for wheat.

The aim of my talk is to examine what the benefits have been for the Australian wheat industry from the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico. That involves evaluating: (a) the use of semi-dwarf wheats in Australia; (b) the benefits to growers from semi-dwarf wheats; (c) the relative contributions made by CIMMYT and Australian researchers to those benefits; and (d) some other issues relating to semi-dwarf wheats in Australia.

Semi-dwarf Wheats in Australia

Australia has been importing wheat varieties throughout its history, and has been using imported breeding lines for more than 100 years. Semi-dwarf wheat breeding material has been imported regularly since the 1950s, mainly from the CIMMYT program in Mexico.

However, few of those imported lines have been suitable for direct release for commercial production in Australia, because our cropping environments are different from those targeted directly by the CIMMYT program. In most cases, the CIMMYT lines have been used as parent lines in Australian wheat breeding programs. The wheat breeders have combined those lines with other Australian varieties to develop improved varieties adapted to the Australian environment.

The first semi-dwarf varieties in Australia derived from those introductions were released from Wagga Wagga in 1973. Since that time, breeders have released new and improved varieties regularly in all States, incorporating semi-dwarf

material originating from CIMMYT. To date, approximately 100 varieties have been released in Australia incorporating CIMMYT genetic material.

Twenty years after the release of the first semi-dwarf in Australia, over 90% of Australia's wheat area is currently sown to semi-dwarf varieties. Western Australia (77%) is the only State with less than 90% of the wheat area sown to semi-dwarf varieties incorporating CIMMYT material.

Benefits from semi-dwarf wheats

Semi-dwarf varieties have shown a significant advantage in yield per hectare over the previous varieties in most wheat-growing areas. In variety trials, CIMMYT-derived varieties were found to have, on average, a yield advantage of 7% over other leading varieties. The yield advantage was greatest in NSW, Queensland and Victoria, and the lowest in the drier parts of the Western Australian wheat belt.

The benefits of these varieties to Australian wheat production are determined by their yield advantage and the area sown to those varieties. On that basis, CIMMYT-derived varieties are estimated to have increased yields in Australia by an average of 5.3% by 1993, ranging from 2.1% in WA to 8.8% in Queensland.

Australia's annual wheat production has averaged 15 million tonnes over the past 10 years. That production would have been some 750 000 t lower, on average, if the CIMMYT material had not been incorporated into Australian varieties.

In monetary terms, the value of that increased production is estimated to have been $142 million in 1993. The average of the past five years has been $137 million per year.

Semi-dwarf varieties have brought to the Australian wheat industry over the past 20 years benefits estimated at $2.9 billion in today's values.

The total benefits that the semi-dwarf varieties have brought to the Australian wheat industry over the past 20 years are estimated at $2.9 billion in today's values. If past benefits had been invested at a real interest rate of 5% per year, the current value of the benefits would be almost $4.5 billion.

CIMMYT's contribution to total benefits

It needs to be recognised, however, that only part of those benefits arise because of the contribution of the CIMMYT material. Part also arises because of the efforts and inputs of the Australian wheat breeders in combining that material with other wheats with agronomic characteristics and quality appropriate to the Australian production environment and markets.

Analysis is under way to identify the relative contributions precisely. However, preliminary analysis indicated that CIMMYT contributed perhaps half of those total benefits (on

the basis of the contribution to pedigrees). That is, Australia's wheat industry receives some $70 million each year as a result of the work of CIMMYT.

Other issues

Other issues relating to semi-dwarf wheats in Australia include their impact on: (a) yield security through resistance to wheat diseases; (b) varietal diversity; and (c) yield performance in some areas of environmental stress.

The different sources of disease resistance incorporated in the CIMMYT varieties have provided Australia's wheat industry with a valuable range of resistances against most major wheat diseases. As a result, Australia's wheat industry has enhanced yield security in the face of new strains of current diseases or of exotic pests and diseases not yet present in Australia.

The impact on varietal diversity is difficult to assess. While the genetic base of Australian wheat varieties is probably narrower than it was in the earlier decades, the dependence on single varieties has been sharply reduced. There is now a more balanced mix of varieties than in the past, although those varieties are often closely related genetically.

CIMMYT lines have provided some important benefits through increased tolerance to some environmental stresses, such as acid soils. The use of CIMMYT material has led to improved yields in those areas.

Conclusions

The title I was given for this talk was 'A windfall for Australia's farmers'. According to my dictionary, the term 'windfall' indicates an unexpected piece of good fortune as a result of events not directly related to the recipient.

It is apparent that Australia's wheat industry has indeed received a piece of good fortune from the work of CIMMYT, currently valued at some $70 million per year.

However, the benefits of semi-dwarf wheats only arose from the combined efforts of CIMMYT and Australian wheat breeders in developing and incorporating CIMMYT material into Australian varieties. Given that concerted effort, 'windfall' hardly seems appropriate. A more appropriate title perhaps would have been ' A boon for Australia's farmers', since 'boon' is defined as a benefit enjoyed, one to be thankful for.

Therefore, I believe that the development and use of CIMMYT's semi-dwarf wheats in Australia over the past 20 years has been a boon for the Australian wheat industry.

The development and use of CIMMYT's semi-dwarf wheats in Australia over the past 20 years has been a boon for the Australian wheat industry.

DR PETER KERRIDGE is the Leader of the Tropical Forages Program at the International Centre for Tropical Agriculture (CIAT) in Colombia. From a family farm in Queensland, Dr Kerridge has made a career in pasture research and development in Australia, Southeast Asia, the Pacific, Africa and Latin America on topics including drought feeds, forage legumes, open grasslands, aluminium toxicity in wheat, nutrient requirements of subterranean clover and dairy pastures, forage management and plant competition.

Tropical Pastures for Australia's North

PETER C. KERRIDGE

INTERNATIONAL CENTRE FOR TROPICAL AGRICULTURE (CIAT) COLOMBIA

A major proportion of Australia's cattle is produced in the North in the tropics and subtropics, the slaughtered value being $1600 million annually. Although they are grazed largely on native pasture, approximately 40% of the area has a potential for cropping or sown pasture. Presently 17% of this potential area already contains introduced species.

These naturalised and sown forage or pasture species exist because they are more persistent or are sown because they are of higher quality than the native species. Of particular interest are the introduced legumes. They will be used more widely in the future because:

- they can increase the feed value of the pasture on low-fertility soils;
- they can halt the declining productivity of sown grass pastures;
- legume–grass pastures sown in rotation with crops can restore soil fertility and thus contribute to a sustainable farming system.

Most of the useful tropical grasses come from Africa and the legumes from South America, where CIAT is situated. Notable examples of legumes are those from the genera *Stylosanthes* and *Arachis*.

Legume sowings in Australia's North now total 1.5 million ha, of which half are estimated to be stylos. The area in stylos is being increased annually by 100 000 ha.

This widespread use of the stylos has not come about without a long history of research and some major setbacks. An annual stylo was becoming naturalised in the North by the 1960s but was devastated by a fungal disease, anthracnose.

Fortunately, other introductions from South America proved to be resistant.

What is the role of CIAT and other CGIAR centres in this quiet pasture revolution that is occurring in north Australia?

Collaborative Research

Australia needs to protect this 20-year investment in research and development of the stylos.

Australia needs to protect this 20-year investment in research and development of the stylos and prevent another catastrophe like the demise of Townsville stylo in the 1960s. Some of the questions being asked are:

- Will the present varieties maintain resistance to anthracnose?
- Are they resistant to the wider range of races of the disease that occur in South America?
- Will new races of the disease evolve in Australia as they must obviously have done in South America?
- How can multiple resistance be introduced into the present successful varieties?

A collaborative project between ACIAR, CSIRO and CIAT is designed to provide a solution to these questions through comparative studies in Australia and South America. Four research sites have been set up in collaboration with CORPOICA in Colombia and EMBRAPA in Brazil. These are 'hot spots' for the disease, places where virulence of the disease is high. Stylo selections that have been selected or bred in Australia are being evaluated at these sites together with stylo selections being used in South America. We will obtain information not only on plant resistance but on the virulence and diversity of the fungus *Colletotrichum gloeosporioides*, the cause of anthracnose disease. This will enable multiple resistance to be incorporated into new stylo varieties being developed in Australia.

CIAT has a strong forage research team, good facilities and good liaison with national agricultural research centres.

CIAT has a strong forage research team, good facilities and good liaison with national agricultural research centres (NARS). CIAT also has crop improvement programs in beans, cassava and rice, and natural resource management programs for the tropical lowlands and hillsides. It can facilitate access to operation in other countries in South America which would not be eligible directly for Australian aid. On the other hand, CIAT cannot participate without itself receiving assistance. The international centres rely completely on donor support.

Exchange of Forage Germplasm

Australia first acquired its resources in tropical forage germplasm at a time when the international centres were

young and developing their own collections. It was a time of free access to those countries willing to export or exchange their germplasm.

But now that basic collections have been made, Australia relies increasingly on exchange of material. The international centres play a major role in this exchange. Recently CIAT passed on, without cost, a collection of 800 accessions of the forage genus *Zornia* to the Australian Tropical Forages Genetic Resources Centre (ATFGRC) in CSIRO. Similarly, Australia benefits from the exchange of tropical forage germplasm from ILCA (International Livestock Centre for Africa) in Ethiopia and ICRAF (International Centre for Research in Agroforestry) in Kenya.

The international centres will continue to provide free access to the forage accessions held in their genetic resource centres and work with national organisations to maintain natural centres of diversity of important species.

The international centres will continue to provide free access to the forage accessions held in their genetic resource centres.

The plant genetic collections such as the 21 000 forage accessions held at CIAT and 15 000 at ILCA form part of the worldwide effort to conserve plant genetic resources. The centres are signatories to an FAO convention to conserve such material and provide unrestricted availability to the world community. The centres also aim to seek protection for naturally occurring genes.

While the major genera have been defined for Australia's North, new species within these genera are likely to be of importance in the future. One such genus emerging is that which contains the common peanut, *Arachis hypogaea.* The perennial, herbaceous legumes in this genus have similar characteristics to white clover and have proved to be the most productive and persistent forage legumes in legume–grass associations in the subhumid and humid tropics. There could be more widespread use in Australia if species adapted to semi-arid environments can be identified.

CIAT is working with the Brazilian national genetic resource center, CENARGEN, and ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), which has the CGIAR mandate for *Arachis,* to explore the full potential of this species not only in terms of improving the common peanut but in opening up new uses as a forage and cover crop. Such germplasm will be freely available to Australia.

Maintenance of Biodiversity

For forage species, it is not possible to collect and maintain sufficient diversity in genetic resource centre collections (what

we call ex-situ collections) for all potentially useful species, simply because of the large numbers involved.

Thus the CIAT collection of the common bean, *Phaseolus vulgaris*, contains 25 000 accessions of the one species while, by way of contrast, the CIAT forage collection of 21 000 accessions includes accessions from 150 genera and 700 species; the largest collection of a single species being for *Stylosanthes guianensis* (1400 accessions). So obviously the forage collection does not contain so complete a sample of the available genetic diversity as does the bean collection.

However, by using new techniques of molecular fingerprinting it will be possible to examine the degree of diversity in natural populations and identify the material that should be collected and conserved in ex-situ collections to ensure a reasonable cover of the diversity that exists in the wild (or in situ). Further, those field sites that represent the greatest diversity will be identified. CIAT has the capacity to undertake this research and to work with national governments in identifying important sites for in-situ protection.

There is a need for a change in attitude and a review of plant variety rights legislation as it affects developing countries.

These efforts in identifying and conserving plant germplasm need to be recognised by developed countries like Australia. There is also a need for a change in attitude and a review of plant variety rights (PVR) legislation as it affects developing countries that have been the source of the original germplasm.

In contrast with the free distribution of the *Zornia* collection to Australia, recently, in order to receive and evaluate an improved forage legume from Australia that originated in South America, we were requested to sign a declaration that stated:

1. 'The seed is supplied to you on the understanding that it is for testing purposes only. If it is entered in trials it should be identified as 'xxxx' and not only by a CIAT number.
2. 'xxxx' is protected by PVR in Australia and in all countries that are signatories to UPOV. Thus it cannot be multiplied for sale except under license. It is doubted if country xxx is in UPOV but CIAT is expected to adhere to this restriction.'

In a similar vein, under plant variety rights (PVR), forage varieties that have simply been selected from a collection of wild species without any improvement by breeding are being released in Australia. Presumably a similar request will be made to the country that supplied the original germplasm. What went out free comes back with a price tag.

How do you expect national governments to react to more requests to collect their native germplasm when they have to

sign such declarations to receive back germplasm that has only been modified by a re-arrangement of genes or simply identified as having utility? More damage is being done by this sort of practice than the paltry royalties that come from registering forage germplasm under PVR.

Scientific Exchange

The advance of science has depended on the exchange of information which has occurred freely in the past. Access to new materials and processes is now under threat due to the movement in developed countries to patent anything that may bring in research funds from private industry. This leads to secretiveness similar to that in the defence industries. The international centres still advocate free exchange of information and will only seek to patent materials to prevent them being patented by others.

Access to new materials and processes is now under threat.

Strategic research

CIAT has marked or identified the gene that controls apomixis in the grass *Brachiaria.* Marking the gene allows a plant breeder to identify this characteristic in young seedlings.

The international centres still advocate free exchange of information.

Why was the work undertaken? Many tropical grasses are apomictic. Seed from such species produces plants that are identical to their mother parent, because there is no sexual crossing involved in seed formation. Traits are therefore fixed and there is no biological variation as in the case of sexual crossing. By being able to manipulate apomixis, one can introduce new traits into a species and then fix these traits easily and permanently. In this case CIAT wished to introduce spittlebug resistance into *Brachiaria decumbens*, a grass from Africa that is planted on 40 million ha in South America and whose productivity is greatly reduced by spittlebug. It may also prove to be advantageous to change apomictic populations to sexual populations to permit more variation and natural adaptation to changing environmental conditions.

Further, there is a good prospect that mapping of the apomixis gene in *Brachiaria* will lead to its cloning, whereby it can be transferred to other plants. This will dramatically reduce the time taken by plant breeders of other crops to fix desirable traits. By being carried out in an international centre the knowledge can be protected for use by all countries.

Technology development and transfer

In South America, integrated crop–pasture systems are now recognised as essential in creating sustainable and profitable farming systems. CIAT has been at the forefront in integrating

crop improvement with natural resource management. By breeding rice varieties adapted to the acid infertile soils usually reserved only for pastures, and developing an integrated rice –pasture system, an economic means of establishing improved pastures and renovating degraded pastures has been demonstrated and is being used by farmers in Colombia and Brazil.

CIAT places major emphasis on involving farmers and the community in the research and development process.

Further, the inclusion of legumes in the pasture has been shown to increase available soil nitrogen, increase earthworm activity, improve soil physical structure and double subsequent rice yields. This type of result is not unique to research conducted at CIAT, similar effects having been demonstrated in tropical areas in north Australia. What is unique about the CIAT research is the integration of germplasm improvement for acid soils with soil management directed to sustainability.

CIAT places major emphasis on involving farmers and the community in the research and development process. This participatory approach initially arose from research by scientists from developed countries working in developing countries. CIAT has been a leader in extending the methodology and in the preparation of training materials for implementation. For example, it led to rapid adoption of climbing beans in Central Africa. It is now being used in the introduction of forage legumes for fallow improvement in the Andean hillsides. The approach is slowly being introduced into Australia using focus and contact groups. But the involvement of farmers themselves in the research process could be developed further than it has been to date. In the Andean hillsides, smallholder farmers are involved in the initial selection of forage germplasm before it is moved on to their farms.

Conduit to National Agricultural Research Centres

As a centre operating in Central and South America, CIAT can facilitate the interaction of scientists from developed countries with those of countries in the region. This can be done simply by way of introduction or by using CIAT as a link in the research process. In some cases it may be most effective to channel funds to a region through a centre with a strong administrative and technical base, which CIAT has. At present, this is achieved through consortium arrangements between donors, the international centres and the national centres. In both the ACIAR-funded Stylosanthes Project and the AIDAB-funded Forages for Smallholders Project in Southeast Asia, CIAT is channelling funds to and developing the capacity of national centres.

European countries make use of international centres to train their students in tropical agricultural research. The trainees become familiar with the region and language and subsequently often become involved in commercial partnerships between Europe and the developing countries.

Mutual Benefits in Funding Overseas Developments

Will financing of the international centres by Australia also help production in other countries? Yes, this is inevitable, but Australia will also benefit. As the Latin American economies develop they will become vehicles for investment and consumer demand. In Asia this has already happened in South Korea and is happening in Thailand, while it is under way in Chile in South America.

The outputs of the international centres—the new germplasm, scientific discoveries and technologies—will continue to have a major effect on domestic productivity of the developed countries. Domestic productivity forms the major part of any country's economy. It is the economic engine. Within the beef industry, exports form a higher percentage of the gross productivity of that industry, but this industry can benefit from the opening up of markets in developing countries where higher living standards have resulted from the outputs of the centres.

Cooperative Endeavours

The work of CIAT on tropical forages complements that in tropical Australia.

Australia has a comparative advantage in the livestock industries and in the excellence of research and development in pasture improvement and management. But the work of CIAT on tropical forages complements that in tropical Australia. Whereas in north Australia the emphasis has been on pasture development for the semi-arid areas, in CIAT it has focused on infertile acid soils of the humid tropics. CIAT has a unique collection of forages adapted to acid infertile soils.

These complementary forage resources held by CIAT and the ASTFGRC have been combined in an AIDAB-funded project to select and deliver forages for smallholder farmers in Southeast Asia. Forages are being used not only for livestock feeding but also for soil improvement and creating more sustainable farming systems. The project is collaborating with the Upland Farming Systems Program of IRRI (International Rice Research Institute). The outcome will be greater livestock productivity and more productive farming systems, particularly in the uplands.

However, it is also likely to open up markets for the export of live cattle from Australia to Southeast Asia which has been increasing and is presently 160 000 cattle per annum. This export trade has been restricted by the shortage of feed in the regions to which cattle have been exported, to the extent that the Australian Meat and Livestock Corporation has officers in the region monitoring the situation.

Final Thoughts

Australia cannot expect to prosper by turning inward in terms of research funding.

Australia cannot expect to prosper by turning inward in terms of research funding. During the 1950s Australia benefited greatly by the recruitment of scientists from overseas and training of Australians overseas.

It also needs to be said that the international centres were not set up to benefit developed countries like Australia. They are primarily concerned with increasing food supplies to improve the welfare of the poor in society both in rural and urban areas, in contributing to greater equity among persons in a community and in developing technologies that are sustainable—both in an environmental sense and in the ability of local communities to continue to maintain new technology without subsidy.

Nevertheless, substantial benefits will come to Australia in the future from the availability of genetic resources of forage germplasm, in scientific collaboration and increasing the welfare of those in developing countries, which in turn opens up markets for Australia. Providing funds for international centres will increase Australia's own domestic productivity.

Trade

Dr Earl Kellogg joined Winrock International Institute for Agricultural Development in 1992 as Senior Vice President and supervises the development and implementation of all its programs. Winrock is a non-profit corporation oriented to helping alleviate poverty and hunger in the US and developing countries. It works in agricultural development, rural economic development, and environment and natural resource management with a staff of around 200 people and estimated annual revenues of $30 million. Prior to this appointment, he worked for the Consortium for International Development and was Professor at the University of Illinois.

International Agricultural Development and World Trade: an American View

Earl Kellogg

Winrock International Institute for Agricultural Development, Arkansas, USA

This is a special opportunity for me—to discuss the interests of the United States in this conference titled 'A Profit in Our Own Country: Benefits to Australia from International Agricultural Research'. Agriculturalists of your country and of mine helped guide the establishment of what is today a global network of agricultural research centres serving the people of developing countries of Africa, Asia, Latin America and the Caribbean.

The vision of the Australian people to be involved in international agriculture is personified in the life and legacy of Sir John Crawford. It is a personal privilege for me to represent Winrock International and the United States at this important meeting sponsored by the fund created in his honour.

The future of international cooperation in agricultural research, production, and trade will affect the welfare of billions of people in all countries and at all income levels. From an American view, the future for assistance and cooperation between the United States and developing countries in agricultural research and development is extremely important. The evidence from the past several years strongly suggests that effective development assistance in agricultural research and development can improve employment and incomes in lower income countries in a way that benefits vast numbers of poor people in those countries as well as American agriculture.

To analyse this evidence, the past, present, and projected future for agricultural production and trade will be briefly reviewed. Then the importance of agriculture and agricultural research in development will be discussed. Finally, the essence of these first two sections will be used to develop the rationale for U.S. assistance to agricultural research and development in lower income countries.

By the end of the 1980s, 75 developing countries were producing less food per person than they were a decade earlier.

Agricultural Production and Trade

Production

Per capita agricultural production in various world regions for the last decade is presented in Table 1. In developed countries and worldwide, there has been almost no growth in agricultural per capita production in the past 10 years. The developing countries of the Far East region—from India and Pakistan, on east through Indonesia and the Philippines—have made remarkable progress. Per capita agricultural production in the early 1990s was 23–25% higher in this region than in 1979–81. No other world region even approached this record. In contrast, per capita agricultural production fell in both Africa and the Near East from 1979–81 to the early 1990s. These regional growth rates mask some troubling country trends. By the end of the 1980s, 75 developing countries were producing less food per person than they were a decade earlier (Pinstrup-Anderson 1994).

Imports

There were some interesting trends in the changes in agricultural imports of various world regions since the 1960s (Table 2). First, agricultural trade increased rapidly in almost all world regions in the decade of the 1970s. Second, Asia was the only world region that substantially increased agricultural imports in both the 1970s and 1980s. Third, Western Europe, the Middle East, and the former USSR/Eastern Europe regions have become less important as importers of the world's agricultural products. Fourth, sub-Saharan Africa, a region of almost 600 million people and declining per capita agricultural production is now an insignificant commercial importer of agricultural products.

Production and import relationship

It is interesting to note the relationship between per capita agricultural production and agricultural imports in world regions in the 1980s (Tables 1 and 2). Asia had the highest growth rates of per capita agricultural production, and also had the most rapid increases in imports of agricultural products. Those regions with declining per capita agricultural production—Africa and the Near East—also had declining agricultural imports in the 1980s. It appears that the lower-income countries that experienced the most growth in agricultural production also had the most growth in their agricultural imports in the 1980s.

U.S. agricultural exports

Three periods have characterised the changes in the total value of agricultural exports in the United States over the past 15

Table 1. Indices of agricultural production per capita in world regions (1979-81=100).

World Region	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
All Developed	97.48	103.70	104.41	104.03	102.53	99.43	102.91	103.21	99.32	98.95
North America	85.54	98.39	103.14	97.36	94.63	87.13	95.28	98.24	96.57	102.62
Europe	102.24	108.63	105.82	107.06	106.56	105.62	106.49	105.36	104.17	100.79
Oceania	104.31	100.20	102.31	101.60	99.27	101.80	96.52	97.16	96.47	98.35
Former USSR	107.14	105.20	105.71	111.66	109.82	107.90	111.46	110.59	95.84	91.30
Other Developed	92.98	95.68	98.00	96.44	96.84	95.03	96.43	93.75	91.10	84.47
All Developing	104.56	106.74	108.20	107.44	107.60	111.13	112.08	113.56	113.99	113.80
Latin America	98.08	98.65	101.48	97.08	99.51	102.20	102.70	101.29	100.91	100.36
Africa	95.54	93.66	98.23	100.23	96.07	99.53	100.33	97.61	98.65	93.14
Near East	98.54	95.56	98.16	99.96	97.15	99.04	91.30	97.48	94.75	96.22
Far East	109.31	113.53	113.75	113.45	114.03	118.16	120.67	123.36	124.53	125.35
Other Developing	94.97	100.02	99.52	96.91	95.74	94.03	96.37	95.60	91.94	91.19
World	100.14	103.90	104.66	103.77	102.85	102.97	104.74	105.36	103.58	103.05

Source: FAO Production Yearbook, Vol. 46, 1992. Table 10.

Table 2. Agricultural imports by world region excluding intra-regional trade.

	Agricultural imports ($ billion)				Growth rates (%)			Share of world (%)			
	1962–64	1969–71	1979–81	1988–90	1960s	1970s	1980s	1962–64	1969–71	1979–81	1988–90
Asia	4	6	25	42	7.0	15.7	6.0	15	18	20	30
North America	4	6	20	24	4.1	13.1	2.2	18	18	16	17
Latin America	1	1	6	4	4.5	20.0	-5.5	3	3	5	3
Western Europe	14	16	51	52	2.3	12.2	0.3	57	51	40	38
Oceania	0	0	1	2	5.3	14.3	4.9	1	1	1	1
Africa	0	1	4	1	9.9	18.6	-13.8	1	2	3	1
North Africa/ Middle East	0	1	14	10	17.6	25.9	-4.2	2	4	11	7
USSR/ Eastern Europe	1	1	6	4	5.6	21.9	-4.0	2	3	5	3

Source: United Nations Trade Database.

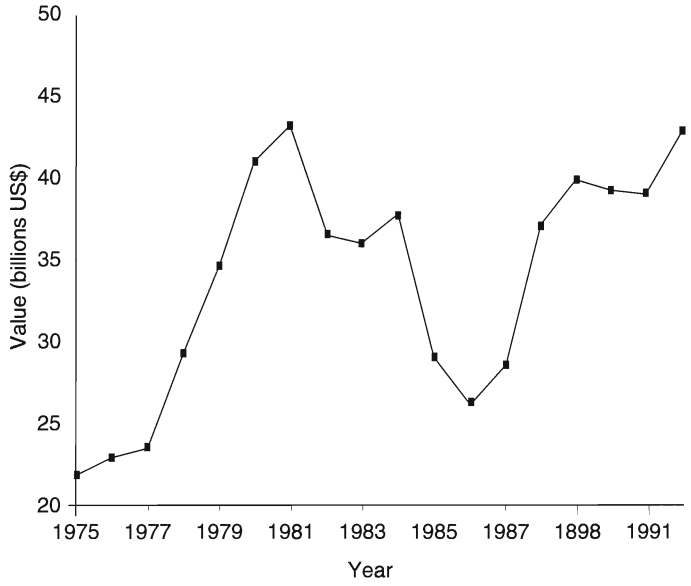


Figure 1. Value of U.S. agricultural exports, 1975–1992.

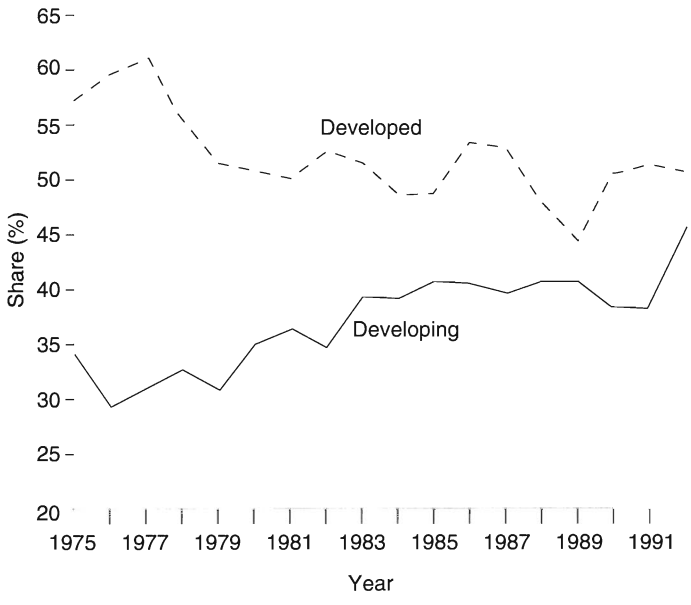


Figure 2. Share of the U.S. agricultural exports to developing and developed countries, 1975–1992 .

years (see Figure 1). U.S. agricultural exports increased by 83% from 1977 to 1981, declined by 39% from 1981 to 1986 and increased again by 64% from 1986 to 1992.

During this 15-year period, however, the proportion of U.S. agricultural exports to developing countries increased steadily from 31.7% in 1975–77 to 44% in 1990–92 (see Fig. 2). Developing countries have been, and continue to be, the most rapidly expanding markets for U.S. agricultural exports.

Future demand

The future demand for agricultural production will likely be quite different between developing countries and developed countries. Crosson and Anderson (1992) have carefully projected the anticipated demand for agricultural products in 2030—only 36 years from now (Table 3). For this analysis, they used grain as a proxy for all agricultural products. Almost all of the projected increase in grain consumption will be in developing countries.

The combination of population growth and increased per capita income in these countries indicates that their demand for agricultural products will be 2.7 times more in 2030 than in 1989. The consumption of wheat and rice will grow more slowly than that of coarse grains. The rapid increase in coarse grains demand will be due largely to increasing consumption of poultry, swine, beef, and other livestock. The consumption growth of coarse grains is expected to almost double, going from an increase of 1.7% annually in the 1980s to 3.2% annually in the four decades between 1988–89 and 2030.

Table 3. Annual grain consumption in the less-developed and more-developed countries, 1979–81 to 2030.

	Quantity (million tons)			Annual increase (%)	
	1979–81	1988–89	2030	1979–81 to 1988–89	1988–89 to 2030
Less-developed countries					
Wheat	195.6	265.6	770	3.7	2.3
Rice	249.4	309.2	634	2.6	1.3
Coarse grains	260.8	299.7	946	1.7	3.2
Total	705.8	874.5	2350	2.6	2.3
More-developed countries					
Total (all grains)	–	802.5	947	–	0.4

Source: Crosson and Anderson 1992.

Past versus the future

It is often instructive to compare what we have accomplished in the past with what we need to achieve in the future. In the 12 years from 1980 to 1992, world agricultural production increased at slightly less than 2% annually, but in developing countries agricultural production increased 3% per year (Food and Agriculture Organization 1992). To meet growth in demand estimated by Crosson and Anderson throughout the next 40 years, world and developing country agricultural production must increase annually about 1.7 and 2.5% respectively. This means that the world farmers must double their agricultural production by 2030 to meet the demand for agricultural products that will nearly triple in developing countries by 2030.

It will not be possible to economically add significant amounts of land to agricultural production in the next 40 years.

Most experts agree that it will not be possible to economically add significant amounts of land to agricultural production in the next 40 years, so all of this increased production must be accommodated on land now devoted to agriculture. Therefore, future increases in agricultural production must come largely from increased yields. Brown (1994) argues it is not realistic to assume that yields will increase 2–3% annually in the next three to four decades, pointing out that corn, wheat, and rice yields have increased a mere 1% annually between 1984 and 1993.

Most experts of international agriculture will argue that continued and increased investments in agricultural research are vital to producing the research results and the economic policy and extension systems that can sustain 2–3% annual increases in yields in developing countries.

Accomplishing these increases in agricultural production in developing countries will be a greater challenge for agricultural research than in the past. There are several reasons for this.

- More research attention will be focused on rainfed agriculture and the less-favoured agroclimatic regions.
- Significant agricultural research effort must be oriented to maintaining the current yield levels. With constant to declining financial support for agricultural research, this means fewer resources will be available for developing new technologies for further yield increases.
- As environmental pressures grow, agricultural research must be increasingly oriented to respond to environmental concerns rather than to short-term production gains.
- We seem to be in a period when crop yields, even in experimental locations, are not increasing very much. To make significant yield increases presents difficult challenges to international agricultural research.

All of this calls for greater emphasis on agricultural research, not less.

Another important consideration with regard to the potential of the future versus the record of the past relates to agricultural policy in the developed countries. Since the middle of this century, North America, Europe, and Japan have implemented policies that stimulated agricultural production. These policies have included price supports, input investments, and export subsidies. Now these policies are changing, giving way to pressures to reduce public expenditures for agriculture.

Trade negotiations have also required that nations reduce many of these agricultural production subsidies and incentives. As a result, agricultural production in many developed countries may decline or, at best, be stable in the foreseeable future. The large surpluses that developed countries have used for concessionary shipments and emergency supplies may decline significantly. The loss of this 'safety net of food' argues for developing countries to increase their investments in agricultural research, thus improving their own food security.

To double agricultural production in the next 40 years could place heavy strains on our natural resources, especially with respect to soil erosion, forest cover and water quality. It is clear the nexus between agricultural production and environmental quality is becoming increasingly important and controversial.

The nexus between agricultural production and environmental quality is becoming increasingly important and controversial.

Relationships between Agricultural Production and Development in Developing Countries

To understand why it is in the best interests of U.S. agriculture to support agricultural research and development, we must understand the relationship between agricultural production and development in developing countries. In this regard, six characteristics of developing countries are important.

- In most developing countries, agriculture accounts for a significant proportion of total economic activity. Up to 70% of the people live in rural areas and more than 40% of their work force is employed in agriculture.
- As people's incomes rise, they spend significantly more on both the quantity of food and on diet diversification in developing countries. Food expenditures may increase by 5–6% for each 10% increase in income. In many developing countries, 40–60% of income is spent on agricultural products. As incomes rise, more is spent to consume

animal products, which increases the demand for feed grains. Primarily because of this, per capita grain consumption in developed countries is typically 2.5–4 times more than in developing countries.

- In general, people working in agriculture in developing countries have lower incomes than those who are employed elsewhere in the economy. An increase in the income for agricultural workers creates a greater demand for agricultural products than the same increase would cause in the non-agricultural sector.
- Although declining, population growth rates in developing countries are still relatively high and will remain higher than those in developed countries for many decades. Nearly 90% of the world population growth in the next 40 years will occur in developing countries. The majority of these people will be in Asia, and they will be poor.
- In developing countries, the performance of the agriculture sector is often an important determinant in how rapidly the non-agricultural sector grows. This is because of the size of the agricultural sector and its positive development linkages to the non-agricultural sector.
- Growth in the non-agricultural sector can be quite high. In many developing countries, this contributed to rapid increases in the demand for imported agricultural products that occurred in the 1970s and 1980s.

These six characteristics indicate there are strong possibilities for relatively high growth rates in the demand for agricultural products in developing countries. For the 4.3 billion people in developing countries, the demand for agricultural products can increase rapidly if they can achieve economic development. But to achieve economic development, most developing countries must increase their domestic agricultural production.

Many studies have shown that the returns to investments in agricultural research are very high.

Importance of agricultural research

The quality and quantity of agricultural research is one of the most important determinants of the level of agricultural development in developing countries. Many studies have shown that the returns to investments in agricultural research are very high. Agricultural research often produces new techniques and technologies that reduce the real cost of producing agricultural products, enabling farmers to increase their incomes and consumers to spend relatively less on agricultural products. This increased agricultural efficiency particularly benefits poorer people, some of whom are agricultural producers and workers and all of whom spend large proportions of their

incomes on food and fibre products. Investments in agricultural research oriented to food grains and fibre products can be a great benefit to the poor in developing countries.

Good agricultural research can also contribute significantly to agribusiness development by:

- improving the quality of raw agricultural products;
- developing new uses for agricultural products;
- reducing prices for agricultural products;
- improving the management of production, marketing, and input systems.

Without continued and increased emphasis on agricultural research, we cannot hope to achieve the production gains that are required to meet the demands for agricultural products in the future in an environmentally sustainable manner. Also, without continued investments in agricultural research, we cannot provide the jobs and increased purchasing power that is desperately needed by poor people in the developing world.

A strong and viable agricultural research system is critical to the prosperity and environmental soundness of this planet during the next 40 years.

Rationale for Supporting Agricultural Research and Development

There are many reasons why it is in the best interests of the United States to encourage broad-based economic development by supporting agricultural research and development in low-income countries.

Humanitarian and geopolitical rationale

It is in the best interests of everyone that we encourage a stable, peaceful and just world. In 1994, 78% of the world's population lived in developing countries. By 2030, over 84% will live in these countries. Sound broad-based development, supported by agricultural research in developing countries, can provide hope and a more secure future for people in developing countries. Improved food security, increased employment opportunities and higher incomes for a broad segment of the people in these countries will lead to increased stability and prosperity for us all.

The poverty and hunger we see in many countries are not consistent with our sense of how human beings ought to live.

The poverty and hunger we see in many of these countries are not consistent with our sense of how human beings ought to live. It is estimated that more than 700 million people in developing countries are under- or malnourished. In South Asia and Africa, 50% of all the people live in poverty (Pinstrup-Anderson 1994). The infant mortality rate in developing

countries of 77 deaths per 1000 live births is 5.5 times higher than in the richer countries where per capita incomes are 15–20 times higher. The hunger, poverty, and poor health conditions in developing countries can be addressed by sound broad-based development programs supported by effective agricultural research and development. It does not seem to be fashionable today to talk about the humanitarian rationale for agricultural research and development. Nevertheless, I believe that humanitarian concerns are one of the strongest reasons that many people in the U.S. support investments in agricultural development in low-income countries.

Economic self-interest rationale

We know that broad-based growth in developing countries increases agricultural imports as people in these countries increase their per capita incomes.

Increased agricultural exports Another convincing rationale for the United States to support agricultural research and development is that it is in our own economic self-interest. We know that broad-based growth in developing countries increases agricultural imports as people in these countries increase their per capita incomes, become more urbanised, increase employment for women, and generate a demand for convenience foods. Because the agricultural sector is a large segment of the economy of most developing countries, particularly with respect to employment and income generation, it must grow and become more efficient for there to be sustained, broad-based growth in these countries.

What is the evidence of the relationship between agricultural growth and agricultural imports in developing countries? A few years ago, I did a study to rank developing countries by the growth of their domestic per capita agricultural production from 1970–82, then divided them into four categories (Kellogg 1985). The quartile of developing countries that had made the most rapid increases in per capita agricultural production also had increased total agricultural, corn, and soybean and soybean products imports at respective rates of 34, 97, and 257% faster than the quartile of developing countries with the slowest growth in per capita agricultural production.

Somewhat more recently, I analysed 65 developing countries and found that increases in per capita incomes of these countries were strongly and positively correlated with increases in their imports of agricultural good and services (Kellogg et al. 1986). A 10% increase in their per capita incomes was associated with a 7.3% increase in per capita agricultural imports. For the lowest-income developing countries, an increase in per capita agricultural imports of 9.7% was associated with a 10% increase in per capita incomes. Therefore, it is clear that increasing per capita incomes in these

countries leads to growth in agricultural imports. This analysis also shows the positive and strong correlation between per capita agricultural production and per capita income in developing countries.

For those developing countries where per capita agricultural production is growing, there is also a positive and significant correlation between such production and per capita agricultural imports. The study found no evidence that increasing agricultural production in developing countries negatively affected their agricultural imports.

Developing countries with the faster-growing agricultural sectors were the faster-growing markets for U.S. agricultural exports.

This evidence indicates that it may be necessary for developing countries to increase their agricultural production to get the widespread income growth that leads to increased agricultural imports. Because of this, developing countries with the faster-growing agricultural sectors were the faster-growing markets for U.S. agricultural exports. Thus, American agriculture has much to gain from improving agricultural and overall development in developing countries.

Regardless of whether or not one agrees with that conclusion, it is clear that U.S. Government expenditures to assist agricultural development in developing countries are relatively small. Our country's domestic agricultural commodity price and farm income support expenditures typically are 25 times larger than our expenditures for agricultural, rural development, and nutrition assistance for developing countries. Or, to put it another way, the U.S. Government spends only 4% as much on agricultural development assistance as it does to support domestic agricultural programs.

There are exceptions to this general proposition that agricultural development boosts broad-based income growth and thus the demand for imported agricultural products. For example, some developing countries have adopted policies that force reductions in their imports and increases in their exports of agricultural products, regardless of the current situations they face. In other countries, unequal income distributions, poverty, and poor performance in the non-agricultural sector substantially constrain any increases in demand that results from increased agricultural production.

The evidence is conclusive: total agricultural exports to developing countries are not, in general, harmed by increased agricultural production in those countries.

The evidence is conclusive: total agricultural exports to developing countries are not, in general, harmed by increased agricultural production in those countries. While increasing production of specific commodities will likely reduce imports of those commodities, imports of other agricultural commodities are likely to rise. It is these mixed results regarding specific commodities that cause conflict between some interests in U.S. agriculture and those promoting development assistance.

U.S. soybean farmers have expressed substantial concern about the possible impact U.S. development assistance may have had in increasing soybean production in Brazil. Increased soybean production and exports by Brazil, causing increases in income and foreign exchange, may have stimulated additional imports of U.S. corn and wheat into that country. Even with this benefit, few American wheat and corn farmers expressed their support for the development assistance that may have helped to expand Brazilian soybean production that stimulated wheat and corn imports. U.S. commodity groups are often more vocal in protesting potential negative impact on their commodity than the support heard from other commodity groups that may stand to gain.

Many developing countries that have had economic difficulties in the past will need to improve their foreign exchange positions and income growth records if they are to continue to be growing markets for agricultural imports. This means agricultural development must be an important part of their development plans.

Finally, macroeconomic forces—such as interest rates, foreign lending, currency values, developing countries' export performances, trade barriers to exports from developing countries, oil prices, and other variables—have major impact on the ability of developing countries to import agricultural products. In addition, the trade and domestic policies adopted by both developed and developing countries will greatly influence the size and composition of developing countries' agricultural imports in the future. If a lack of export opportunities and reduced assistance for agricultural research and development assistance force developing countries to turn inward, they may adopt import substitution and self-sufficiency policies that will constrain their agricultural imports.

Developing countries are the best hope for expanded markets for the world's agricultural exporters.

Developing countries are the best hope for expanded markets for the world's agricultural exporters. But, for this hope to be realised, developing countries must generate employment opportunities and significantly increase incomes for the billions of their people who now live at or near poverty levels. This will require agricultural research and development that improves the welfare of these people.

Effective development assistance in agriculture (including agricultural research) that improves employment and income in developing countries can bring far-reaching benefits to countless numbers of impoverished people as well as those involved in American agriculture. Thus, the broader picture is one of mutual benefit, both for agriculture in the United States and for agricultural development in poor countries.

Reverse technology flow Sound investments in international agricultural research can produce new agricultural technologies and techniques that benefit farmers and agribusiness in developing and developed countries. While they are properly oriented to the needs of developing countries, international agricultural research centres and national agricultural research systems in developing countries have and will continue to produce technology that often has application to improving agricultural profitability and efficiency in developed countries. The extent and substance of this reverse technology flow to American agriculture is too large to describe completely in this presentation. However, there are numerous examples in the literature.

Improved semi-dwarf wheat and rice varieties developed at international agricultural research centres have made significant contributions to increasing grain production in the United States.

Improved semi-dwarf wheat and rice varieties developed at international agricultural research centres have made significant contributions to increasing grain production in the United States. Varieties and lines developed at the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico have been used to breed improved spring wheat bread varieties that have been directly planted in southwestern states of the U.S. In 1984, 36% of the U.S. wheat area was sown to varieties with CIMMYT germplasm in their ancestry. The area has undoubtedly expanded since then, but more precise figures are not available. The semi-dwarf varieties imported from Japan in the 1950s were used to breed varieties that are grown on 60% of the wheat area in the U.S.

Rice varieties and lines developed at the International Rice Research Institute (IRRI) in the Philippines are widely used in the United States. There was IRRI ancestry in about 66% of the rice planted in the U.S. in 1992.

Farmers in the states of Idaho and Washington are planting 'crimson', a new lentil variety developed from germplasm originating in Egypt and supplied by the International Centre for Agricultural Research in the Dry Areas (ICARDA).

American researchers are multiplying a new chickpea variety from ICARDA that contains resistance to a blight disease found in the U.S. It also has the potential to increase yields by 50% compared to chickpea varieties now grown in Idaho and Washington.

The International Plant Genetic Resources Institute (IPGRI) has made significant worldwide contributions to agriculture. The most significant impact IPGRI has made on U.S. agriculture has been the shipment of a large number of germplasm accessions from IPGRI collecting missions to gene banks in the U.S. Out of approximately 206 000 accessions collected by IPGRI, at least 20 621 samples are now stored in gene banks in the U.S. available to American plant breeders.

Other examples of technology from international research being used in the U.S. include:

- the genetic source for golden nematode resistance in potatoes discovered in germplasm from Peru;
- the source of modern resistance to rust in wheat discovered in genetic material from Kenya;
- improved productivity of dairy goats in the U.S. through the disease and production system research of Kenya;
- new varieties of soybeans for American farmers from 535 breeding lines and varieties from Brazil received between 1973 and 1986.

The sources of origin of most agricultural products are in developing country areas. It is in developing countries that most genetic diversity exists for many of our important crops and animal species. For example, only five food crops are native to the continental United States, and these are minor berries and nuts (IFPRI 1992). As scientists of the developed world search for genetic materials to fight disease and pests and improve tolerance for drought and toxicities, they need access to the germplasm in these centres of origin in developing countries.

The discovery and sharing of germplasm is becoming an issue of considerable public concern in many developing countries.

The discovery and sharing of this germplasm is becoming an issue of considerable public concern in many developing countries. Some countries now view this germplasm as a national resource or treasure that must be controlled, particularly regarding export. There are some persons involved in this issue who maintain that these germplasm 'rights' should include payment to farmers in developing countries as compensation for their maintaining this basic genetic resource over time.

No matter how one views these current developments, it is clear that unless developed countries assist and participate in international agricultural research with financial resources and scientists, access to important germplasm in developing countries will become more difficult.

Improving our scientists Another important part of the economic self-interest argument for participating in international agriculture research involves educating and improving the human resource in the scientific community of developed countries. Producers, business people, educators and scientists in the agricultural sector in developed countries must have the ability to operate effectively in an increasingly interdependent world. In the U.S. we cannot be successful teachers, researchers, agricultural policy-makers and agribusiness personnel without a deeper understanding of the global dimension of our

agriculture. One of the best ways to gain this understanding is for our agricultural personnel to participate in international agricultural research and development programs.

Sustainable environment rationale Finally, the rationale that may be the most important long-run reason for supporting agricultural research in developing countries relates to the environment. We all know that many environmental problems are not confined by national boundaries. Greenhouse gas emissions, carbon sequestering, water pollution, fish harvesting, pesticide poisoning, forest degradation, soil erosion and other environmental concerns affect each of us in one way or another. Imagine the loss of forests, deteriorated soil quality, human hunger and disease that would have occurred if international agricultural research had not helped develop new technologies and new institutional and economic policies that allowed us to develop more productive crops and livestock, improved land management practices, and more effective input and output marketing systems.

If we were confined to the agricultural technology of the 1950s to produce and distribute the food and fibre for the needs of the 1990s, environmental problems would be much more severe. And, I am certain, millions more people in the world would be suffering from the effects of these environmental problems. Similarly, without continuing agricultural research investments in developing countries in the future, we will find significantly more land being devoted to agricultural production to meet rising demands. This will cause substantial environmental problems, such as loss of forests and soil degradation.

We have to make the same progress in agriculture from the 1990s to 2030 as we did from the 1950s to 1990s if we are to feed and clothe the additional 2–3 billion people expected in 2030 and do it in an environmentally sustainable manner. This will require that all countries participate in agricultural research and development in developing countries. We must do this for the benefit of our own economic and environmental interests, and also because we all want this to be a more just and peaceful world.

To feed and clothe the additional 2–3 billion people expected in 2030 will require that all countries participate in agricultural research and development in developing countries.

Agriculture of Australia and the United States has contributed much and has benefited greatly from investments in international agricultural research. This includes our farmers and agribusiness personnel, our universities, our scientific institutions, our public and private funding agencies, and our people. During the next three decades, there will be major changes in the developing countries of the world. What happens as a result will in many ways depend on the effectiveness of

agricultural research and development. One billion more people in the next 12 years—mostly Asians and Africans—to feed, shelter and employ is a massive challenge. It will affect the quality of life in those countries. It will also affect how we live in the United States and Canada, Australia, Japan, and western Europe.

We must commit the resources necessary to put agricultural research to work for the national development of the developing countries. Our leaders of a generation ago—Sir John Crawford, George Harrar, Robert Chandler, Winthrop Rockefeller, and many, many others—set the course for us. Let's not lose sight of the goal, for the needs of the 21st Century are even greater than those of the 1940s. It is to our own best interests to support international agricultural research, but it is also our greatest contribution to the future of our children and grandchildren, and to all of humankind.

References

Brown, L. R. 1994. 1994 State of the World. Worldwatch Institute, Washington, D.C., USA. p. 185.

Crosson, P. and Anderson, J. R. 1992. Resources and Global Food Prospects: Supply and Demand for Cereals to 2030. Technical Paper 184. World Bank, Washington D.C., USA.

Food and Agriculture Organization 1992. 1992 Production Yearbook, Vol. 46. Rome, Italy.

IFPRI 1992. 1992 Facts and Figures: International Agricultural Research. International Food Policy Research Institute, Washington, D.C., USA, and the Rockefeller Foundation, New York, NY, USA.

Kellogg, E. D. 1985. University involvement in international agricultural development activities: important issues for public education. In: Proceedings of the 1985 annual meeting of the Association of U.S. University Directors of International Agricultural Programs.

Kellogg, E. D., Kodl, R. and Garcia, P. 1986. The effects of agricultural growth on agricultural imports in developing countries. American Journal of Agricultural Economics 68(5),1347-1352.

Pinstrup-Anderson, P. 1994. IFPRI, 1994 World Food Trends and Future Food Supply, Food Policy Report. Washington, D.C., USA.

PROFESSOR KYM ANDERSON is Professor of Economics and Foundation Director of the Centre for International Economic Studies at the University of Adelaide, after working at the GATT Secretariat in Geneva. His research interests and publications are in the areas of international trade and development, as well as agricultural and environmental economics and the economics of politics.

Why Should Australia Spend More On International Agricultural Research And Development?

KYM ANDERSON

DEPARTMENT OF ECONOMICS AND CENTRE FOR INTERNATIONAL ECONOMIC STUDIES, UNIVERSITY OF ADELAIDE

Aid-funded international agricultural research need not harm agricultural-exporting economies such as Australia's, because the direct effects on farm trade of that aid via the boost to farm production in developing countries can be more than offset by indirect and longer-term effects on both farm and non-farm trade, resulting from the boost to incomes and hence consumption and investment in those countries.

Not only is that aid likely to have a positive effect on Australia's economy, but as well it is likely to be more beneficial to us than aid to the non-farm sectors of developing countries or to spending that money on investments in Australia, the prime reason being the very high returns to international agricultural research investments.

In real terms, bilateral and multilateral aid funding by OECD countries for agricultural research and development in developing countries has fallen about 20% during the past decade.[1] From Australia, official agricultural development assistance has fallen even more, from 14.2 to 10.5% of total aid spending outside Papua New Guinea (Jarrett 1994).

Three reasons are typically given for this decreased emphasis on agricultural assistance. One is the presumption that the problem of feeding the world has been solved. This presumption is not altogether surprising, given the glut of subsidised food stockpiled in Western Europe and the United States—and hence very low food prices in international markets—during much of the 1980s. But it is nonetheless a quite inappropriate view, as it ignores the reality that agricultural research needs to be ongoing if yields are to be even maintained, let alone keep pace with global demand increases due to population and per capita income growth.

The second reason sometimes stated to explain the decline in foreign aid to agriculture is the concern expressed by some environmental groups that the modern agricultural techniques promoted by international agricultural research degrade the natural environment and human health. This claim too is questionable, particularly when the alternative of less food consumption by the poor is considered, but space limitations preclude further discussion of it here.[2]

Thirdly, in food-exporting rich countries such as Australia and the United States, hard-pressed farmers have argued strongly against aid money going to agricultural research in developing countries. The basis of their argument has obvious intuitive appeal: with more farm production in those countries there would be less need for them to import farm products from developed countries such as Australia. Yet it is an empirical fact that countries whose agricultural output is growing fastest are also the countries whose imports of farm products are growing fastest. This apparent paradox can be resolved by recognising that our farmers' argument against such aid focuses only on the direct and immediate farm production effects, and ignores the indirect and longer-term effects that flow from raising incomes and hence consumption and investment in the aid-receiving countries. The first part of this paper traces through the main indirect effects and shows why it is likely that aid-funded investments in international agricultural research would *benefit*, rather than harm, the Australian economy.

It is almost certainly in Australia's narrow economic interest to direct a larger share of its aid budget to international agricultural research.

The remainder of the paper addresses the following question: even if Australia were to benefit economically from aiding agricultural research and development in developing countries, would our economy not benefit more by directing that aid to sectors producing goods which do not compete with Australia's exports? Or, to be even more selfish, wouldn't our economy be better off not giving aid at all and instead directing those aid funds to domestic uses, such as funding more agricultural research and extension in Australia? While it is not possible to give unequivocal answers to these questions, the paper suggests several reasons as to why the answers may well be 'no', especially if a larger proportion of that aid were to be spent on policy research and analysis. The paper therefore concludes that on balance it is almost certainly in Australia's narrow economic interest (not to mention interests in political stability, military security, aiding the poor and other social and foreign policy objectives) to direct a larger share of its aid budget to international agricultural research, including policy research.

Benefits to the Australian Economy from Aid-funded Investments[3]

The conventional argument put forward by farm groups is that agricultural research in developing countries reduces costs of production and raises farm output there, and so causes them to reduce their net imports (or expand their net exports) of food and fibre. If that happens in enough developing countries, the international price of farm products would fall. For both reasons—reduced net imports and a fall in international prices—farmers in Australia and America expect their export earnings to be reduced if more aid is directed to international agricultural research and development.

This argument is incomplete, however, because it focuses only on the developing countries' supply conditions. In particular, it ignores the effects of greater spending and saving by farmers there as they become wealthier. Their higher gross incomes would be spent partly on extra inputs such as fertiliser, pesticides, stud livestock and other modern inputs that are necessary to make the most of the new technologies, partly on household consumer items, and partly on boosting savings (thereby making more funds available for investment).

Extra spending on food would absorb some of the extra farm output, so the net effect on farm trade is less than the effect due to output growth alone. Added to that is the boost in net imports (or reduction in net exports) of farm inputs and non-farm products because of extra spending on those items. In so far as Australia supplied some of those products, so its total export earnings to those countries would fall less than the gross reduction due to reduced earnings from food and fibre exports alone.

An increase in farm incomes boosts the demand for non-tradables, leading to an expansion of non-tradables output and an increase in their price.

But that is not the end of the spending part of the story, because a substantial share of spending in those countries is on products and services which, by their nature, cannot be traded internationally. An increase in farm incomes therefore also boosts the demand for non-tradables. This leads to an expansion of non-tradables output and an increase in their price, which has three consequences for tradables. One is that resources have to be attracted out of tradables sectors, including agriculture, to enable non-tradables production to increase. Another is that domestic demand for tradables that are substitutes for non-tradables, including farm products, rises because of the rise in the consumer price of non-tradables. And the third consequence is that incomes of producers of non-tradables also are boosted, creating a second-round spending effect which adds to the demand for all tradables.

Both shifts—in the demand for and the supply of tradables—reduce further the adverse effect of the aid-funded adoption, adaption and/or production of new farm technology on Australia's export earnings. Even though exports to developing countries of some farm products may fall, exports of other farm outputs and inputs and of non-farm products may rise sufficiently to leave Australia's economy better off.

Manufacturing is the sector where natural-resource-poor countries have a strengthening comparative advantage.

In addition to these immediate effects, there is an important longer-term effect. Higher incomes mean greater savings in those developing countries. Where are those additional private savings of developing countries most likely to be invested? In the case of the relatively densely populated countries (which includes most of our Asian neighbours), the highest private payoffs are likely to be in more and better education (they too want to become cleverer countries), and in the industrial sector and complementary service sectors because manufacturing is the sector where these natural-resource-poor countries have a strengthening comparative advantage.[4] That is, we can expect resources over the longer term to be attracted away from agriculture to industry, and more so because of the boost in rural income resulting from greater aid flows. That would improve Australia's terms of trade and add further to the likelihood of Australia's current account improving as a consequence of giving more aid.

Is there any empirical evidence to support the above notion that agricultural income growth in developing countries could result in growth in their imports, particularly from Australia? Indeed there is. An earlier study (Anderson 1989) examined the correlation between those two variables for the period 1970–84 for the 53 developing countries with populations above one million for which data were available. It found those variables to be positively correlated regardless of whether real agricultural GDP growth is expressed on a per capita or per farm worker basis, whether imports referred to all merchandise or just farm products, and whether those imports were from the world, just developed countries, or just the United States or Australia (Table 1).

Certainly causation cannot be inferred solely from positive correlations, particularly in this case since output in other sectors may have grown even faster than farm output and the income growth from the former may be the main reason for the surge in imports. But equally certainly this evidence does not support the conventional view of some farm groups that agricultural development in poor countries harms agricultural and other exports of countries such as Australia.

Table 1. Coefficients of correlation between developing countries' per-capita growth rates in agricultural output and imports, 1970–1984.

	Growth in real per-capita imports from:			
	World	Developed countries	United States	Australia
Growth in real agricultural GDP				
Total imports				
—per capita	0.34	0.33	0.28	0.23
—per farm worker	0.23	0.22	0.24	0.09
Agricultural imports				
—per capita	0.15	0.07	0.07	0.09
—per farm worker	0.10	0.08	0.10	0.01

Source: Anderson (1989, Table 1), based on World Bank and FAO data.

Table 2. Median social rates of return to further investment in agricultural research, by region and commodity group.

	Number of studies	Median marginal rate of return on research expenditure (%)
By region		
Africa	10	41
Asia	35	57
Latin America	36	46
United States	44	50
Other OECD countries	24	40
International agricultural research centres	4	81
By product group		
Cereals	69	55
Oilseeds	16	64
Livestock	20	43

Source: Huffman and Evenson (1993, Tables 4 and 6).

Agricultural research is an area for further investment in developing countries that has an exceptionally high rate of return.

Wouldn't Foreign Aid to Non-farm Sectors be More Likely to Help Australia?

Again it might appear to be intuitively obvious that if our foreign aid to developing countries is to be made sector-specific, then directing it towards sectors producing goods we import would be more beneficial to us than directing it towards sectors competing with our exports. But that need not be so for several reasons—and one that overrides all others has to do with the fact that *agricultural research is an area for further investment in developing countries that has an exceptionally high rate of return. Indeed it is difficult to imagine any other large investment area where further spending could yield a higher return.*

According to the latest compilation of empirical evidence on this matter by Huffman and Evenson (1993), summarised in Table 2, social rates of return to further investment in agricultural research are still around 50% per annum in developing countries, despite massive investments since the 1950s. Even more spectacular is the estimated marginal rate of return for further investments in the CGIAR international agricultural research centres, at around 80% per annum. Furthermore, the new technologies in prospect suggest these high returns can be expected to continue well into next century (Crosson and Anderson 1992).

Despite these high social returns, sufficient private-sector money cannot be expected to flow into this area. This is because private returns typically are less than half the social returns to agricultural research, the reason being the difficulty in capturing more than a small proportion of the gains. Biological research on crops is especially problematic in this respect (notwithstanding plant variety rights legislation), since once a new crop variety is released, seeds can be readily multiplied.

Why don't national governments of developing countries overcome this market failure by subsidising this activity? They in fact do, but at very inadequate levels. They are loathe to invest heavily in this area partly because of the long time it takes (on average, seven years) before the beneficial results from agricultural research manifest themselves in higher farm incomes. Political leaders there, even more so than in rich democracies, typically have much shorter time horizons than seven years. Another part of the explanation is that farmers in poor countries are politically weak compared with other groups, because of the relatively high costs of getting together to act collectively—not least because of the free-rider problem when the group size is so large (Anderson 1981; Roe and Pardy 1991).

For these reasons the very high rates of return to further investment in developing-country agricultural research will continue to fail to attract sufficient investment from within these countries or from the private sector of richer countries. Thus a large boost to developing-country and global income can be expected per dollar of aid funding channelled specifically into agricultural research. Moreover, Table 2 suggests the returns would be especially high if more of that aid funding was channelled through the CGIAR international agricultural research centres.[5] In part that even higher return is because much research is equally applicable to several countries in a region, and economies of scale in research can more easily be reaped by organising its production beyond the national level (Fischer, these proceedings).

Types of Agricultural Research with the Highest Payoff

Table 2 suggests additional investments in agricultural research would have a higher payoff in crops than livestock. This is not surprising because it is easier to capture the gains from livestock research through the selling of bloodlines from registered studs than through trying to police plant variety rights legislation, hence private-sector funds are more forthcoming in livestock research. The same is true of farm machinery research, and it also applies to the development of farm chemical inputs such as fertilisers and pesticides.

Policy is one other relatively neglected area of agricultural research in developing countries.

But there is one other relatively neglected area of agricultural research in developing countries that has received scant attention. It has to do with policy. Ministries of agriculture in poor countries typically have very few well-qualified economic policy analysts. One consequence is that the farm policy regime often distorts resource use within the sector more than it otherwise would. Even more important is that the sector overall tends to be discriminated against through the setting of artificially low domestic prices, the taxing of farm exports (including via exchange rate overvaluation) and especially, albeit indirectly, the assisting of the industrial sector via protection from import competition (Bautista and Valdes 1993).

These policy choices ensure that agriculture contributes less to GDP and its growth than would be the case with a more neutral policy regime. However, as an economy develops its policy mix tends to gradually move away from taxing agriculture and towards assisting farmers, for reasons to do with the changing political power of farm and other interest groups (Anderson et al. 1986; Tyers and Anderson 1992).

Providing more information on the extent, causes and effects of these distortionary policies would help reduce their incidence. Again, this might be done more effectively through the economics divisions of the CGIAR's international centres and, especially, via its International Food Policy Research Institute (since national ministries tend to build up allegiances to agricultural industries and so are less likely to argue against assistance boosts to agriculture as the economy develops). As discussed below, this would have clear benefits for Australia in so far as it reduces the probability of newly industrialising countries following the lead of the more advanced industrial economies in increasingly protecting their agricultural sectors from import competition.

Areas of Agricultural Research that Benefit Australia Most

Where to direct such assistance is not easy to determine, even if one were to leave aside broader foreign policy concerns and focus only on the narrow economic benefits such aid might have for Australia. Several considerations need to be kept in mind. For example, avoiding countries with industries similar to ours, simply because agricultural aid to such countries may make them more competitive with our farmers, ignores the fact that Australian agribusinesses supplying inputs to modernising farm industries might boost Australia's export earnings enough to more than compensate for any reduction in exports of farm products. It also ignores the externalities that such aid generates in providing contacts and lowering information costs which boost exports of farm and non-farm technologies, of teaching and research training services, and of various consulting services in addition to merchandise.

It is the most densely populated, natural-resource-poor developing countries whose comparative advantage will increasingly complement Australia's as their incomes and capital stocks grow.

Another consideration worthy of attention relates to the fact that it is the most densely populated, natural-resource-poor developing countries whose comparative advantage will increasingly complement Australia's as their incomes and capital stocks grow (Anderson and Garnaut 1985). Hence the savings share of the income boost from aiding agriculture is more likely to be invested in non-farm industries in such countries than in more land-abundant countries. It happens that most of the Asian countries (and numerous sub-Saharan African countries) are extremely densely populated. Hence if all other things were equal, our agricultural aid might be directed more towards such countries. And since the propensity to save and invest profitably is unusually high in East Asia (including now Indo-China), that provides a further economic reason for focusing aid on those countries.

A third consideration has to do with the under-supply of economic policy analysis in these countries. If more and better policy analysis and advice were forthcoming from, for example, the economics departments of international agricultural research centres, *and heeded*, GDP growth would be faster. Initially that might result in greater farm output in countries where the underpricing of farm products was reduced. But in the long term it would lead to less risk that the drift towards overpricing of farm products would occur as those economies grow. And it is that over-pricing tendency that has caused farm export revenue for Australia to grow only slowly, not just in Europe but also in East Asia.

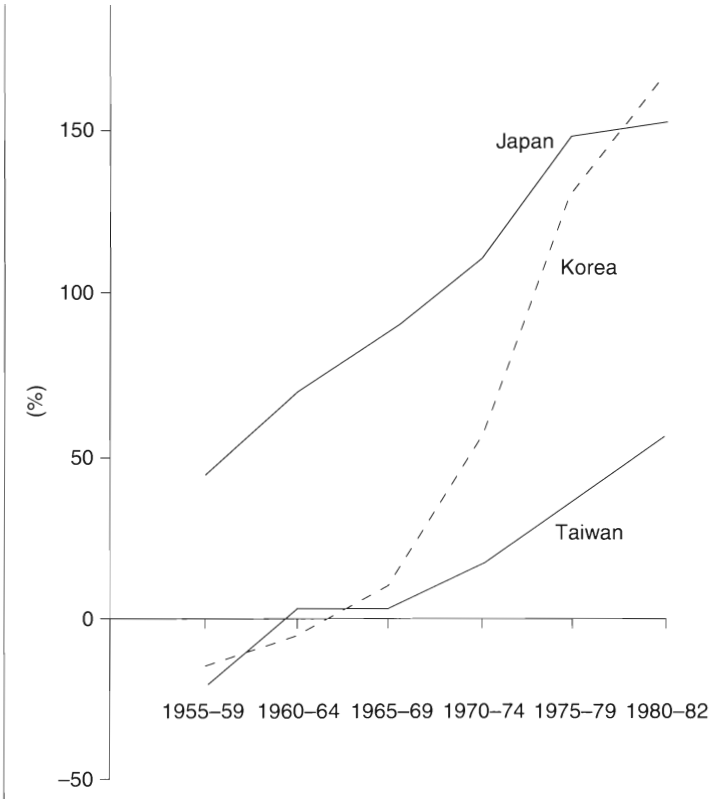
As Figure 1 shows, Korea and Taiwan followed Japan in raising their agricultural protection levels in the course of their industrial development, with their transition to high-protection status being even faster than Japan's. More high-quality agricultural economic policy research and analysis at early stages of economic take-off could reduce such tendencies in other countries, to the benefit of traditional farm-exporting economies such as Australia's.

Australian Aid versus Investment in Our Own Economy

Apart from the usual reasons for giving aid (building familiarity and trust between rich and poor countries, reducing the risk of military conflict, helping the most needy, etc. (see Dillon, these proceedings), and the fact that the income boost from more aid raises incomes in and hence imports by developing countries, there are several other sound economic self-interest reasons for Australia continuing to expand aid to agriculture in developing countries rather than selfishly investing that money at home.

One additional reason is that other OECD countries are doing it, so if Australia were to withdraw then it would reduce its chances of securing commercial sales with developing countries in the future. We have seen in the past a clear link between food aid and subsequent commercial sales, whereby large concessional sales at early stages of development often translated to large commercial sales as those poor economies became richer (e.g. U.S. PL480 shipments to Korea and Taiwan from the 1950s). A similar tendency is bound to operate with technological aid in the form of agricultural research personnel and funds. This is particularly so for Australia, given that its comparative advantage in that area is well known, because we would be perceived as being especially selfish if a substantial portion of our tied aid was *not* in that form.

We have seen in the past a clear link between food aid and subsequent commercial sales.



Source: Anderson and Hayami (1986 p. 22)

Figure 1. The percentage by which domestic food prices exceed international prices in East Asia, 1955–82.

More than that, the biases that emerge in price and trade policies in developing countries are not always independent of the interests of donor countries. A case in point is US influence in Northeast Asia. There the domestic prices of foodgrains are set much higher (relative to prices in international markets) than those of feedgrains and oilseed products used by livestock producers in those countries. That is, the rhetoric of food self-sufficiency which is used to justify import restrictions is applied less strictly to products exported by the U.S. (feedstuffs) than to other farm imports. An important effect of this is an artificial encouragement to the livestock industries in East Asia, thereby harming Australian exports of meat and milk products (Tyers and Anderson 1992).

There is also the possibility that the strength of preferences for food and fibre depends in part on the products first being home-grown. To the extent this is true, the long-term demand in East Asia for exotic goods such as dairy products would be enhanced by initially aiding the development of local dairy

herds. It may be even more true in the case of wool in a country such as China: once textile mills establish wool-processing capacity and downstream clothing factories develop markets for woollen products based on local wool, then as those markets and the capacity to supply them expand, so too will the demand for raw wool—a demand that local graziers in densely populated China would be incapable of satisfying so that imports would become increasingly necessary (as has already become evident—see Anderson 1990).

Furthermore, there is the distinct possibility that agricultural research abroad can be of benefit to Australian agriculture directly. Brennan (1989, and these proceedings) notes, for example, that the wheat breeding program at CIMMYT in Mexico, to which Australian scientists have contributed, has boosted Australian wheat yields to an extent that far outweighs the financial contribution Australian aid has made to CIMMYT's budget. A similar conclusion can be drawn from many other studies, including a recent one by Davis and Lubulwa (1994) concerning Australian aid to tropical fruit research in developing countries.[6] Such 'reverse technology' flows are especially likely to occur from the international centres in the CGIAR system because of their focus on 'broad adaptation' technologies that can be readily adapted to and adopted in a wide range of circumstances, including Australia's. A striking example during the past 25 years is research on germplasm (Fischer, these proceedings).

There is the distinct possibility that agricultural research abroad can be of benefit to Australian agriculture directly.

An increasingly important example in the years ahead will be research aimed at reducing soil and other environmental degradation. As Ryan (these proceedings) puts it, agriculture in Australia 'is based very largely on exotic species, fragile land systems, and low-fertility soils, ... [and] ... without continual international transfusions of genetic resources and scientific technology, Australian agriculture is simply not sustainable'. Past experience suggests both the extent and the speed of such transfers of technology appropriate for Australia's very diverse ecological circumstances are likely to be highly correlated with the extent of financial and personnel involvement by Australia in international agricultural research.

Conclusion

In short, there are numerous reasons for expecting Australia to benefit economically from aiding agricultural research in developing countries, apart from the usual ones such as helping the needy and promoting peace and understanding between rich and poor countries. A major reason we would gain is because those recipient economies would grow faster

Recipient economies would grow faster with more aid, and fastest if that aid were tied to the grossly under-invested area of agricultural research.

with more aid, and fastest if that aid were tied to the grossly under-invested area of agricultural research. With their higher incomes would come more trade, including import trade from Australia. The boost to our export earnings is likely to be especially great if that research aid (a) is channelled to densely populated Asia (since there a large share of the higher incomes is likely to be invested in non-farm production which will improve our terms of trade), and (b) is directed towards economic policy research in addition to the usual scientific areas.

'Free riding' on the aid contributions of other high-income countries is simply not a sensible option. By not being there as a significant donor and participant, we would run several considerable risks—of becoming aware of new technologies less rapidly than others, of having less influence on the international research agenda, and of having less influence on agricultural policies in developing countries. Meanwhile other donor countries would take the opportunity to persuade recipient countries to bias their price and trade policies in favour of trade with the donor—as has already happened in Korea and Taiwan, for example, where feedstuffs attract low import duties to further boost the highly protected livestock sector, thereby boosting US farm exports but harming Australia's and New Zealand's.

Fortunately, there are many other reasons in addition to narrow economic ones for Australia assisting the rural sectors of our poorer neighbours, and they will be sufficient for many Australians to vote for such aid. But the good news is that there are also sound economic reasons for boosting that aid. It remains to make more use of arguments such as those presented at this conference to convince our more sceptical and less generous citizens that by doing good for others we are very likely to end up also doing well for ourselves.

End Notes

[1] According to Braun et al. (1993), the amount of bilateral and multilateral assistance to agricultural development in the third world fell from $12 billion p.a. in the late 1970s to $10 billion in 1990 (expressed in constant 1985 US dollars).

[2] A more appropriate response to those concerns of environmentalists that have legitimacy is to further invest in research aimed at developing more-sustainable farming systems, rather than returning to old, less-productive methods (Ryan, these proceedings).

[3] This section draws on an earlier, more technical paper by the author (Anderson 1989), as well as on papers given from a U.S. perspective at conferences in the latter 1980s such as de Janvry and Sadoulet (1986), Kellogg et al. (1986), Paalberg (1986), Falcon (1987) and Purcell and Morrison (1987).

[4] For more on why such countries are becoming increasingly the suppliers to the world of manufactured goods, see for example Balassa (1979) and Brown and Julius (1993). China is an especially clear example of this: during the past 15 years, investment in and output from the industrial sector has far outpaced that in agriculture, and most notably in rural areas (Anderson 1990; Findlay et al. 1994).

[5] As well, channelling aid funds through the CGIAR system reduces the likelihood of aid to national research systems simply displacing domestic spending on agricultural research.

[6] That study estimated the net present value of a $6 million aid-funded investment in research in Southeast Asia was over $230 million (in 1990 Australian dollars), of which $45 million accrued to Australia.

References

Anderson, K. 1981. Politico-economic factors affecting public agricultural research investment in developing countries. In: Bellamy, M.A. and Greenshields, B.L., eds, The Rural Challenge. London, Gower, 162–168.

Anderson, K. 1989. Does agricultural growth in poor countries harm agricultural-exporting rich countries? Agricultural Economics 3(4), 309–321.

Anderson, K. 1990. Changing Comparative Advantages in China: Effects on Food, Feed and Fibre Markets. Paris, OECD.

Anderson, K. and Garnaut, R. 1985. Australia's trade growth with developing countries. The Developing Economies, 23(2): 121–137.

Anderson, K., Hayami Y. and others 1986. The Political Economy of Agricultural Protection. Boston, London and Sydney: Allen and Unwin.

Balassa, B. 1979. The changing pattern of comparative advantage in manufactured goods. Review of Economics and Statistics, 61(2), 259–66, May.

Bautista, R.M. and Valdes, A. eds. 1993. The Bias Against Agriculture: Trade and Macroeconomic Policies in Developing Countries. San Francisco: Institute for Contemporary Studies Press for ICEG and IFPRI.

Braun, J., Hopkins, R.F., Puetz, D. and Pandya-Lorch, R. 1993. Aid to Agriculture: Reversing the Decline. Food Policy Report, International Food Policy Research Institute, Washington, D.C.

Brennan, J.P. 1989. Spillover effects of international agricultural research: CIMMYT-based semi-dwarf wheats in Australia. Agricultural Economics 3(4), 323–32.

Brown, R. and Julius, D. 1993. Is manufacturing still special in the new world order? In: O'Brien, R., ed., Finance and the International Economy, 7. London: Oxford University Press.

Crosson, P. and J.R. Anderson 1992. Resources and Global Food Prospects: Supply and Demand for Cereals to 2030. Technical Paper No. 184, The World Bank, Washington, D.C., ch. 9.

Davis, J. and A.S.G. Lubulwa 1994. Evaluation of postharvest research: results for an application to tropical fruit research projects. Paper contributed to the 38th Australian Agricultural Economics Society Conference, Victoria University, Wellington, New Zealand, 8–10 February 1994.

de Janvry, A. and Sadoulet, E. 1986. The conditions for harmony between Third World agricultural development and U.S. farm exports. American Journal of Agricultural Economics, 68(5), 1340–46.

Falcon, W.P. 1987. Aid, food policy reform, and U.S. agricultural interests in the Third World. American Journal of Agricultural Economics, 69(5), 929–35.

Findlay, C., Watson, A. and Wu, H.X., eds 1994. Rural Enterprises in China. London: Macmillan (in press).

Jarrett, F.G. 1994. An Economic Evaluation of Australian Aid. Canberra: Australian Development Studies Network, p. 40.

Huffman, W. and Evenson, R.E. 1993. Science for Agriculture. Ames: Iowa State University.

Kellogg, E., Kodl R. and Garcia, P. 1986. The effects of agricultural growth on agricultural imports in developing countries. American Journal of Agricultural Economics, 68(5), 1347–52.

Paalberg, R.L. 1986. Farm development in poor countries: the disputed consequences for U.S. farm trade. American Journal of Agricultural Economics, 68(5), 1353–57.

Purcell, R.B. and Morrison, E., eds 1987. U.S. Agriculture and Third World Development: The Critical Linkages. Boulder: Lynne Rienner.

Roe, T.L. and Pardy, P.G. 1991. Economic policy and investment in rural public goods: a political economy perspective. In: Pardy, P.G., Roseboom, J. and Anderson, J.R., eds, Agricultural Research Policy. Cambridge: Cambridge University Press, ch. 1.

Tyers, R. and Anderson, K. 1992. Disarray in World Food Markets: A Quantitative Assessment. Cambridge: Cambridge University Press, ch. 4.

Dr Donald MacLaren is the head of the Agricultural Economics and Extension Section of the School of Agriculture and Forestry at the University of Melbourne. His main research interest is in the area of agricultural policies and international trade. He has been a consultant with Agriculture Canada, the Commission of the European Communities and the European Parliament.

After GATT—What Now?

DONALD MCLAREN

DEPARTMENT OF AGRICULTURE THE UNIVERSITY OF MELBOURNE PARKVILLE VICTORIA

Over the last seven years the major focus of agricultural trade economists has been on the Uruguay Round negotiations: analysing the policy issues and building quantitative models which could be used to estimate the distribution of benefits from various degrees of agricultural trade liberalisation. Much has been learned but there are new issues emerging which will require further analysis.

In this paper, I will first highlight the role played by Australia in shaping the agenda for the agricultural component of the negotiations; second, describe the possible benefits to Australian agriculture of the outcome; and third, in trying to answer the question 'After GATT—what now?', indicate where I think some serious issues remain to challenge us.

Australia's Proposals for Agricultural Policy Reform in the Uruguay Round

The scope of the agenda for agriculture in the Uruguay Round was influenced to a considerable degree by the Cairns Group and by Australia within it. In the four years following Australia's petulant behaviour at the GATT Ministerial Meeting in 1982, a much more positive attitude was adopted towards international diplomacy in the area of agricultural trade policy.

The Cairns Group proposal, which was submitted to GATT in 1987, contained a comprehensive set of ideas which included: targets for reduced levels of domestic farm income support that would be monitored by an aggregate measure of support (AMS); the removal of the special status enjoyed by agriculture in relation to export subsidies (under Article XVI) and special waivers (Article XXV); the harmonisation of sanitary and phytosanitary regulations; and the encouragement of decoupled income support as a substitute for price support

measures. The main thrust was the reduction in domestic support, improved market access, the removal of export subsidies, harmonisation of sanitary and phytosanitary regulations and, of critical importance, the strengthening of and adherence to the disciplines imposed by the Articles of GATT.

Australia's Gain from the Uruguay Round

The gains to Australian agriculture will not be dramatic and will not be realised fully until the end of the decade.

At first sight, the provisions contained in the Agreement on Agriculture in the *Final Act* seem to be consistent with the Cairns Group proposal. Over a six-year period beginning in 1995, domestic support on average will be reduced by 20%; barriers to imports will be converted to ad valorem tariffs and rates then reduced by 36% on average with a minimum of 15% for any one item; and the value of subsidised exports will be reduced by 36% and the volume reduced by 21%. However, the base periods against which these reductions are to be effected are 1986–88 for domestic and import support and 1986–90 for export subsidies. In some cases, a proportion of these reductions has already been achieved and credit granted. Therefore, in quantitative terms, the gains to Australian agriculture will not be dramatic and will not be realised fully until the end of the decade. The Australian Bureau of Agricultural and Resource Economics (ABARE) estimates that the annual increase in exports by volume will range from less than 0.5% for sugar and sheep meat, to 7% for beef, to 10% for dairy products; also, that world prices will increase from 1% for sugar, to 6% for beef to 20% for cheese; and finally, that the increase in the total annual value of agricultural exports is estimated to be $950 million.[1]

The outcome of the negotiations for agriculture was again dominated by bilateral deals between the United States and the European Union, the very situation which the Cairns Group had been established to prevent. The Blair House Accord of November 1992 weakened in crucial respects the content of the *Draft Final Act* of December 1991. Perhaps one of the most important was the decision to apply the 20% reduction in domestic support to the total of agricultural production rather than to apply it, as intended by Dunkel, to each product. This change will allow governments to avoid making reductions in politically sensitive sectors, such as dairy and sugar, where trade distortions are greatest. Another important difference between the *Draft Final Act* and the *Final Act* is that the compensatory payments of the European Union and the deficiency payments of the United States have been exempted from the 20% reduction in domestic support because, it has been argued, these measures are decoupled.[2]

On the positive side, while it is obvious that farm lobbies remained powerful in the United States, the European Union and Japan, it is also obvious that public opinion had shifted during the course of the Round. At the same time that governments were becoming more sensitive to the budgetary costs of agricultural policies, urban-based lobby groups were becoming more influential in questioning the wisdom of the continued intensification of agriculture which price support programs encouraged. The major concerns of these groups revolved around the link between intensive farming technologies and the rural environment, and around the link between the quality of foodstuffs and human health. Together, these lobbies have provided a brake on the previously unfettered influence of farm lobbies on governments. Therefore, while the percentage changes agreed to in the *Final Act* appear modest, especially when compared with total liberalisation of agricultural policies, these additional lobby groups may enable governments in the future to be more radical in disengaging from intervention in their respective agricultural sectors.

While it is obvious that farm lobbies remained powerful in the United States, the European Union and Japan, it is also obvious that public opinion had shifted during the course of the Round.

In addition to the Agreement on Agriculture, there will be other positive changes emerging for the conduct of agricultural trade. For example, the establishment of the World Trade Organisation and, with it, enhanced powers for the Dispute Settlements Procedures should have a substantial effect on governments which are reluctant to abide by the Articles as they affect agricultural policies. The experience with Dispute Panels which have been established to adjudicate in agricultural matters has been most unsatisfactory: sometimes clear-cut decisions have not been forthcoming and when they have been, governments have often ignored the ruling and continued with their illegal behaviour. Under the new procedure, an appeal is possible but, if that is lost, then adherence to the original decision of the Panel is required because the 'defendant' no longer has an effective power of veto.

After the Uruguay Round

The ratification of the *Final Act* ends one extremely important chapter in international trade negotiations on agricultural protectionism. The Uruguay Round was the first in which domestic agricultural policy instruments were subject to negotiation and effective bounds placed on the use of those instruments which distort international trade. Nevertheless, there remain a number of significant issues in agriculture that will have to be resolved.

First, agricultural protectionism has not been abandoned and once the percentage reductions are achieved by the year

2000, further changes in agricultural policies will be required. The forms of change will depend on the experience with decoupled income support, on the levels and volatility of prices in international markets, on the state of world food security, and on the continued influence, relative to that of the farm lobby, of those groups concerned with the issues of environment and of human health.

Moves towards free trade areas and other forms of trading blocs have now developed a momentum of their own.

Second, because there was concern at various stages throughout the Uruguay Round that the negotiations would fail, a number of countries moved to develop regional trading blocs as a form of insurance against failure of the multilateral trading system. These moves towards free trade areas and other forms of trading blocs have now developed a momentum of their own. As a consequence, the international trade patterns which are predicted on the basis of a less distorted multilateral trading system may prove to be distorted in different ways by regional trade groupings. Therefore, from the Australian perspective it is not yet obvious what may happen to exports of Australia's agricultural products to its developing markets in Asia and particularly those in the ASEAN countries.

Third, towards the end of the Round it became apparent that a coalition of environmental and development interests viewed the prospect of economic growth which is stimulated by international trade liberalisation as a bad outcome rather than a beneficial one. As a consequence, this coalition became hostile to the GATT and to its successor, the World Trade Organisation (WTO). However, as a number of economists have argued, the link between environment, environmental policy and trade policy is an extremely complex one and one which will only be handled successfully through a strong international institution such as the WTO. As far as agriculture is concerned, the reduction in farm-gate prices, which is brought about by lower levels of income support in the major regions of the United States and the European Union, will lead to less intensive forms of food and fibre production by making intensive agricultural technologies less profitable. Therefore, there will be gains in terms of reduced pressure on the rural environment.[3]

While the position in the industrialised countries is relatively clear, that in the developing world is more complicated. The complication arises because some countries tax the agricultural sector rather than subsidise it, thus breaking the link between international and domestic market prices. For these countries, changes in such policies are not covered by the outcome of the Uruguay Round. For the developing countries which subsidise agriculture, they will be bound by the

outcome of the Round but they will be given 10 years rather than six to make reductions by two-thirds of the rates applying in the developed economies.

Finally, there is the link between the liberalisation of agricultural trade and the state of food security in the developing countries. It is to be expected that reductions in farm income support will lead the major donors of food aid, namely, the United States and the European Union, to reduce their donations. At the same time, poor food-importing countries may lose from higher world prices, although the evidence from quantitative economic modelling is contradictory. In particular, since many of these countries tax rather than subsidise agriculture, this greater vulnerability to world market conditions may force policy changes which will lead to an increase in domestic production.

In these circumstances, the gains to agricultural research will be enhanced and it could be possible to persuade the developed and newly industrialising countries to contribute some of the budgetary savings from their reduced agricultural support to the additional funding of agricultural research in developing countries through the CGIAR system. Given long-run projections of world supply–demand balances for foodstuffs, such additional research will be crucial to ensuring food security through its effects on enhancing the rate of economic growth in the developing world.

Conclusion

The outcome of the Uruguay Round for agriculture was less dramatic in qualitative terms than had been proposed by the Cairns Group and the United States in 1987. However, in qualitative terms the outcome of the Round marks a turning point in the long post-war development of agricultural protectionism. Governments have at last signalled they accept that the status quo is no longer a feasible option. As a consequence, the mechanisms used to support farm incomes will change to ones which are less distorting of international markets, and those which continue will be used more sparingly, i.e. once reduced, they are bound against any increases. There will be gains in economic efficiency in all countries which have agreed to alter their agricultural policies.

The outcome of the Round marks a turning point in the long post-war development of agricultural protectionism.

Nevertheless, there remain some important issues which will require further analysis before solutions are forthcoming. These include: what will happen after the year 2000 when the transition to greater liberalisation is completed; the trade-and food-balance effects that will be generated by the newly forming trade blocs; the international actions which will be

Australia has an important part to play in providing scientific expertise and economic philosophy.

taken to ensure that trade policies are not used to pursue domestic environmental objectives; and the effect that reduced agricultural protectionism will have on world food security.

Of these four issues, in my opinion the last two are the most serious and will be the most difficult to solve. In the context of this seminar, the last is the most important and will only be solved through a combination of successful agricultural research in developing countries and through the implementation of sensible economic policies everywhere. In both of these elements, Australia has an important part to play in providing scientific expertise and economic philosophy.

End Notes

[1] ABARE 1994. World Commodity Markets and Trade. The Outlook Conference, Canberra, 1–3 February, p. 70.

[2] The difference between the Dunkel proposal and the Blair House Accord for the Australian farm sector has been estimated by agricultural economists at ABARE to amount to US$132m per annum.

[3] This was certainly one of the objectives for the reformed Common Agricultural Policy as of 1992 and it has become an increasingly important component of United States farm legislation.

DR LINDSAY FALVEY is an internationally known consultant across the fields of agriculture. He has previously been Managing Director of Coffey-MPW Pty Ltd and MPW Australia, at times when respectively they were the largest exporters of services from Australia and the fastest growing company of its type. He maintains active links with international agricultural research and agricultural industries in Australia, and was the recipient of the 1993 Award for Excellence in agricultural consulting from the Australian Association of Agricultural Consultants.

Benefits to Australian Industry from International Agricultural Research

LINDSAY FALVEY

AGRICULTURAL CONSULTANT

Australia's exports of agricultural produce now favour Asia, while exports to traditional markets have dropped significantly; for example, 45% of our agricultural exports were to Europe in the 1960s whereas this figure is now probably less than 25%. It is also noteworthy that while developing countries imported some 5.3 million tonnes of food in the period 1961–65, current trends suggest that this will rise to something like 80 million tonnes by the year 2000. The National Farmers' Federation puts Asia's share of world income at some 25% at present whereas it was around 14% in the 1960s and is expected to rise to 30–40% by the year 2010. Australian industry is focused on producing a profit and this is increasingly derived from Asia. But is this in response to simple market forces or is there a deeper understanding of the mechanisms of market creation?

Australian industry is enjoying an ongoing relationship with Asia. The recent euphoria over business opportunities in Asia is merely an acknowledgment of a trend that has been developing over a period of some 20 years. Our large companies such as BHP and CRA and hundreds of smaller companies have entered the market in response to normal business indicators. Agricultural companies have been among the foremost of these, and the views of industry on the merits of business transactions with Asia may well be: *We have been there years before the current political promotion of Australia in Asia.*

Agricultural Development and Market Opportunities

Industry decisions are based on clear commercial principles. In the agricultural field, there is a growing recognition of the

process of development and the principles leading to related commercial opportunities. Put simply, this means that expanding markets are a focus for private sector initiatives and that the opportunities they create are seen to be linked to economic progress. A smaller section of industry understands that the process involves development of agriculture itself as the first industry to provide an economic surplus as a basis for growth of other industries. They indeed see that *agriculture is the primary industry.*

Much agricultural investment and employment in Australia is in the processing sector. Thus off-shore involvement of Australia is also likely to include the processing sector.

One of the industries which succeeds primary agricultural production is food processing, which continues to be a semantic and investment anomaly when we talk of agricultural development. While in most developing countries agriculture accounts for between 40 and 80% of employment, much agricultural investment and employment in Australia is in the processing sector. Thus off-shore involvement of Australia is also likely to include the processing sector. Yet agricultural processing is often overlooked in discussions about international agricultural research and development.

We have not previously experienced the high and sustained economic growth that is occurring in Asia, and in recent times a growth that has occurred while some developed economies experience very low growth or even temporary economic contraction. The increases in demand associated with this growth are perhaps best understood by way of simple example: meat consumption in Taiwan increased some 500% between 1961 and 1981, causing an increase in demand for cereals for livestock consumption from 16 000 to 3.4 million tonnes (from 1% of cereals being used for livestock to 60%). Such rapid creation of markets for agricultural products is evident even to the least philosophical of exporters.

Crawford Fund publications and other authoritative sources note that *agriculture primes the pump* of economic development. This is obviously the case for some rapidly expanding economies. One with which I am particularly familiar is Thailand, where I worked for five years nearly 20 years ago and to where I have returned about every two months since for various business purposes. The Thailand of today is conspicuously different from that of 20 years ago—consolidation of small farms in some areas, foreign joint ventures in exotic crops and leadership in some horticultural fields are but part of a bountiful harvest of agricultural developments. At the same time a middle class has arisen with access to credit and an apparent consumption ethic which demands increasing quantities of, among other consumer goods, new food products appropriately packaged.

The Crawford Fund statement is obviously true in those countries with an agricultural resource; in Asia an interesting exception is Singapore with its service-based economy which is seen by Australian industry as a similar prospect for processed and fresh food exports. Perceiving Singapore as similar to other expanding Asian economies suggests that the sophistication of the viewpoint of industry may vary but that virtually all concerned players recognise the demand created by increasing affluence. It appears that only a small group recognises the linkages between agricultural development and market opportunities.

Only a small group recognises the linkages between agricultural development and market opportunities.

Changes in Industry Attitudes

Are attitudes in industry changing? I believe they are. About 10 years ago, I recall speaking to a service club meeting in a major Australian regional city about a dairy plant financed by Australian aid and managed by our company in what was then Burma. The audience was predominantly dairy farmers and dairy processing management whose questions focused on, from their viewpoint, the illogicality of assisting potential competitors. I believe if we went back to the same forum today, a wider discussion concerning the development of new markets would have replaced the assumptions of static economics.

Informed individuals in industry are keenly aware of the benefits accruing to Australia from international research in fields which relate to their own industries in Australia. Examples include advance knowledge of diseases that may affect our livestock and agricultural industries, the production of vaccines that are of wide commercial benefit including in Australia, new genetic material such as the pastures used extensively in our northern cattle industry, and the introduction of whole new industries such as the Australian chickpea industry. Australian-funded agricultural research assistance also generates goodwill toward Australia, which can provide the edge when competing with other developed countries for trade and investment access in expanding economies.

Estimates of direct benefits from agricultural aid to Australian suppliers are around 80% through the 1980s and in excess of 100% in the early 1990s. Trade benefits are evident in the opening up of new markets (as appears to have occurred after Australian aid provided wheat to Ethiopia, which had not previously purchased Australian wheat but which has subsequently done so, and in the Philippines where export of live cattle has followed their initial purchase through Australian aid).

Industry places importance on the linkages between aid and future commercial opportunities.

Opportunities from Aid Linkages

Industry places importance on the linkages between aid and future commercial opportunities. To approach expanding markets without prior introduction to their specific requirements and the culture of the country concerned is possible but requires a longer time-frame than the alternative approach of being introduced to the market through prior aid projects. Australia is highly regarded for its agricultural expertise and AIDAB quotes figures of 15–30% of its program being allocated to agriculture. However, there are indications that the proportion which industry would consider to be agriculture is in decline, despite meeting the combined aid objectives of assistance to the poorer sections of communities (who commonly live in rural areas) while creating commercial opportunities. This is a matter of concern to all of us.

Most of the world's poor, some 740 million of an estimated one billion, are in Asia despite the rapid development of the region. Sixty per cent of these live in ecologically sensitive rural areas where development is likely to be especially difficult—agricultural research is a clear need in association with agricultural development activities. Industry seems generally supportive of aid to the poor and feels that, where possible without comprising the intent of aid, it should also benefit Australian industry.

We are all aware that agricultural industries in Asia are in various stages of transition and one of the key requirements in this phase is new knowledge. Our own interests are obviously served by providing the assistance that these countries need at this time. The need appears to be for both agricultural research and development. The two are inextricably linked in my view and so should be in a number of aid initiatives. Our national expertise is in agricultural research and development and informed sections of industry seem to have the view that Australian aid should provide that expertise and focus on relevant activities at which we excel rather than competing with other aid donors for sometimes inadequately identified and routinely designed projects.

Optimising the Benefit

A number of reviews of our aid, two of which relate to agriculture, have been conducted over the past five years. The first concerned the success rate of agricultural projects in general and concluded that they were difficult to implement and for that reason may be less successful than some other project types. A major reason for the difficulties was given as inadequate knowledge of local conditions—surely we must see

this as an instance of the need to integrate research with development projects. I certainly lean more towards this reasoning than one of reducing investment in agriculture, which could be an alternative response to such a conclusion. There is scope here for all of us as research, industry and development specialists to jointly advise the aid program with the intent of improving the image and efficiency of agricultural aid. The second review, and one for which I must accept responsibility, concerned livestock aid projects and included in its conclusions the need for applied research as a phase for many technical development projects.

I have recently had the interesting task of reviewing agricultural research systems in developed countries for the World Bank. Certain trends common across these countries—such as requirements for increased fiscal efficiency and research linkages across national boundaries—are likely to become evident sooner or later in developing countries. Industry funding of research, which is well developed in Australia's agricultural research environment, is another trend that should extend to developing countries as government administrative systems improve. Such change is expected to increase the linkages between primary producers and processors and markets and to accelerate development. The majority of Australian industry is not aware of such longer-term ramifications and will probably remain focused on the foremost indicator of opportunity, purchasing power and other popular trade issues such as GATT.

Closer relations are necessary between industry and international aid administrators and researchers.

Closer relations are necessary between industry and international aid administrators and researchers. While industry overall has a rudimentary knowledge of the processes of market creation in the agricultural sector, development of a greater understanding should provide benefits of mutual advantage to international development and industry profits. A public relations exercise, perhaps managed by the Crawford Fund, would be an important first step in this exercise.

Environment

DR JIM RYAN is Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in south central India, after serving as Deputy Director of ACIAR. He has had a distinguished career as an economist specialising in tropical agriculture. After serving as a senior economist in the NSW Department of Agriculture, he worked extensively in various countries including India, Brazil and the USA. He was a member of the influential Technical Advisory Committee of the CGIAR, and has served on various other international institutions.

Developing Sustainable Farming Systems

J. G. Ryan

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

There are many concepts of what constitute 'sustainable farming systems'. The definition used for the purpose of this presentation is the one accepted by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR), which is:

> 'Successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources' (TAC 1989).

One measure of the adequacy of world food availability is to divide current total world food production by current total world human population. By this measure, the basic nutritional needs of humanity are being met.

However, we know that problems of poverty, distribution and local availability disrupt this calculation. We are also coming to realise that current agricultural production is having ever-increasing detrimental effects on the resource base of farming lands and the environment as a whole. As human population continues to grow, and with it food demands, pressures on this resource base can only increase.

Quite simply, food security remains a vital issue, particularly for hundreds of millions of poor in the developing countries of Asia and Africa. In addition, it is looming as a longer-term threat to all as a result of the effects of degradation of the natural resource base.

This presentation describes how the international agricultural research and development community is facing up to this challenge. It particularly focuses on Australia's current involvement in these concerns, as well as its potential

involvement in the future, highlighting some examples of particular relevance to Australian agriculture.

International Interventions in Agriculture

In the 1950s and 1960s the quantum shortfall in food production to meet the needs of the post-war population explosion was the main concern of those viewing agriculture from a global perspective. This prompted major international efforts, notably the development of international agricultural research centres (IARCs). These efforts led to the Green Revolution and the prevention of predicted famines during the 1970s and 1980s. Of course, instances of famine and malnutrition persisted, but reasons could largely be attributed to social upheavals and pervasive poverty, resulting in inadequate local production and/or distribution of foodstuffs.

In the 1990s, concerns of how to meet world food demands are again arising.

In the 1990s, concerns of how to meet world food demands are again arising, but this time from the following new perspectives:

- Despite declines in population growth rate in Asia, total population increases (even based on low growth rates) predicted for the turn of the century and beyond are truly alarming. In Africa, where growth rates remain high, the situation is even more perilous. Although the absolute numbers are small by Asian standards, by 2030 they may be more comparable.
- In well endowed lands as well as marginal lands, the rate of deterioration of the agricultural resource base has increased rapidly.

Evidence of resource-base deterioration is well documented. An example is the GLASOD (Global Assessment of Human-Induced Soil Degradation) map set produced by UNEP with Sutch collaboration. Particular problems are arising due to:

- increasing salinity and waterlogging problems in the major irrigation areas of Asia, which produce most of Asia's food;
- soil erosion and nutrient depletion in marginal rainfed lands;
- rapid environmental degradation in hilly areas, such as the Himalayan region and the African highlands;
- ever shorter clearing–regeneration cycles in traditional slash-and-burn agricultural systems; and
- desertification in Africa and elsewhere.

Such deterioration of agricultural lands is also readily visible in Australia as desertification of marginal areas, soil erosion, salinisation and (more recently) acidification.

Australia and the Newly Emerging Scenario

An inadequate international response to the looming threats to food security and poverty alleviation arising from problems in the food production/environment protection nexus must inevitably lead to social upheaval. In an ever-shrinking world due to the communication revolution, Australia cannot hope to remain immune from these upheavals, especially as the areas most likely to be affected (in Asia and Africa) are in relatively close proximity to Australia.

Thus a concerted international effort to develop and implement sustainable farming systems in Asia and Africa is in Australia's interest from this perspective at least. Broader issues of social justice, humanitarianism, and equity would also encourage an Australian involvement in action to provide improved food security internationally.

Furthermore, if an international response does successfully address these problems, then those nations taking a high profile in this response are those most likely to reap the commercial advantages of sustained agricultural development, and of the consequent flow-on to other development activities, in Asia and Africa in particular.

It is important for Australia to recognise that involvement in such international efforts permits first-hand access to relevant technologies and expertise that may prove useful when tackling the challenges of developing sustainable farming systems at home. Such technologies may supplement or even supersede those currently in practice in Australia.

It is important for Australia to recognise that involvement in international efforts permits first-hand access to relevant technologies and expertise.

This involvement also permits first-hand access to the markets where new development is occurring, a concept well understood by countries such as Japan, and one that needs to be appreciated more clearly in Australia. Simply put, you have to 'be in it to win it'.

Particular advantages of a strong involvement in international efforts to develop sustainable farming systems include:

- a broadened perspective for Australian scientists and other professionals in agriculture, which feeds back into innovation in Australian agriculture;
- exploitation of educational and consultancy services offered from Australia;
- development of professional and personal linkages, which impact creatively on Australia's international relations in the longer term;
- a broadened industry perspective.

The huge potential in Asian markets for the products of Australia's temperate agriculture has hardly been tapped.

Australian agriculture is highly export-oriented, but on a relatively narrow commodity base. Greater knowledge of trends in international agriculture leads to better understanding of the markets and ability to adjust to new opportunities. For example, the huge potential in Asian markets for the products of Australia's temperate agriculture, including out-of-season and niche markets, has hardly been tapped.

Australia already benefits from these effects in its economy, as a direct flow-on from the internationalisation of its agricultural research efforts. The potential to capture additional benefits, directly to Australian agriculture and indirectly to Australian business and the general community, is huge.

Potential for Synergistic Australia–IARC Interaction

There are many examples of the mutual benefits derived from interaction between agricultural research conducted in Australia and that conducted through bilateral programs, UN agencies or IARCs. Time will not permit a fair sampling of past achievements in this presentation, but a flavour of these is given as follows.

- The facilitation of germplasm acquisition to Australia of IARC-mandated plant species of agricultural importance, including:
  - —tropical forage and pasture legumes from South America through CIAT
  - —semi-dwarf wheats from North America through CIMMYT
  - —chickpea from South Asia through ICRISAT.
- The linkages formed between ACIAR and national and international programs to improve tropical grain legumes in Southeast Asia.
- Physiological and adaptation studies on wheat, collaboratively undertaken by Australian scientists and CIMMYT.
- The numerous interactions between Australian researchers and IRRI scientists aimed at rice improvement in Australia and elsewhere.
- Pasture and livestock projects in China and India, especially aimed at degraded lands.
- Introduction of mechanised agriculture developed in Australia for marginal Mediterranean iso-environments of North Africa.
- An ACIAR project on cropping system sustainability in Kenya.

Land Resource Deterioration

There are many examples of research relevant to the development of sustainable farming systems that have potential for significant collaboration between Australia and the international agricultural research organisations.

One of the most important problems is land degradation, in particular desertification. As defined in UNCED's Agenda 21, desertification is:

> 'Land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities'.

Of the various threats to the sustainability of the physical resource base, the loss of topsoil through erosion—by both wind and water—is probably the single most important. According to the United Nations Environment Programme (UNEP), 3.6 billion ha, or 70% of the world's potentially productive drylands, are currently threatened by desertification.

In Africa, a population of about 400 million, two-thirds of all Africans, inhabit agroclimatic zones consisting of 1.3 billion ha of arid, semi-arid, and dry sub-humid areas. Recurrent droughts are a permanent fact of life throughout these drylands. Other problems contributing to desertification include uncontrolled population growth, inadequate soil and crop management practices, multiplication of livestock beyond the carrying capacity of natural rangelands, and deforestation.

Like Africa, Australia has extensive areas of arid, semi-arid and dry–humid lands. Significant areas have experienced some form of degradation during the past 200 years, the result of imposing essentially European agricultural systems on a fragile resource base. The effects of this imposition have varied, reflecting various climatic and socioeconomic factors. The problem in Australia may not be so much one of loss of productive land, but rather one of reduced productivity of marginal lands that have been degraded.

The problem in Australia may not be so much one of loss of productive land, but rather one of reduced productivity of marginal lands that have been degraded.

ICRISAT is taking a leadership role, together with its sister centre ICRAF, the International Centre for Research on Agroforestry, in the development and implementation of a Desert Margins Initiative. Relating primarily to sub-Saharan Africa, but also including the desert margins of Asia, the Initiative also involves several other CGIAR Centres in a collaborative venture with international, regional, and national institutions.

Some of the major objectives addressed by the Initiative are to:

- combat desertification;

- mitigate global warming;
- conserve biodiversity; and
- provide increased food security.

These objectives will be achieved by promoting improved and innovative crop/tree/livestock production technologies that are ecologically sound, economically viable, sustainable, and culturally acceptable. Specific outputs will include:

- provision of food, fodder, and fuel for the indigenous population, thus enhancing the quality of life while arresting deforestation;
- development of strategies to cope with climatic changes;
- improvement of climate and crop monitoring methods and data collection;
- better awareness among policymakers, the scientific community and farmers of the likely effects of climatic change and the need to preserve biodiversity;
- establishment of a cadre of skilled scientists to ensure the sustainability of the initiative;
- guidelines for the design and implementation of policies that encourage farmers to adopt sound technologies;
- better appreciation of the need for meteorologists, agriculturalists and farmers to work together to address the problems of the desert margins.

Land management in Australia is focused on a mix of policy mechanisms to achieve ecologically sustainable management of natural resources, including land, water, vegetation and nature conservation. This is set against a background of applicable institutional arrangements, land tenure, and social and economic conditions.

Resource management problems, meanwhile, are addressed through the cooperative action of Government, private landholders, and the community. Approaches seek to integrate economic and environmental objectives with the aim of achieving ecologically sustainable development across the continent as a whole.

Australian participation in the Desert Margins Initiative could provide new insights for Australia's Landcare program.

The 'Landcare' movement is the centrepiece of this process. I believe that Australia's success in achieving the sustainable management of its resources can provide valuable insights for other parts of the world. Similarly, Australian participation in the Desert Margins Initiative could provide new insights for Australia's Landcare program.

Modeling of Agricultural Systems

Mathematical models play an increasingly important role in agricultural research. The relationships between the different

components of agricultural systems are far too complex for simple 'intuitive' or conceptual models. Through mathematical or simulation modeling, it is possible to quantify the major variables and processes that determine the dynamics of an agricultural system in a physically and biologically meaningful way, and to describe the interactions between these factors and processes.

Modeling is an important tool in developing sustainable agricultural systems, some of which may be less dependent than traditional systems on external inputs such as chemical fertilisers, fossil fuels, and pesticides.

Australia, which long ago recognised the importance of simulation modeling in agricultural research, has developed considerable expertise in the field. The Agricultural Production Systems Research Unit (APSRU) in Toowoomba, which is a cooperative venture between the Queensland Department of Primary Industries (QDPI) and the Division of Tropical Crops and Pastures of CSIRO, is among the world's leading groups in the field of modeling of agricultural systems.

Australia, which long ago recognised the importance of simulation modeling in agricultural research, has developed considerable expertise in the field.

For the past six years, ICRISAT has cooperated closely with QDPI in a project aimed at arresting soil erosion in the light-textured soils of the Indian semi-arid tropics. This cooperative project has resulted in important information on the factors that cause soil erosion and on ways of preventing erosion through vegetative covers, porous barriers such as vetiver grass hedges, soil cultivation, and soil amendments such as crop residues.

The results of field experiments in India have been used to calibrate and validate a simulation model for soil erosion. The model, which is known by its acronym PERFECT, was developed by scientists at QDPI. This model was designed primarily for the semi-arid environment of Queensland, but turned out to work very well under the semi-arid conditions of India as well.

The results of this cooperative project not only benefited ICRISAT and the Indian national programs, but also the Australian scientists involved. The testing of simulation models under a wide range of environmental and geographical conditions increased the precision and value of these models for application under Australian conditions.

In addition, although the Australian scientists were exposed to environmental conditions with which they were quite familiar, the socioeconomic conditions they encountered were utterly new to them. Dealing with completely different farming systems in a climatically familiar environment broadened the scientific horizons of all the scientists involved in the project.

Legumes in Farming Systems

The role of legumes in contributing to the sustainability of cropping systems is well documented. The ability of legumes to fix atmospheric nitrogen is perhaps the most important quality, but many other positive effects are also significant.

Australia has long used legumes in its relatively low-input, extensive agriculture, from the 'sub and super' technology right through to the current expansion in cultivation of grain legumes (e.g., lupin, chickpea). Most cultivated legumes grown in Australia are exotic, and additional germplasm acquisitions must be imported.

Access to a wide range of germplasm is fundamental to any crop improvement effort. Now that many countries around the world are beginning to assert sovereignty over their native germplasm resources, the presence of international institutes maintaining world collections of the seeds of cultivated species held in trust becomes crucial to the free flow of germplasm across national borders.

Australia has been a leader in biological nitrogen fixation (BNF) research and rhizobium inoculation technology. This knowledge has been widely disseminated, with the assistance of the IARCs. However, valid technology for Australia does not always work adequately in other environments. There is now a two-way exchange in progress between Australia and international BNF researchers, giving benefits to both parties.

Drought is a major factor determining sustainability of rainfed cropping systems, and is a particularly important determinant of crop yields in Australia. There is well-established, ongoing and promising collaboration in drought research between Australian and IARC scientists, with studies ranging from agroclimatic analysis of drought-prone environments to identification of drought-resistant crop genotypes.

Australian scientists are keen participants in a global grain legumes drought research network.

A good example is an ACIAR project, conducted jointly with the Government of India and ICRISAT, aimed at improving the water-use efficiency of peanut. Also, Australian scientists are keen participants in a global grain legumes drought research network, coordinated by ICRISAT and ICARDA.

Australian, Indian, and ICRISAT researchers are collaborating on specific challenges of common interest with regard to improving sorghum in the semi-arid tropics. The parties to such partnerships can only gain from these endeavours to ensure rapid, frequent and free exchange of information in this research area.

Another example of direct benefits to Australia derived through close contacts with IARCs is the acquisition of very

promising chickpea lines introduced for cultivation in Western Australia. These lines were selected for cold tolerance by ICRISAT scientists in northern India and ICARDA scientists in Syria.

Chickpea is a crop of great potential for the wheat belt of Australia. While offering a promising and profitable alternative to cereals, it can also help restore the nitrogen economy of degraded wheatlands. The crop's ability to utilise otherwise unavailable phosphorus at depth offers substantial savings for farmers, and attendant benefits to soil structure.

Food legumes, or pulses as they are called in Asia, seem to be favoured as much by insects as they are by the vegetarians of South Asia. Integrated pest management, or IPM, offers considerable promise as a cost-effective and environmentally friendly way of alleviating constraints to enhanced productivity of pulses. Australia's long history of successes with biological control methods, such as its prickly pear research, puts it in a good position to significantly contribute to the world body of knowledge in the fight against insect pests. ACIAR has a major biological control program, a key weapon in IPM.

Australia is in a good position to significantly contribute to the world body of knowledge in the fight against insect pests.

Another IPM initiative involves three collaborating partners—ICRISAT, the Natural Resources Institute in the UK, and the cotton industry in Australia. The three partners are working together to determine the extent of resistance to insecticides of the number one insect pest of both cotton and pulses, the pod fly. IPM strategies are being designed that involve a more judicious and strategic use of new insecticides to prevent further development of resistance by the insect. Success in this project would clearly be of huge benefit to many countries.

Phosphorus

A workshop held at the ICRISAT Asia Centre in Hyderabad in March of this year indicated possible ways to internationalise future research on problems of global importance. This workshop aimed at developing a global project to exploit recent advances in knowledge of plant nutrition and molecular biology to most efficiently use phosphorus in cropping systems.

It was sponsored by ICRISAT, FAO and IAEA, and Australian scientists strongly participated. A pathway was charted towards developing a global consortium of scientists to tackle a global problem at the heart of sustainable agriculture; namely phosphorus management.

Australian scientists, as important contributors to this effort, can expect to gain from external funding for their research and ready access to latest research on phosphorus cycling in cropping systems. And Australian industry will reap the benefits of the improved technologies arising from this research internationally. Everyone will win!

Time constraints prevent me from citing numerous other opportunities for Australian participation in the global challenge to develop sustainable farming systems. There are many such examples of Australia's comparative advantage as an effective participant. Australia would, therefore, be at or near the head of the queue to capture the resultant benefits.

Conclusion

Without continual international transfusions of genetic resources and scientific technology, Australian agriculture may simply not be sustainable.

In simple terms, Australia can ill afford not to be an active player in international agricultural research.

In the GATT era, agriculture will be increasingly internationalised. And in a world ever more concerned with environmental pollution and degradation, we can expect significant market volatility driven by consumer demands for safe and reliable foods. At the same time, consumers and policymakers will seek a global agriculture that both sustains the environment and conserves biodiversity.

The implications of these developments for the Australian economy are quite basic and far-reaching. They involve policy adjustments, and real commercial opportunities will arise from special advantages (such as marketing 'Australia Clean' food). In addition, substantial technical and industrial challenges will need to be resolved in order to sustain the natural resource base and provide increased productivity.

International agriculture is intensely competitive. So far, Australia has had success with its exports largely because they are high-technology products designed to reliably supply an acceptable quality at a competitive price. This is possible only because of the technology built into those products. To maintain that competitive edge and comparative advantage, while at the same time sustaining the natural resource base, Australia must strive to continue to improve its technology and its management systems.

Sustained and well-targeted research is a basic requirement for this objective. Australia is recognised internationally for its contributions to agricultural research. Our country's agriculture, however, is based very largely on exotic species, fragile land systems, and low-fertility soils. The truth is that without continual international transfusions of genetic resources and

scientific technology, Australian agriculture may simply not be sustainable.

The exchange of international research, from which Australia has already received significant benefits, is crucial in view of the looming threats to global food security. It is therefore very much in Australia's interest to continue to support a strong international agricultural research capability.

Dr Ann Hamblin is Vice Chair of the International Board for Soil Research and Management in Thailand. She works in Australia at the Bureau of Resource Sciences, and was closely involved with the development of the government's Ecologically Sustainable Development strategy. She has recently completed the task of chairing an expert group to develop indicators of agricultural sustainability for Australia and New Zealand, which has generated much international interest.

Saving the Soil

ANN HAMBLIN

INTERNATIONAL BOARD FOR SOIL RESEARCH AND MANAGEMENT (IBSRAM) THAILAND

Land or Soil? That is the question! Soil has never been a sexy subject in science or in commerce, but *land*—the larger-scale spatial extension of soil—is a different matter. Whether it is as the territorial expression of nationalism, or in the identification of landowners as the ruling class, or in using 'new land' development to fuel the engine of economic growth, land has always represented the most basic form of power, wealth and belonging.

It is therefore ironic that governments and investors have proved hard to convince that investment in R & D for soil and land management should be taken seriously. Perhaps we did indeed need the paradigm shift which has only been seriously articulated in the last few years by the politicising of 'sustainable development' through Agenda 21 to realise the truth of the old Yankee saying 'Put yer money in land lad, they aint making any more of that stuff'.

More seriously, we have to recognise that adverse changes to land have long-lasting, financially as well as physically, harmful effects. While we are all able to recognise this when viewing the historical deforestation or salinisation of the eastern Mediterranean or Mesopotamia, it is harder to accept that we are involved in the same processes today through our inability to balance long-term needs against short-term gains.

- One of the problems scientists have in convincing policy makers of the need for such investment is the long-term nature of change in land-related properties, compared with the short-term financial and political goals of modern societies.

Successful application of soil research to 'saving the soil' *has* provided agronomists and farm managers with well-tested management practices that ensure sustainable farming systems by:

- using crop and pasture rotations, retaining surface residues, minimising cultivation, using alley and shelter-crop systems, and the like.

However, cynics may feel there is a credibility gap between the claims of scientists and the catalogue of land degradation ills that are documented for many parts of both the industrialised and developing world.

Compared with the obvious achievements to food production that have occurred through applying the findings of soil chemistry via the continuing expansion of the world fertiliser industry, or the application of civil engineering to irrigation and dam construction securing food supplies in many of the semi-arid and arid regions, the achievements of natural resource scientists in obtaining sustainable land management and minimising soil loss appear small.

It is now common in high-income countries to criticise the widespread heavy use of fertilisers and irrigation in developing countries' food production. However, real criticism should be confined to inefficiencies of use, through government policies of inappropriate subsidisation, rather than to the use of such inputs. Without their use, there would be no luxury of adequate food supply for the majority of the world's population today, or in the future.

Criticism and concern for excessive use leading to eutrophic waterways, rising ground waters and salinisation are justified.

Nevertheless, criticism and concern for excessive use leading to eutrophic waterways, rising ground waters and salinisation are justified.

- Much of the value of Australian-aided scientific work in this area is directed to identifying appropriate management systems to correct historical forms of land and water deterioration, which stem from exploitive and overly optimistic past attitudes on the inexhaustibility of land area and capacity.

The Socio-political Dimension

Experience in Australia, just as much as in developing countries, has also taught us that it is very difficult to implement good management practices effectively across whole rural communities and landscapes, rather than just among small groups of leading farmers.

- Movements such as 'Landcare' in Australia, or farmer cooperatives and grower associations in many countries, reflect the efforts of rural communities and governments to provide farmers with the organisational and informational tools they need to manage their land and production sustainably.

Farming systems are the product of socioeconomic as well as technological and biophysical factors, and the units of production are small, dispersed, mainly family groupings widely varying in literacy and skills, goals and perceptions.

- The recent spate of discussion papers assessing the sustainability of agriculture in various parts of the world has recognised the influence of the policy framework, the infrastructural status, social groupings and economic system of each region to a far greater extent than earlier discussions which focused largely on how to raise productivity by technical means.

One of the most active groups in appraising the measures needed to achieve more integration between rural industries and the environment has been that bastion of economic rectitude, the OECD. Spurred on by the implications of the changes which the new GATT agreements will bring to European and North American agriculture, and faced with the costs which subsidising over-production has brought to urban communities and the environment, OECD working groups on agriculture and the environment have been energetically seeking ways to match rural landscape preservation with production.

New Ways of Doing Business

The international scientific community has also energetically developed a number of conceptual frameworks to assess and monitor whether land management systems are more or less sustainable.

- In many instances, they are finding that we simply do not know whether a particular practice is safe, maintains soil and water quality or has undesired side-effects, because the system has not been in operation for sufficient time.

Providing farming systems that are both productive and sustainable appears to be a complex and challenging task.

Providing farming systems that are both productive and sustainable appears to be a complex and challenging task.

Do we have the right structures, methods and people to succeed? In common with many of our developing country neighbours, Australia has been reassessing the status of rural soils and water in recent years and, in view of the catalogue of severe land degradation and water quality problems, has developed significant Federal and State programs for tackling these issues.

Although 'Landcare' is probably the most widely known, other government-backed schemes such as vegetation replanting schemes, legislation to control clearing, national strategies for improved water quality, the formation of the

Internationally, Australian scientists have been active in developing new initiatives towards landcare.

Murray–Darling Basin Commission, all reflect a strong commitment to redressing the damage done.

- Internationally, Australian scientists have been equally active in developing new initiatives towards landcare. Some years ago an International Board for Soil Research and Management (IBSRAM) was established largely through Australian initiative.

This CGIAR-affiliated organisation has its headquarters in Thailand, and uses a *network approach* to test and implement the principles of sustainable soil management in some 22 developing countries of the Asia–Pacific and sub-Saharan African regions. Its work complements the research and development done by the International Agricultural 'Regional' Centres such as ICRISAT, ICARDA and CIAT, by using coordinators to liaise between national agricultural agencies and the international scientific community. Common experiments, testing principles and processes of soil management are interpreted to suit local cultural and environmental conditions, and experimental results are then pooled and compared among the collaborators.

Successes from Forming International Networks

One of the great advantages that Australia has over other developed countries working in soil and land management with the tropical and subtropical regions is the similarity of our home environment with theirs. Most of Australia's rural industries are carried out in similar climates, characterised by erratic rainfall, risk of drought and erosion, and using similarly old, fragile and infertile soils. This has produced a close understanding between resource scientists and government agencies who understand each other and have common goals.

By using collaborators in developing countries Australia is able to take advantage of a range of low-cost, well-run experimental sites that greatly augment the information we can gain from higher-cost field research in Australia. The feedback of information and techniques to Australian land managers is much faster than it would otherwise be, because results can be verified over many site-years. These are the indirect benefits from such investment.

Using this method Australian scientists have tested the effectiveness of small amounts of soil amendments such as lime, in combination with residue retention and low-level fertiliser additions to slow or halt acidification in wet environments in Asia and Africa. Australia's low-input agriculture is in

fact little different to the *low-input* farming found in much of upland Asia and Africa in terms of tillage, fertiliser and agro-chemicals.

Direct benefits can occur through 'serendipity' situations as the following shows.

- ACIAR has supported research aimed at halting the drop in ground-waters in northern China that has occurred through tube-well pumping for irrigated fruit trees. Deliberate under-irrigation combined with denser stands prunes the root system. While up to 80% savings on water consumption have been achieved in China, an unlooked-for benefit has occurred in Australian fruit production as well. The same technique applied in Victoria has worked to reduce rising saline groundwaters in the Shepparton district. The quantity and quality of fruit has not been affected—if anything, it has increased.

In other instances the return to Australia has been more dispersed, but still direct benefit.

- Salt presently affects over 1.5 million ha of agricultural land in Australia and the area affected is found larger after every survey. (This is a relatively small problem compared with countries such as Pakistan and Thailand with 6 and 3 million ha of salted land, respectively.) Western Australian research on salt-tolerant shrubs, such as the saltbush *Atriplex*, has been mutually beneficial to both Australian and Asian rural development programs, through screening and testing superior performing lines in the severity of Asian environments.

Western Australian research on salt-tolerant shrubs has been mutually beneficial to both Australian and Asian rural development programs.

- These shrubs have an important role for stock grazing. Forage shrubs and trees also provide much-needed fuelwood, household timber and shade in developing countries. In an recent study in Western Australia the financial benefit from using saltbush for feed during periods of low pasture production has been demonstrated with a bio-economic model to be highly profitable on a whole-farm basis.

An IBSRAM-coordinated network operating in Asia has been developing systems of sustainable land management for steeply sloping lands—those that are somewhat euphemistically termed 'less-favoured'. Such lands are coming under increasing environmental pressure from expansion of rural populations into previously uncultivated regions. They include steeply sloping, rocky hillsides, highly leached, acidifying soils in very wet regions, and black-clay soil lands which have been traditionally too heavy to cultivate easily.

The principles of how to manage steeply sloping land are clear.

The principles of how to manage steeply sloping land are clear; they should always have a vegetative cover, be cultivated across slope not up and down, have some form of terracing or drainage to remove excess water, and be planted to perennial tree crops.

This sounds fine, but is not easy to implement when food crops such as maize yield a higher short-term profit, and when weeds threaten to smother all perennial crops. Contouring and terracing are very labour-intensive and have no immediate financial gain. The solutions tested by the IBSRAM network are to identify plant species that can be used as vegetative contours, trapping any soil between the strips, but providing some form of additional income.

The key to success is to find the right species to act as hedgerows or contour banks. IBSRAM's experience is that farmers, working with local agricultural agencies and international scientists, find the right types together better than any one group working alone.

This network has has some significant successes in adoption. Farmers in Loudian province of southwest China, where rocky slopes comprise over 80% of the land surface, have adopted a strip cropping pattern of improved land-use in which maize is grown on small patches of hillside between hedges of a cane-bearing legume shrub, that can be used for basket manufacture as well as forage. This has proved popular with village women as a supplementary source of income. There are 30 million rural people in this province of China alone. The impact of such a change in land-use in the upstream portion of catchments potentially may have profound effect downstream in the crowded floodplains.

The same principle of stabilising the upper reaches of catchments so that the lower reaches remain environmentally intact is also being promoted in Australia, through such initiatives as Total Catchment Management, and the activities of the Murray–Darling Basin Commission. The technical expertise gained in controlling the highly erosive, rapidly degrading environments in Africa, Asia and Latin America through the cross-fertilisation of scientists' expertise is paying off in developing better management systems to conserve and restore our rural resources.

This two-way channel of technical communication can also be a valuable conduit to the introduction of small-scale technological products suited to the Asian or African small-holding operation. Examples from existing ACIAR-supported projects include introduction of sulfur-coated fertilisers for use in sulfur-deficient soils in Southeast Asia, through a process

developed in the University of New England, and the development of small-scale tillage implements for cropland surface management in semi-arid areas, through collaboration between ICRISAT and Australian groups.

When we consider the effort which has already been undertaken by the international research organisations to develop diplomatic links with their host countries, this valuable source of local knowledge of rural conditions should not be overlooked by potential Australian investing interests.

The Last Word

With increasing life-expectancy and a maturing political identity Australians should extend their investment horizons to match the long-term nature of the benefits that accrue from supporting international agricultural research.

Australians should extend their investment horizons to match the long-term nature of the benefits from supporting international agricultural research.

DAVID CONSTABLE is a former chairman of Victoria's Rivers and Water Supply Commission and General Manager of its successor body, the Rural Water Commission. In 1987 he was appointed as inaugural Director of the Centre for International Irrigation Training and Research at the University of Melbourne. He is also a Vice President Honoraire of the International Commission on Irrigation and Drainage and a Senior Consultant for the International Irrigation Management Institute and the World Bank.

Water Rights—And Wrongs

David Constable

International Irrigation Management Institute (IIMI), Sri Lanka

Water pervades all aspects of human life—fresh water resources are an essential component of the earth's hydrosphere and an indispensable part of the world's ecosystems. The availability of adequate water and food remains a fundamental issue in addressing world population and environmental security.

These fundamental elements of food and water are brought together in irrigated agriculture, which on a global scale uses more than 85% of the water extracted from surface sources.

There have been substantial achievements following concerted efforts in agricultural research and development over the 30 years or so to the early 1980s, which have been largely responsible for achievement of a rough balance in food production and population growth on a global basis, setting aside another critical issue in regional poverty for the moment.

However, in looking at 'Water Rights' and 'Wrongs', we are now facing a situation where on the one hand, there are few countries in the world where there is a clearly defined framework for the identification and management of individual and community water rights, and on the other, in most countries, developed and developing alike, the 'wrongs' in terms of resource degradation are becoming increasingly evident.

Processes to fix the rights and right the wrongs are now seen as emerging priorities, and should attract the interest and involvement of agricultural water-users and policy-makers.

Within Australia, major irrigation development had largely been completed by 1970, and research and management efforts over the last 25 years have been directed towards improving the performance of irrigated agriculture, and 'righting the wrongs'. There is a large reservoir of knowledge and expertise

being built up within Australia, which is now relevant to many other countries.

Challenge for Irrigated Agriculture

By 1980, 55% of the world's total food grain production was achieved under irrigation, and despite a slowdown in the expansion of irrigated area, FAO predictions are that this percentage will rise to some 65% by the year 2000.

By the year 2025, the irrigated areas of the world will need to contribute 80% of the necessary incremental food output over 1990 levels.

Looking further ahead, by the year 2025, the irrigated areas of the world will need to contribute 80% of the necessary incremental food output over 1990 levels, based on the demands of a world population firmly predicted to be some 8000 million.

The demographic changes associated with this population growth, involving increased urbanisation and industrialisation, will increase competition for available water supplies and create additional potential for environmental degradation.

It remains a sobering recognition that a significant proportion of irrigated agriculture development to date has not delivered all of the anticipated benefits, despite some spectacular advances in research into plant breeding and crop management. In some areas, the incidence of waterlogging and salinisation of lands poses a threat to future productivity and environmental balance.

Irrigated agriculture is a complex undertaking, involving interactions between farmers and professionals representing a number of disciplines and technologies, of which agricultural science and engineering are significant ones. Intervention by governments has been essential to initiate large irrigation development projects, because of the necessity to mobilise the financial resources involved, together with the physical resources of land and water.

Traditionally, water supply systems supplying services to agricultural users have been managed by government agencies. In many cases responsibility for managing inputs to the farm production system on the one hand, and the water supply system on the other, has been in separate Ministerial areas, further adding to the difficulties in developing integrated research and development thrusts. As early as 1980, the International Commission on Irrigation and Drainage (ICID) and the World Bank recognised that existing institutional deficiencies in water supply system management would inhibit overall project performance, and were largely instrumental in the establishment of the International Irrigation Management Institute (IIMI) in 1984, with a charter to carry out research for improvement in irrigation system management.

The clear challenge for irrigated agriculture is to increase overall production, without significant increase in available agricultural land, and with reduced water use.

The circumstances giving rise to this challenge formed part of the background against which the U.N. Conference on Environment and Development (UNCED) was held. The outcomes from UNCED outline future development requirements.

Irrigated agriculture must increase overall production, without significant increase in available agricultural land, and with reduced water use.

What Are the World Needs?

The guidelines and philosophies for future development strategies to provide adequate food and water for increasing populations without creating long-term environmental degradation are expounded in the UNCED Report–Agenda 21–Chapter 18 (Freshwater Resources).

The development of future programs must lie within an integrated approach to water resources management, based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good.

Such integrated water resources management, including the integration of land and water related aspects, should be carried out at the level of the catchment basin or sub-basin, with pursuit of four principal objectives:

(a) to promote a dynamic, interactive, iterative and multisectoral approach to water resources management that integrates technological, socioeconomic, environmental and human health considerations;

(b) to plan for the sustainable and rational utilisation, protection, conservation and management of water resources based on community needs and priorities within the framework of national economic development policy;

(c) to design, implement and evaluate projects and programs that are both economically efficient and socially appropriate, based on an approach of full public participation in water management policy-making and decision-making;

(d) to identify and strengthen the appropriate institutional, legal and financial mechanisms to ensure that water policy and its implementation are a catalyst for sustainable social progress and economic growth.

In pursuit of those objectives, development programs will have seven priority thrusts.

1. Integrated water resources development

- Institutional strengthening, improved national policy formulation

- The creation of 'enabling environments', with changes in legal, administrative and institutional processes
- Increased training and development of human resources

2. Improved water resources assessment

- Surface and ground water

3. Protection of water quality and ecosystems

- Integration of measures for protection of existing and potential water supply sources
- Prevention of future pollution
- Abatement of existing pollution where feasible

4. Drinking water supply and sanitation

- Accelerated programs to provide minimum standards of water supply and sanitation in developing countries.

5. Water and sustainable urban development

- Water supply, waste water treatment, pollution control

6. Water for sustainable food production and rural development

- Major challenge to increase efficiency of water use and increase food production

7. Impacts of climate change

- Accelerated research programs to overcome the current uncertainties

Implementation and management of projects and the delivery of services should be carried out at the lowest appropriate level.

Implementation and management of projects and the delivery of services should be carried out at the lowest appropriate level, and a concentrated effort in building up the community capacity to do this will be required.

Such capacity building is required at four levels:

1. Sector level

- National water resource assessment
- Policy and development planning, administrative structures, water law

2. Institution level

- Integrated resources management
- Strategy and program coordination

3. Individual Agency/Community Level

- Development of managerial competence
- Integrated policy, planning, management and budgetary control processes
- Creation of organisational environment to optimise use of collective skills of individuals

4. Individual Level

- Increase skills and competence of individuals
- Provide for personal development

What Does Australia Have To Offer?

Firstly, Australia has a range and depth of experience from our own development patterns probably unequalled in the world. In the driest continent on earth, there have been national imperatives that strengthened our research capacity and institutional development over a relatively short period, just on 100 years, for example, from initial irrigation developments to a fully mature water economy by the early 1970s.

Australia has a range and depth of experience from our own development patterns probably unequalled in the world.

This development pattern has had the following features.

- An initial phase of private development with limited success
- A following period of some 70 years of reconstruction and extension of irrigation infrastructure by relatively strong and technically competent agencies at the State level
- The introduction of intensive agriculture guided by national research capacity provided by CSIRO, the universities, State agricultural departments and agro-industries, in the absence of indigenous agricultural development
- A strong legal and regulatory basis for water resources assessment
- A strong legislative basis for the allocation and administration of Water Rights
- A strong legislative basis for the establishment and regulation of local water authorities

These are some of the 'rights' which have provided a legacy of knowledge, experience and expertise in research, extension and operational management.

However, it is also the experience of the last 25 years in attempting to 'right the wrongs' from the sometimes bitter experiences in terms of the impact of that development on land and water resources and the associated ecosystems, that provides Australia with a further reservoir of research expertise and talents relevant to the needs of the developing world.

This is best exemplified by the nationally coordinated research programs in developing future management strategies in the Murray–Darling Basin in south-eastern Australia, in extent the fourth largest river system in the world and underlain by one of the most complex hydrogeological systems on earth.

Some of the research techniques and outcomes, and the institutional arrangements for community participation in strategy development and program implementation have

already had application by IIMI in salinity mitigation programs in the Indus Basin in Pakistan, and have attracted interest for potential in addressing environmental concerns associated with the Aral Sea problem in Central Asia, and the Mekong Basin, among others.

Australian strengths include innovative applied research programs leading to high levels of field performance.

Other Australian strengths include:

- innovative applied research programs within irrigation agencies leading to high levels of field performance in terms of regulation, control and measurement of water;
- development of financial management strategies for improved asset management in irrigation systems;
- research and implementation of measures for cost recovery from water users, both urban and rural, recognising water as a social and economic good;
- measures for the further devolution of management control of water supply systems to local and regional communities, including irrigation farmers;
- review of Water Legislation to reflect modern trends in resources management and agency accountability;
- the development of market mechanisms for the transferability of Water Rights, and supporting legislation;
- the development of a comprehensive approach to improving managerial and technical skills in the water industry.

On this latter point, Australia was the only country identified in international conferences as part of the UNCED process to have developed training programs based on National Assessments of Training Needs.

The Australian experience has already figured largely in the development of World Bank technical manuals for guidelines for strategy development in the management, operation and maintenance of irrigation systems, and for training programs in irrigation agencies.

Support for International Research: What is Australia's Gain?

In irrigation management much of the research is site- and system-specific. However, technology adaptation and transfer are important elements in the development process. To this end, the World Bank and ICID in 1990 initiated the International Program in Technology Research in Irrigation and Drainage (IPTRID), which encourages collaborative action among developing countries, donors and research institutions in the assessment, formulation, implementation and monitoring of priority research projects.

Indeed, during its own post-war development period in the 1950s and 1960s Australia has probably gained a great deal more from international research, and from the interaction of researchers and professionals in international associations, than it contributed in cash or kind.

Some of Australia's gains during this period included the adaptation of modern canal design and construction techniques, use of new materials and the introduction of new and improved technology, notably micro-irrigation.

This paper suggests that the position may now be reversed, in that we might have more to give than receive. However, the maintenance of research skills and the continuing development of individual research personnel by their involvement in international activities does have positive benefits for their activities in Australia. It would be reasonable to assume, for example, that Australian financial support to programs in IIMI and IPTRID would result in additional involvement by Australian institutions and individual professionals.

However, it is suggested that there are other strategic implications which would justify continuing and even greater Australian support to the international programs in the irrigation and water resources areas. It is not fanciful to suggest that competition for water is certain to produce international tensions, even open conflict, within the next decade between countries sharing international river basins.

It is not fanciful to suggest that competition for water is certain to produce international tensions, even open conflict, within the next decade.

More than 65% of the irrigated areas of the world lies in Asia and the Indian Sub-Continent. Australia is one of the few countries which has direct operational and management experience and supporting research capacity which is most relevant to these irrigation systems. It is one of the few countries with established legal and institutional frameworks to successfully manage water as a scarce resource.

Contributions to research programs would almost certainly create opportunities for Australian involvement in education, training and capacity building. These in turn are links in the chain of association and commercial involvement that are important to Australia's future in the Asian region.

DR GEOFF MILLER is internationally renowned for his work in agricultural policy, economic development and international trade. He left his position as Secretary of the Department of Primary Industries and Energy to be Australia's candidate for the position of Director General of the United Nations' Food and Agriculture Organisation. He has been chairman of the Australian Primary Industries and Energy Research Council and served on the Policy Advisory Council of the Australian Centre for International Agricultural Research.

Summary and Conclusions

Geoff Miller
Agricultural Consultant

When I sat down this morning, faced with the unexpected task of thinking about how I might sum up proceedings, I realised I had to work through all of the papers and then listen to all of the discussion. As the day progressed it dawned upon me that today has been a day of good news, that is, good news only. The Australian psyche is such that when we hear only good news, we're suspicious. We have this deep underlying cynicism. That cynicism is nowhere better expressed than in the realm of politics, and associated with politics in the ever vigilant news media that we have here in this country. It is, after all, politics and the media that we are ultimately trying to influence through this seminar.

Now, why is it that we have all been here today? I mean, is this just the converted preaching to themselves? If the benefits of international agricultural research are as great as we say they are, then why is it that the funding shortfall doesn't immediately disappear? Or is it that we're a group of people looking at the issues through rose-tinted glasses? Are we in fact colouring what we see by selecting the logic to suit our own interests? This is a question that must be addressed openly if we want to be taken seriously.

I'm going to start by being a little provocative and ask you, 'Is the CGIAR system so wonderful?' My answer is 'Almost, but not quite.' The system does have problems. Not all of the projects in the CGIAR system yield 30% plus internal rates of return. Not all of the Centres are well governed. There has been a multiplication of objectives pursued, a multiplication of Centres, a multiplication of expectations, and at the same time there has been a simultaneous reduction in the budgets. There's room for improvement in the governance and in the

management of the system, including in the financial management. There's room for enhancement of collaboration between the Centres, and between the Centres and the national agricultural research systems of the developing countries themselves.

Australians are at the forefront of efforts to advance further the performance of the CGIAR.

Yet, just as Australians have been leaders in agricultural science within the CGIAR system, and in the development of the system, so too are we at the forefront of efforts to advance further the performance of the CGIAR. Many of you outside rural research in Australia are probably not aware of the quiet revolution that has occurred in Australian agricultural research and development over the past decade or so. That revolution has not merely been a response to budget cuts, it has been a ground swell of proactive initiatives to lift the performance of the system.

The innovations include foundation of the new Research and Development Corporations for each agricultural industry and sector and the new Cooperative Research Centres that bring research institutions together and into closer collaboration with industry. They also include dramatic changes in the internal management systems in the CSIRO, the state agencies and the universities.

The Australian agricultural research and development system has been bruised by the budget cuts of the 1980s and the early 1990s but not as badly bruised as the CGIAR system. These proactive initiatives are among the principle reasons for that. What we have today is a genuinely internationally competitive agricultural research and development system here in this country—not a perfect one, but an internationally competitive one—that has gone through enormous adaptation over the past decade.

Those of you here not involved in agricultural research should rest assured that we look upon the CGIAR system the same way as we do our own system. The CGIAR has been responsive, very responsive. Even as it is today, its benefits to humanity are enormous. Its benefits to Australia are very great. But our agricultural research and administration leaders will continue to work hard to advance the performance of the CGIAR system.

It's against that background that I'd like to restate the benefits that flow to Australians as a result of their investment in the international agricultural research system. There are six pipelines through which these benefits flow, as they've been discussed today. Both John Dillon and Earl Kellogg in their papers gave us taxonomies and there's another one in the two-page handout called *Australia: Doing Well by Doing Good,*

which I'll come back to. But I'll briefly follow John Dillon's taxonomy.

John Dillon, first, listed improved agricultural technology as a pipeline through which benefits flow to Australia. Tony Fisher, John Brennan and Peter Kerridge have given us an enormously rich array of illustrations and practical examples of how those benefits have flowed to us.

The second pipeline through which benefits flowed to us is through enhanced trade. Earl Kellogg, Kim Anderson, Don McLaren and Lindsay Falvey today debunked the myth that expanded agricultural production in the poorest developing countries results in reduced opportunities for Australia in international agricultural trade.

In this most recent session, the third pipeline through which benefits flow to Australia—that is, through improving the management of our own environment and natural resources—has been the subject of discussion by Jim Ryan, Ann Hamblin and David Constable. But, as was evident from that session, benefits from improvements in the international physical environment will also flow directly to Australia.

John then went on to list three further avenues through which benefits flow to Australia. I think these three further pipelines have been quite significantly understated during the course of today's proceedings.

The first of those, and the fourth on my list, is what John called the complementarity we gain from our own science in participating in international agricultural research. I would go much further than that. The Australian agricultural research and development system—not just the public sector agricultural research and development system but also the private sector agricultural research and development system that Lindsay Falvey touched on briefly—is an internationally competitive sector of the Australian economy. As a services industry it can bring enormous benefits to this country itself.

The more internationally competitive and the larger Australia's agricultural research and development system, the more Australian agriculture will be enhanced.

The more internationally competitive and the larger Australia's agricultural research and development system, the more Australian agriculture will be enhanced. Our agricultural sector will benefit, but so too will the Australian economy, directly through the efforts of people working in the services industry. Remember that provision of services is the area that's most rapidly growing in world trade, and the provision of agricultural research and development services is an area in which we excel. So that's the fourth pipeline through which benefits flow to Australia.

The fifth pipeline, as John listed, is more diffuse and pragmatic. This is through the international political arena.

The magnitude of the political benefits that flow to Australia through our excellence in international agricultural research and development is simply not understood in this country.

Now during the last 15 months or so I was privileged to visit 66 countries around the world, most of them developing countries. I can tell you that the magnitude of the political benefits that flow to Australia through our excellence in international agricultural research and development is simply not understood in this country.

In developing countries—and the vast bulk of countries around the world are developing countries—agriculture is a much larger sector of the economy. Agriculture ministers are top ministers in governments in the developing world. Therefore agriculture ministers have a much bigger impact on the perception of Australia as a nation. The decisions that other countries take to support, or withhold support for, Australia in international political forums is heavily conditioned by what foreign agriculture ministers think of this country.

In pursuing our foreign policy objectives there is a substitution that can occur between diplomatic effort and genuinely productive effort in promoting agricultural growth and development.

On occasions I have had agriculture ministers, and even on one occasion a president, say things to me like, 'There's been a lot of fuss about your country closing its embassy here. We're concerned about that, but by God don't you take out the assistance that the Australian Centre for International Agricultural Research is providing!' I think we need to be much more aware that in pursuing our foreign policy objectives there is a substitution that can occur between diplomatic effort and genuinely productive effort in promoting agricultural growth and development.

Another example relates to Australia's experience in Vietnam. Australia is very well placed commercially and highly respected in Vietnam, despite the fact that we were on the opposing side during the course of the Vietnam war. There's one reason for that and only one reason. Australia, through AIDAB and IRRI, was able to get in straight after the war and make a major effort to increase agricultural production in that country. Expanded agricultural production has been the key ingredient in getting the country back on its feet.

The role of the Cairns group internationally constitutes yet another example. We would never have had the respect needed to establish, develop and manage the Cairns group during the course of the international trade negotiations if we hadn't established a reputation at the very forefront of world agriculture—and I mean professional world agriculture. So I think that fifth benefit that John Dillon mentioned warrants somewhat more attention than it's had.

But the sixth pipeline as John has listed it, is the moral and psychic benefit. We Australians are humanitarian. It is our contribution to humanity that is ultimately the most

important avenue or pipeline through which benefits flow to this country, as a result of our efforts in international agricultural research. If you visit the third world, if you see the enormous numbers of people living in dire rural poverty, and the degradation of resources associated with that globally, then you cannot—as a human being—walk away from our responsibilities as a nation. You cannot deny that a country like Australia, with such an enormous comparative advantage in dealing with those problems, should put in the outmost effort to do so. I believe that, properly informed, all Australians would wish their leaders to rise to that challenge—not merely for the selfish material benefits that in themselves make a compelling case, but for the sake of humanity.

In concluding, I come back to the theme of my summing up. The question that I asked at the beginning was why are we here today. The corner stone of our political system in this country is the market for votes. The political system is driven by self interest. That's not necessarily a bad thing. It's a characteristic of democracies. Its not a bad thing as long as the self interest that drives politics is well informed and enlightened—that it is real self interest and not self delusion.

We're here today to make a small contribution to ensuring that, in relation to international agricultural research, our political system is driven by enlightened, genuine, self interest and not narrow, false perceptions of self interest. I hope that as you leave here today, after having sat through and enjoyed a lot of excellent presentations, and having taken away in your briefcases some outstanding papers, that you will use all this material to help develop that enlightened self interest.

Finally, let me commend to you this little two-page document which has been produced, again behind the scenes, by the excellent Secretariat under Derek's direction. This little paper *(Australia: Doing Well by Doing Good)* summarises most of what we've heard during the course of the day, in a series of pungent points and practical examples. Let us all resolve as we leave here to make the best use of the excellent work that's been done. The political system cannot be relied upon to inform itself. It is indeed in our national self interest to ensure that our contribution to international agricultural research and development increases substantially in the future.

Closing Remarks

RT HON. J.D. ANTHONY

It is all too easy when considering issues concerned with the Third World, the environment, and overseas aid, to exaggerate or to over-simplify, to become either emotional or cynical, to preach doomsday or to bury one's head in the sands of blind optimism. A major aim of the Crawford Fund is to encourage a reasoned and balanced attitude soundly based on the available evidence, with a readiness to modify that attitude as new evidence is published. I do not think that we could have had a better example of this reasoned and balanced attitude than the papers that have been presented today together with the outstanding summary statement by Dr Geoff Miller.

As I remarked at the outset, it is important that we should understand the enormous benefits that come to Australia as a consequence of our involvement in international agricultural research. At the same time, however, we must never forget that these benefits are secondary to the main aim—which is to help raise the quality of life of those who today are suffering indescribably from poverty, hunger, disease and utter hopelessness.

Hope and progress for these deprived people begins with the development of their agriculture and rural industries. This is why we keep stressing the critical role of research in developing the improved and sustainable technologies which constitute the basis of agricultural development. In arguing that aid policies in Australia and throughout the world should give higher priority to agricultural research and development, we are not merely pushing a particular sectoral interest.

Agriculture is not called a primary industry for nothing. In poor communities or countries, improvements in agriculture have widespread economic and social consequences, which lead to better health and nutrition, an improved status for

women, smaller families, higher personal incomes, better education and national economic growth. Now is not the time to review the evidence for all this—perhaps we will do that in a future seminar—but I can assure you that there is no doubt about it. And this is what puts aid for agriculture into a different category to aid for, say, health, or education, or women's affairs. Of course all these things are important and deserve our support—but they simply do not make the widespread, seminal impacts on social and economic development that agriculture does.

Improvements in agriculture have widespread economic and social consequences, which lead to better health and nutrition, an improved status for women, better education and national economic growth.

My final task is to thank all those people and agencies whose hardwork and cooperation have combined to make this such a successful occasion.

We are immensely grateful to all those who have spoken and chaired sessions throughout the day. I want particularly to mention Earl Kellogg, Jim Ryan, Tony Fischer and Peter Kerridge who have come such vast distances to speak to us. They, like all the other speakers, are extremely busy people and their willingness to give us so much time to support our efforts is a reflection of how they assess the importance of this topic.

We could not have run today's seminar without the excellent cooperation of AIDAB, the Department of Primary Industries and Energy, and ACIAR, and we warmly appreciate such wholehearted support.

Ladies and Gentlemen–I hope that you have enjoyed the day as much as I have. I thank you all again for coming, and I declare the seminar closed.