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SUBMISSION TO THE JOINT STANDING COMMITTEE ON TRADE AND INVESTMENT 2016

Inquiring into any measures to further boost Australia's trade and investment performance, including, but not limited to, barriers to trade; reduction of red tape and structural challenges and opportunities for the Australian community.

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SUBMISSION TO THE JOINT STANDING COMMITTEE ON TRADE AND INVESTMENT

The Joint Select Committee on Trade and Investment Growth is inquiring into any measures to further boost Australia's trade and investment performance, including, but not limited to, barriers to trade; reduction of red tape and structural challenges and opportunities for the Australian community.

As part of its remit, the Committee will investigate how the research and innovation sector can better assist in overcoming Australia's geographic, economic and labour challenges, with a focus on commercialisation including, how technology imports and exports could be further facilitated.

Theme

Agricultural innovations are providing opportunities to increase Australian trade and investment opportunities whilst assisting poor farmers in developing countries.

Current government investment in the Australian Centre for International Agricultural Research (ACIAR) is contributing to trade and investment opportunities, both directly and indirectly, in Australia, and in a number of developing countries, with a particular focus on the Indo-Pacific region.

Introduction

ACIAR is the Australian Government's specialist agricultural research-for-development agency. Funded through the Australian aid program, ACIAR does not undertake research itself, but identifies opportunities and brokers partnerships to undertake international agricultural research and capacity building, the results of which contribute significantly to the aid program and achievement of its goals.

ACIAR's research portfolio covers crops, livestock and fisheries, natural resources and forestry, and socioeconomics and policy. Under these areas, the Centre funds and manages research partnerships through projects and programs designed to generate new technologies, new approaches and new knowledge, leading to innovation at the farm level and along the value chain, greater capabilities in research and production, and better informed agricultural policy in partner countries. Projects are designed so that new knowledge and innovation also feeds into Australian agricultural systems where appropriate.

Capacity building is a major priority for ACIAR. The people-to-people relationships built from our projects and fellowships indirectly effect the policies which promote trade and investment through the good will generated in the countries in which we work. Building the capacity of research scientists has a mutual benefit for developing countries and Australia.

ACIAR's research-for-development program may not be specifically targeted at boosting Australia's trade and investment performance, however it does have both direct, and indirect, impacts on the export of Australian agricultural products, technology and knowhow. Innovation, along with adaptability and flexibility, are essential to ACIAR's work, and these are built into the way in which ACIAR works with our in-country collaborators.

Independent studies show benefits that have flowed to Australia to exceed $2.5 billion, and Australia's contribution to international agricultural research centres delivering annual benefits to Australia estimated at more than $100 million a year.
This submission highlights, by way of case studies, how ACIAR's contribution to research-for-development supports Australia's national interest. It contributes directly to regional peace and security, economic prosperity and new trade, investment and business opportunities for Australia and in partner developing countries. One example is how, in the case of biosecurity, agricultural partnerships have enabled Australian researchers and biosecurity practitioners to gain hands-on experience of managing exotic pests, diseases and invasive species in the context of ACIAR projects overseas. They are now able to mitigate the impact of biosecurity threats to Australian agriculture and the environment via an 'advance warning' of advancing pests, diseases and invasive species, and by helping to control them offshore.

Working with the private sector is fundamental to how ACIAR develops successful partnerships. The role of private partners within ACIAR's research partnerships has both changed and grown in recent years, reflecting the increasing engagement of the private sector in agriculture in many parts of the developing world, and increased understanding of the links between innovation, economic growth and food security. Success stories, which highlight mutual benefits to Australia and the developing country partner, include a collaboration with chocolate company Mars Inc. which is helping cocoa farmers in Indonesia, a project in Vietnam linking small-scale producers with supermarkets in Hanoi, and the rise of commercial farmers' groups in Timor Leste under the Seeds of Life program.

ACIAR facilitates research for development partnerships that include Australian industry actors. The connectivity of Australian researchers with close links to Australian agricultural industries provides a unique understanding of trade opportunities for Australian suppliers of agricultural goods and services. This includes: better mutual understanding leading to the supply of off-season perishable items to meet seasonal supply-demand gaps (for example mangoes and sweetpotato); increased identification of opportunities for investment into agribusinesses for which Australia has a comparative advantage (such as macadamias, timber) but also services such as postharvest grain management and logistics, and input suppliers.

Australia has benefited tremendously over many years from research and development corporations where money raised from levies on products is used to fund research and development for the benefit of farmers and the Australian taxpayer. Most, but not all industries, have levies. Recent ACIAR research funding has been the stimulus for the Australian Melon Association (AMA) to support levies on

melon growers for research and development, Biosecurity and Emergency Plant Pest Responses. The levy should commence on 1 July 2016.

AMA's initiative was bolstered by the discovery of a new disease of melons in the Northern Territory. The disease was identified when ACIAR project pathologist Dr Len Tesoriero was conducting a survey focused on Fusarium diseases in melons, as part of the Australian component of a Philippines vegetable project. The disease had not been found in Australia before. After diagnostic testing it was found to be due to cucumber green mottle mosaic virus (CGMMV).

The early discovery of the disease and subsequent biosecurity responses have possibly saved the melon industry across Australia from losses due to a potentially crippling disease. Previous attempts to obtain support for a levy failed, but the outbreaks of CGMMV have changed people's minds. Thus ACIAR's research has helped the melon industry focus on its future, which should be of great benefit to the $150m a year Australian industry.

ACIAR also assists with 'preferred' trading partner status, either informally or formally, through genuine un-burdened assistance. For example, discussions with wheat industry officials to improve wheat productivity in Myanmar, may assist in approving wheat import into Myanmar to meet the substantial supply-demand gap.

Biosecurity

Australia is free of many of the major pests and diseases of people, animals and plants that affect livelihoods, reduce agricultural productivity, and damage the natural environment overseas. Australia exports most of its agricultural production so that research that contributes to improving biosecurity to control agricultural pests and diseases in its developing country partners contributes to Australia's trade and investment performance.

Effective biosecurity is essential to protect Australia's agriculture and natural environment from pests (including invasive animals and plants) and disease. Biosecurity underpins Australia's trade, as well as agricultural productivity and trade within the region. ACIAR's partnerships play a fundamental role in maintaining and enhancing biosecurity.

ACIAR is working with the Department of Forgein Affairs and Trade's Pacific Horticulture and Agriculture Market Access (PHAMA) program and partner agencies in seven Pacific island countries to increase understanding of, and compliance with, biosecurity measures. The work focuses on ginger, taro, papaya, breadfruit, mango and other commodities. Positive impacts include reduced risks of incursions of additional fruitfly species, nematodes and a range of diseases not yet found in Australia.

Another ACIAR project in the Pacific islands is trialling 'plant clinics' linked to the PestNet identification service. This project is working with national plant protection agencies and the Secretariat of the Pacific Community to provide early warning of pest and disease threats to horticulture.

In Mekong countries (Thailand, Laos and Cambodia), an ACIAR project is working with national plant protection organisations and Australia's Plant Biosecurity CRC (itself a partnership of many organisations) to develop 'remote microscopy'. The project links enable field staff in these countries to seek expert advice online to identify pests and diseases that they find in the field or in horticultural products goods being traded across international borders.

A cluster of ACIAR projects is assessing biosecurity hazards and improving practices to reduce risk in livestock market chains in the Mekong region. Research on pig diseases is linking public and animal health institutions in a 'One Health' approach to control parasites that are transmitted from pigs to people in Laos. Other projects are helping to develop biosecure market-driven beef production systems that will increase regional trade in cattle and beef.

In the Mekong countries, ACIAR projects link local and Australian veterinary researchers to understand and manage the threat posed by major transboundary diseases of livestock such as foot-and-mouth disease and haemorrhagic septicaemia, which helps to improve the productivity of local livestock and increase regional trade in animals and animal products. Another project aims to develop improved methods to assess disease risk and improve strategies for disease control to support the South East Asia and China Foot-and-Mouth Disease (SEACFMD) control program of the World Organisation for Animal Health (OIE) and partner countries in the Mekong region.

In the Philippines, *Fusarium* wilt has devastated commercial banana production in a series of Asian countries and now threatens the crop in the southern Philippines, where banana exports provide a major contribution to employment and the economy. Based on previous ACIAR-funded work in Indonesia, a new project is working with farmers to develop practical, integrated management strategies for this disease, to help maintain the county's exports of bananas.

Pork accounts for about 60% of all meat produced and consumed in the Philippines, and most pork is produced by smallholder farmers. The eradication of foot-and-mouth disease from the Philippines has created the opportunity to export pigs and pork to hitherto closed markets such as Singapore. ACIAR research on pig respiratory diseases is developing disease surveillance systems and improving the productivity and competitiveness of pig-production that will improve opportunities for regional trade.

In Indonesia and Papua New Guinea (PNG), an ACIAR project is working with national commodity research organisations and industry, supported by Australian universities, to enhance preparedness for and manage incursions of, exotic pests such as coffee berry borer and cocoa pod borer.

PNG is Australia's nearest neighbour and animal, plant and human diseases travel (both naturally and with human assistance) from PNG to northern Australia. In PNG, an ACIAR project is working to improve the identification and control of animal pests and diseases by enhancing animal health services available to smallholder farmers. The increased knowledge of the occurrence and distribution of animal diseases (including diseases that also affect humans) in PNG, and the increased capacity for earlier detection and response, that will result from this project will help maintain and improve PNG's animal health status and help to improve Australia's biosecurity.

Past and present ACIAR research in Indonesia and PNG has helped to identify and control pests and diseases of bees, including serious bee mites that are exotic to Australia. A project on improving value chains for honey in PNG, Fiji and the Solomon Islands will also help to control bee pests and diseases and thus increase production, enhance smallholder farmers' livelihoods, and increase opportunities for trade and investment.

Australian fish health experts from universities, CSIRO and state fisheries agencies have undertaken research supported by ACIAR on diseases of aquatic animals such as finfish and prawns in various countries of South East Asia. Some of these diseases occur in Australia, but others do not.

In PNG, an ACIAR project linking the National Fisheries Authority with Australian experts, focuses on mitigating the risk of invasive fish species such as the snakehead, walking catfish and climbing perch. These species are air-breathers that can remain alive out of water, so they can be easily transported between islands in the Torres Strait. They are highly invasive, and if they reach northern Australia they would undoubtedly have a significant effect on aquatic biodiversity as well as on food and sport fisheries.

In Africa, biosecurity training of 15 African Fellows helps to protect Australia's borders with detection and early diagnosis where some plant diseases and pests are endemic. Through the Australia Africa Plant Biosecurity Partnership, the capacity of African plant quarantine/biosecurity officials from 10 different sub-Saharan countries is being enhanced to enable early detection, diagnosis and treatment of plant pests and diseases and pests. This helps protect Australia's agriculture and environment from plant pests and diseases potentially carried on plant products exported to Australia, such as cut flowers, and to other countries.

A project in Tanzania and Zambia aims to reduce childhood undernutrition by identifying and testing opportunities to enhance the role that women play in improving poultry and crop integration and efficiency to strengthen household nutrition. Controlling Newcastle disease in poultry leads to significant reductions in poultry mortality and improvements in productivity. This enables families to consume both eggs and poultry meat (thus improving their nutrition) and to trade poultry and eggs in regional markets.

In southern Africa, ACIAR research is aiming to provide opportunities for smallholder farmers to meet market requirements. A project in Botswana has assessed ways to improve the competitiveness of smallholder beef cattle producers by focusing on market-oriented research to improve value-chain coordination. A proposed new project in Botswana aims to increase the production and productivity of small ruminants (particularly goats) by improving animal health and developing market value chains. A new project in South Africa is assisting smallholders to work with commercial partners to supply niche markets for pasture-finished cattle in the region.

Innovative technologies

ACIAR makes a unique contribution to the development and deployment of technology to increase agricultural productivity in developing countries and in Australia, thereby boosting Australia's trade and investment capability.

Future increases to agricultural productivity in Australia, through improvements in the efficiency of agricultural practices due to new technology, emerging technology relevant to the agricultural sector, and overcoming barriers to the adoption of emerging technology, will continue to be dependent on the connectivity between Australia and international agricultural research.

The Happy Seeder

Systematic assessment of the commercialisation potential of research products developed by ACIAR's research partnerships in India, such as the Happy Seeder and its derivatives, and some seed systems, has been undertaken. It has been found that the Happy Seeder has the potential to deliver significant benefits to Punjabi farmers and to rice farmers in Australia.

Burning is the normal method of rice stubble management in mechanically harvested rice-wheat growing areas of North-West India. This causes air pollution and loss of soil health as well as impacting on human and animal health. In one ACIAR project a new generation of seeders capable of direct drilling wheat into heavy rice residue loads without prior burning was developed (Happy Seeder technology), reducing the environmental and community impacts of residue burning.

A progressive farmer in the Indian Punjab displaying his tractor-towed Happy Seeder to other farmers and project staff. The seeder sows wheat into the unploughed stubble of the previous rice crop. Photo: Simrat Labana

Collaboration between Australian and Indian engineers and scientists has resulted in tremendous synergy leading to the development of technology poised to solve the

problem of direct drilling into heavy stubbles and trash around the world (Blackwell, J. Charles Sturt University). CSIRO undertook limited testing of the technology in Coleambally, New South Wales. A major objective of our work was to quantify the effect of the mulch on water savings or increasing water productivity.

Direct drilling and stubble retention offer many benefits, including large fuel savings, rapid turnaround between crops, increasing the chance of double cropping, improved soil properties, and reduced air pollution (particulates in smoke and greenhouse gases). Mulching, as opposed to incorporation, offers the additional benefits of moisture retention and weed suppression.

Sorghum breeding

A 5-year project that began in 2014 is aimed at boosting the capacity and productivity of the Ethiopian sorghum breeding program, providing germplasm, tools and skills to underpin genetic gain for productivity in water-limited environments. The project, led by the University of Queensland, is supported by the Bill and Melinda Gates Foundation (BMGF) (85%) and ACIAR (15% - $600,000). This innovative co-funding arrangement helps BMGF by mobilising world-leading Australian expertise in sorghum breeding, and is providing ACIAR considerable leverage on its investment.

The intercropping technologies are not only used for maize and legumes, but also for other crops such as sorghum which has ready market with the breweries. Photo: Liz Ogutu, ACIAR

Thanks to the complementary objectives and mandates of BMGF and ACIAR, and their pooled resources, the project has been able to support research and capacity building in Ethiopia, as well as advanced scientific research in Australia. Impacts are expected over various time frames.

The exchange and joint analysis of germplasm between the two countries will benefit breeding programs in both countries, while the acceleration of genetic gains in the Ethiopian breeding program will result in the release of improved sorghum varieties within 5–10 years. Their adoption by Ethiopian farmers will increase productivity and resilience; about 1 million smallholder farmers are targeted.

Advanced research will result in increased knowledge on sorghum physiology and water use efficiency, which will provide the foundation for further sorghum improvement over the longer term (10–15 years), benefitting both countries as well as others.

Plant Breeding

Improved plant and animal varieties are a major source of innovation with the potential to vastly improve the productivity of Australian farmers. Through ACIAR projects over the past three decades, plant breeding organisations (public and private) in Australia have been able to access a broad range of genetic diversity, the raw material of plant breeding. The application of plant genomics data is now accelerating the breeding of new varieties. ACIAR projects on water-efficient sorghum, deep-rooted wheat and disease-resistant mungbean provide the framework to exchange promising genetic material with partner countries. The continuous breeding and release of improved varieties will remain dependent on regular access to genetic diversity.

This will require Australia to continue to support the International Agricultural Research Centres of the CGIAR and the gene banks they host and manage. It is also important that Australia remains engaged in the international negotiations about genetic resources: the International Treaty on Plant Genetic Resources for Food and Agriculture provides a workable legal framework but only covers a subset of crop species. Under the Biodiversity Convention, access to genetic resources is more constrained and may act as a barrier to future productivity improvements.

Molecular Marker Assisted Wheat Breeding

Stem rust is a fungus disease of wheat, and in 1999 a new stem rust pathotype, Ug99 or TTKS, was identified in Uganda. It was virulent on many commercial cultivars of wheat and is capable of overcoming a number of important stem rust resistance genes. Additional variants derived from 'Ug99' and designated as TTKST and TTSSK, were shown to exhibit virulence to genes Sr24 and Sr36 respectively and points to the continued evolution of Ug99. This pathotype has spread to other East African nations and to Yemen, and there is a high likelihood that it will reach and threaten the wheat-growing regions of Asia.

An ACIAR funded project successfully delivered a new and robust molecular marker capable of identifying the smallest chromosomal introgressed segment containing the stem rust resistance gene, Sr22. This gene currently provides resistance to all stem rust isolates in Australia, India and against Ug99 and its derivatives. Furthermore, tests conducted in Ethiopia by Internationla Maize and Wheat Improvement Center (CIMMYT) scientists, where other virulent stem rust races adapted to durum wheats occur, showed that Sr22 was effective against the specialised Ethiopian races.

The use of the robust Sr22 molecular marker as a breeding tool has been deployed in India through another ACIAR-funded project and in Australia through the Australian Cereal Rust Control Program's relationships with breeding companies.

The project was able to show that adult-plant stem rust resistance genes were present in the targeted Australian varieties, such as Hartog, as well as the North American variety Thatcher (known for its specific interaction with a broad-spectrum adult plant resistance gene, Lr34/Yr18). In order to progress with marker development for the Thatcher-based adult plant resistance genes, a new set of genetic populations will be required due to the confounding rust-resistance phenotypes observed with the Australian cultivars Meering and Oxley.

This small research activity enabled interaction with Indian Council of Agricultural Research partners and field-rust evaluations at different sites in India. The team concluded that the location at the Indian Agricultural Research Institute regional station, Wellington, provided one of the consistent sites for achieving rust epidemics for experimental studies. Specifically, this and other ACIAR projects have identified new rust resistance genes which will protect the Indian and Australian wheat crops against wheat rust, over the years to come.

Cooperation in plant breeding, such as the current program with India on Molecular Marker Assisted Wheat Breeding, will provide private wheat breeding companies with new genes and markers, enabling them, over the medium term, to deliver improved wheat varieties to Australian farmers. Progress made towards a "deep rooting" wheat may similarly benefit Indian and Australian wheat growers in water limiting environments and contribute significantly to Australia's agricultural trading potential. Both activities will have a direct impact on Australia's trading capability.

Benefits from deep-rooted wheat in India and Australia

The intensification and stabilisation of rain-fed maize-legume cropping systems has offered considerable promise for boosting productivity, improving food and nutrition security and helping reverse the decline in soil fertility and improving trade and investment opportunities in Australia.

ACIAR is supporting an Indo-Australian project on root and establishment traits for greater water use efficiency in wheat. It is utilising an Indo-Australia Program on Marker Assisted Wheat Breeding (IAP-MAWB) modality. This innovative partnership modality will assist in increasing agricultural productivity in Australia.

The project is developing wheat varieties with deeper, faster-growing roots that better exploit soil moisture and increase yields in rainfed or minimally irrigated systems in India and Australia. At core sites in both countries, root growth rates, rooting depth and potential for genetic improvement is being researched as the two countries also co-develop protocols to measure root growth in controlled environments and leaf temperature in the field.

Wheat breeding populations are being developed, combining desirable traits for roots and shoots. Parallel with this, molecular markers for root traits are being developed via an over-arching joint program for faster wheat breeding in both countries. The second phase of this research aims to apply these outputs to deliver useful breeding lines and molecular markers. The parental lines identified using the tools and methods developed in the project will be used to genetically map the root traits and breed deep-rooted adapted wheat varieties. The benefit of deep water uptake on yield and water use efficiency will be determined.

At three Australian and five Indian core sites the joint research team will study root growth rates, rooting depth and potential for genetic improvement. The team will also co-develop protocols to measure root growth in controlled environments and leaf temperature in the field. In addition, the team will investigate shoot characteristics that influence crop establishment and water-use efficiency.

Desired outcomes are development of wheat breeding populations that combine desirable traits for increasing yields in water limited conditions in Australia and India, and identification of molecular markers that indicate traits for deeper roots and better crop establishment.

Chickpea Pulses

Chickpeas are pulses grown widely in West Asia, Africa and India, where they are a traditional foodstuff and an important source of protein in the human diet. As they are legumes, chickpeas incorporate nitrogen into the soil and thereby reduce the amount of fertiliser needed for other crops. Chickpea production began in Australia in the 1970s and has grown steadily since then, becoming increasingly important as a high-value export crop.

Indian production has remained static in that time, despite the large increase in population. Yields are low in India and most parts of the world because the crop is grown in drylands that are rarely irrigated. Chickpea cultivation has been pushed onto more marginal lands as the area of irrigated land has increased in India, because the crop is not considered to require irrigation.

Labourers preparing bags for harvesting chickpeas at the Indian Institute of Pulses Research, Kanpur. Photo: ACIAR

It is possible, however, to improve the performance of chickpeas in these conditions by identifying plants that produce higher yields and tolerate drought better. One ACIAR project has set out to assess chickpea germplasm and determine the factors that enable some lines to tolerate drought better. Following on from this, selective breeding will result in lines well-suited to drought-prone areas of India and Australia.

Development of Maize Germplasm Boosts Production in Africa and Australia

Maize is often considered an unreliable crop for Australian rain-fed production systems due to a lack of well-adapted hybrids. Yields may vary from 1-10 t/ha depending on the season. In the wet tropics yields range from 5-9 t/ha. To promote a competitive Australian maize industry, the Queensland Department of Agriculture and Fisheries has developed a maize pre-breeding program in conjunction with ACIAR.

This program aims to develop a germplasm adapted to Australian growing conditions that fulfills the grain quality requirements of the maize industry. The program works closely with the major seed companies in Australia to avoid redundancy. It fosters links between private and public research and development efforts.

An increasing demand for maize for stockfeed and other applications has brought together Australian subsidiaries of global seed companies, such as Pacific Seeds, with the Grain Research Development Corporation (GRDC) and ACIAR, as part of the Sustainable Intensification of Maize-Legume cropping systems for food security in Eastern and Southern Africa (SIMLESA) project.

Maize farmers in Chimoio, Mozambique. Photo: John Dixon, ACIAR

The focal countries of the SIMLESA partnership program are Ethiopia, Kenya, Malawi, Mozambique, Tanzania and Australia. The program aims to improve maize and legume productivity by 30% and to reduce the expected downside yield risk by 30% on approximately 500,000 farms within ten years.

Farmer attending to his maize fields in Ethiopia. Photo: John Dixon, ACIAR

This is to be achieved through participatory research and follow-on development with farmers, extension agencies, non-governmental organisations, universities and agribusiness along the value chains. Through sub-regional research organisations and existing networks, the program fosters spillovers of improved crop systems management practices, knowledge and germplasm to other countries in the east central and southern Africa regions, and now into Australia.

The benefits for Australia of battling Panama disease in Indonesia and the Philippines

It seems that every few years a fear emerges that the global commercial banana industry is threatened with extinction. Usually the focus of the scare-stories is Panama disease, caused by the fungus 'Foc' (short for *Fusarium oxysporum* f. sp. *cubense*). The new form of the disease has virtually wiped out commercial Cavendish production in Malaysia and Indonesia, and recently there have been outbreaks, for the first time, in Africa and the Middle East.

The unfortunate discovery in 2015 of Fusarium Wilt Tropical Race 4 in bananas in the Tully Valley and the current battle to contain it, has highlighted the considerable contribution that ACIAR has played through recent project work in Indonesia and the Philippines. The Australian researchers, funded in part by ACIAR, and the research outputs generated, are proving to be of enormous benefit to the management of the recent outbreaks in North Queensland. They will continue to add value as the Philippines project delivers on planned milestones for research in the partner country and Australia. Learnings from the research will provide the Queensland industry with the tools to continue production for many years as the industry evolves to take on better varieties and new production systems.

A banana plantation devastated by Panama disease (Tropical Race 4). Photo: Richard Markham, ACIAR

The front line in ACIAR's battle with Foc-TR4 has now shifted to the southern Philippines, where ACIAR has recently launched a new project. There, some of the key players who were involved in the Indonesian project—Bioversity International and Queensland's Department of Agriculture, Fisheries and Forestry—have taken on board the lessons learned and are now trying to apply them to managing the disease, in collaboration with Filipino research organisations and commercial industry partners.

While the Indonesian project looked at specific antagonists to Foc, especially other fungi living in the soil that could compete with and control it, the Philippines project is focusing on encouraging farmers to grow groundcovers between the banana plants. Groundcovers can provide a favourable environment for a range of these antagonists to develop naturally. They also provide additional benefits, such as reducing soil erosion and surface water flow that can carry the fungus from plot to plot, as well as reducing the risk of farm workers carrying the disease in contaminated soil on their shoes.

There are real benefits to Australia from this research. For example, Australian researchers and industry partners are evaluating and gaining experience in the use of groundcovers to manage Foc Race 1, which attacks Australia's Lady Finger bananas. It will also serve as something of a 'dress rehearsal', in case Foc-TR4 should ever threaten the heart of Australia's commercial banana industry—the Cavendish plantations in Queensland and northern New South Wales.

Tony Pattison discusses with a banana plantation manager which of a range of local groundcover species might work best. Photo: Richard Markham, ACIAR

Conservation Agriculture

Conservation Agriculture (CA) is a set of soil management practices that minimise the disruption of the soil's structure, composition and natural biodiversity. CA has proven potential to improve crop yields, while improving the long-term environmental and financial sustainability of farming.

Progressing farm mechanisation for CA is a challenge of considerable complexity involving new combinations of farmer practice, technological, entrepreneurial, and institutional and policy innovation. Undertaking research that contributes to knowledge, practice and impact in this domain is correspondingly challenging.

The use of Australia's expertise in conservation agriculture in SIMLESA, described above, and related projects, has the potential to encourage import of ancillary CA equipment, such as farm machinery, from Australia. In Kenya, a medium sized farm already imports much of their machinery from Australia.

The research, and demonstration of no-till farming in dryland areas, conducted by ACIAR in a range of countries has provided opportunities for Australian suppliers of farm equipment and spare parts. For example, the point openers – tynes for no-till seeders – are exported from an Adelaide firm. As CA is promoted and spread into partner countries, new opportunities for the Australian expertise in this area may open up.

Using zero-tillage (ZT) seeders in Iraq

Between 2005 and 2014 the Australian Government, through ACIAR, supported a project with the overall goal of improving the productivity and sustainability of crop production in the drylands of northern Iraq. The project was designed specifically to develop and promote CA in Iraq. It was based on consolidating and expanding research conducted in Ninevah and Aleppo in Syria promoting conservation cropping practices (mainly zero-tillage and early sowing) to areas within Ninevah, and the new governorates of Kirkuk, Salahaddin and Anbar in Iraq.

The project was a partnership led by the International Center for Agricultural Research in Dry Areas (ICARDA) involving the Ministry of Agriculture and Directorate of Agriculture in the governorate of Ninevah, (and later in Anbar, Salahaddin, Kirkuk, and Erbil), the University of Mosul and various other Iraqi universities, and the University of Western Australia, the University of Adelaide and the University of South Australia.

Through experiments on research stations and in farmers' fields at multiple locations in northern Iraq, Syria and Jordan, it was demonstrated that the elimination of ploughing plus direct sowing with zero-tillage (ZT) seeders provided significant benefits to the dryland cropping systems of the Middle East.

ZT Seeder at work in Jordan. Photo: ICARDA

The research unambiguously established that zero-tillage and other CA technologies resulted in cost savings, increases in grain yield production, reduced environmental degradation, and improved soil quality. In particular, CA reduces the risk of crop failure due to dry conditions and the effects of climate change. Zero-tillage alone, without the other two pillars of CA (i.e. soil cover and diverse crop rotations), produces cost savings and often results in yield increases, especially as this allows farmers to sow their crops early, which increases water use efficiency.

These findings were consistent with the Australian experience of CA technologies developed over the past three decades. The project was also a catalyst in commercial release of superior wheat, barley and field pea varieties, some originating from ICARDA and Australia. The project is an example of successfully adapting and applying Australian knowledge and skills for the benefit of partner countries.

It was identified that a lack of affordable, small and simple ZT seeders was a major impediment to widespread adoption of CA in the Middle East. Consequently,

machinery experts from Australia worked closely with local workshops and project partners to enhance their knowledge and skills, and produce inexpensive kits that allowed farmers to convert their conventional seeders to ZT.

Adapting conservation agriculture for rapid adoption by smallholder farmers in northern Africa

Another ACIAR project aimed at driving and deepening the understanding of CA amongst many farmers, researchers and other stakeholders, was conducted in three countries - Algeria, Morocco and Tunisia. It encountered major environmental challenges such as poor or unseasonal rainfall, the challenge of a foreshortened program, the challenge of distances, and the challenge of different local and regional knowledge.

The project faced many challenges: change in mindset of farmers, extensionists and decision makers toward zero tillage; affordablity and availability of ZT machinery; the integration of livestock under CA and the trade-offs of residue management; keeping good agronomy practices while implementing CA; bringing stakeholders with different/divergent interests together in a platform promoting CA; and convincing policy makers, development agencies and private sector to invest in CA.

In spite of these challenges, the project succeeded in establishing three operational innovation platforms on CA that brought major stakeholders to implement the project activities in a bottom up approach and the testing of selected ZT drills options allowed the development of a low-cost ZT drills in the three countries using the Australian expertise and the partnership of local manufacturers. An integrated weed management process improved productivity by 50 to 90 %. Investment in capacity development was seen through the various training and knowledge sharing events organised both in the region and in Australia, involving researchers, extensionists, farmers, NGOs and policy makers.

The legacy of the project was the building of multidisciplinary, multi-institutional and multinational research for development dedicated teams and the establishment of a regional network linking North African countries to international centres and Australia.

Tyned and disc seed drill options in the Mekong

Rice remains the cornerstone of Cambodian agriculture. Over the last few years production systems have undergone more radical change than in the last few hundred years. The major changes relate to the spread of direct-seeding, a significant increase in irrigated rice, and the uptake of mechanisation to replace animal draught for land preparation.

The project analysed, adapted and developed capacity for the use of new machinery options which were shown to provide farmers with the capacity to better establish direct-seeded rice. The widespread adoption of direct seeding in rice-based systems has led to greater pressure from weeds, which the majority of Cambodian farmers are now more efficiently controlling by using herbicides.

The ACIAR tined drill outside the CARDI workshop in Cambodia. Photo: ACIAR

Another focus of the project was on refining suitable options for mechanisation, both in wet and dry-direct seeded rice and in conservation or zero-tillage cropping. Improvement in rice establishment through mechanisation introduced by the project has provided options to reduce the burden of labour shortages in the rural communities in Cambodia.

A range of tyned and disc seed drill options have been evaluated and improved, and a Cambodian drill solution suitable for existing 2-wheel tractors was developed in cooperation with a private machinery manufacturer.

Farmer field schools were successfully completed and key information on weed management, machinery innovations, crop establishment and fertiliser application have been utilised by participating farmers.

The project has made a significant contribution to defining and refining best practice recommendations for crop establishment, weed management and cropping systems which will underpin new technology packages. Rapid changes in practices occurred in the target districts between 2010 and 2013. Adoption of best practice in farming systems, lower seeding rates, better weed management, yield-targeted fertiliser application and improved machine seeding options, are likely to be adopted in the next 5 years as a result of the project.

The ACIAR modified rotary tillage unit ready for testing in NSW, Australia. Photo: ACIAR

With the increased use of saline groundwater in both Cambodia and Australia for rice irrigation, it was critical to determine whether water salinity or soil toxicities and other yield constraints affect the potentially higher yield of these irrigated systems. In Cambodia there is a significant amount of work left to do with regard to integrating non-rice crops into the system. In Australia, a potential new model for the screening of rice cultivars for salinity tolerance is being explored which may have significant impacts for assessing salinity tolerance in all field crops.

This has been a large and successful project. It has brought together four Cambodian and three international project partners. It has identified that rice productivity in Cambodia can be increased by the adoption of more intensive cropping programs of two or even three crops per year, utilising mechanisation and better weed control. The project leaves a legacy of rice crop establishment, weed management, fertiliser management and mechanisation trial results, the CLEAR database, and improved skills of researchers in Cambodia in the conduct of socio-economic analysis of agricultural research trials.

Value Chains

ACIAR invests in research of emerging markets that not only provide insights and implications for the livelihoods of smallholder producers in the region, but also information and insights which are directly relevant to Australian trade interests.

For example, small research activities are undertaking a review of regional beef markets and trade in China and South east Asia exploring strategic approaches to pro-poor market and consumer research in China and the Mekong region and analysing mango markets, trade and strategic research issues in the Asia Pacific.

Cattle and beef markets and trade have developed at a rapid pace in China and South East Asia in recent years, with important implications for rural development, food security, human nutrition, bio-security, trade and the Australian industry. ACIAR and other agencies have invested in projects to develop national beef industries and to reduce the disease risks associated with trans-boundary trade. However, policy-makers and other stakeholders lack information to systematically assess, map and forecast scenarios for beef market and trade development on country and regional levels.

A small research project is analysing model cattle and beef supply, demand and trade in China, South Eeast Asia and Australia. The specific objectives of the project are to: review and collate data on national beef industries in the region for input into the design of future modelling; review major trade flows in the region, including primary investigation of specific flows that are not well documented; and to review modelling approaches, identify partnerships and design for the next phase of the project.

To achieve these objectives, a number of inter-related activities will be undertaken in Australia, China and South East Asia, including literature and data reviews, targeted fieldwork, face-to-face meetings and consultations, and regional workshops.

There is considerable potential for thousands of poor smallholder farmers in Vietnam to benefit from developing markets in regional Chinese markets, in addition to strong local markets. However, as well as facing serious productivity constraints, these farmers generally lack information on local and regional market opportunities and requirements.

Current research complements other ACIAR work in Vietnam, and aims to address knowledge, partner and data gaps related to market and consumer research for Vietnamese temperate and tropical fruit and vegetable products. It focuses on priority vegetables, temperate fruit (plums, peaches and persimmon) and mangos. It will identify how fruit and vegetable market dynamics in the Mekong Region are changing and investigate supply-demand patterns, trade flows and consumer preferences in north-west Vietnam and south-west China. It will provide insights on implications and opportunities for smallholder farmers and pro-poor agribusiness development in Vietnam.

Collectively these projects improve the understanding of rapidly changing food consumption patterns (in-home and out-of-home) in emerging economies (e.g. Indonesia, Vietnam and China), and reflect changing patterns in consumer preferences and food demand. This provides insights into Australian trade opportunities for clean, safe and healthy fresh and processed food, and agribusiness-food services (e.g.
post-harvest management, transport and logistics, and food safety technologies and processes) in the region.

The projects also provide an understanding of market dynamics for beef-cattle, mango and horticulture products including formal and informal trade flows and price transmission, and their drivers throughout the China-South East Asia region. This provides information about the comparative advantage of Australian cattle, beef, mango

and other horticulture products in the region, likely future demand patterns in established and emerging markets, opportunities for Australian FDI and services to support industry development, and ability to better predict implications of ASEAN country policy changes in the areas of market access, biosecurity, liberalisation on Australian trade.

Feed improvement for mariculture in Vietnam and Australia

An ACIAR Fisheries project has brought together researchers, feed millers and fish producers in Vietnam and Australia in a partnership to improve all aspects of feed formulation, manufacture and use in fish farming in both countries. The project improved the capacity for nutritional research in Vietnam and consolidated nutritional research capacity in Australia. Nutritional models were developed to account for growth prediction and utilisation of nutrients. Finfish (barramundi, grouper and cobia), mud crab and spiny lobster were the key species studied. The project built on efforts related to diet development and replacement of fish meal and fish oils from three previous ACIAR projects.

The project initiated the Regional Aquafeed Forums (RAFs), which is an annual meeting of feed manufacturers, fish farmers, researchers and policy makers in Vietnam. The RAFs have directly facilitated the integration of the various sectors of the aquaculture industry, helping it to become a mature and economically important industry (aquaculture exports from Vietnam are worth approximately US$5 billion annually). Continuation of the RAFs will ensure the impacts of the project will continue in the future.

Feeding fish in marine cages in Vietnam. Source: Chris Barlow, ACIAR

The project team was successful in developing nutritional technology for barramundi, cobia, grouper, mud crabs and lobster. The skills and knowledge gained can be applied to other species. There is potential to apply the lessons from this research to Australia. Project partners include CSIRO Marine and Atmospheric; Vietnam Research Institute for Aquaculture No. 2; University of Nha Trang Vietnam; and NSW Fisheries.

Brett Glencross and barramundi in Indonesia. Photo: Chris Barlow, ACIAR

Shark resources in PNG and Australia

The shark fishery in PNG is the country's fifth most important export fishery and is worth about K8 million annually. Sharks are also important to the artisanal fishery and are a potential resource for ecotourism. However, there is no detailed information on the sustainability of the fishery and the shark and ray resources of PNG are in general

poorly understood. It is also highly likely that the shark resources of PNG are shared with neighbouring countries, e.g. Australia, Indonesia, and adjacent South Pacific island nations such as the Solomon Islands.

One ACIAR project aims to describe the biological, economic, social, catch and gear characteristics of the fisheries exploiting shark and ray resources. It also intends to assess the status of the stocks of key species to determine the extent to which they are, or could be, shared with Australia and Indonesia and provide advice on necessary changes to current management plans.

Tiger Shark caught on a shark longline boat operating out of Rabaul. Photo: Noah Lurang Jr.

Another similar ACIAR project is assessing the number, type and distribution of tuna fishery fish aggregating devices (FADs) across the Indonesian archipelago. As a priority for a next phase of cooperation with Australia on pelagic fisheries research, Indonesia identified the need to address information gaps surrounding these two species and the fisheries based on them. There is recognition of the benefits that will accrue from building on the achievements of earlier ACIAR project collaborations on Indonesia's tuna fisheries and the need to further expand the research capabilities within Indonesia's Agency of Marine and Fisheries Research and Development.

New crops for Australia

A number of ACIAR projects in the horticultural sector have the capacity to grow Australian trade and increase investment by linking Australian chocolate producers with partner countries providers.

Innovations open up new opportunities in cocoa and chocolate

Queensland's small-but-growing cocoa industry and Australia's growing engagement in the high-end market for single-origin chocolate illustrate various

dimensions of the relationship between Australia's dynamic agricultural innovation system and the new opportunities that can be created for trade and economic development:

Over many years, ACIAR has developed partnerships and supported collaborative research, linking cocoa experts in Australian universities (especially University of Sydney, Curtin and La Trobe), State and Territory departments of primary industry (especially Queensland's Department of Agricultural and Fisheries, Q-DAF) with their cocoa research-and-development counterparts in neighbouring countries (especially Indonesia, Papua New Guinea (PNG), Solomon Islands, Vanuatu, Fiji and Samoa).

When Australian chocolate-maker Cadbury Ltd teamed up in 1999 with Rural Industries Research and Development Corporation (RIRDC) and the DPIs of Queensland, Northern Territory and Western Australia to evaluate the feasibility of producing cocoa in Australia, these existing partnerships paved the way for obtaining the latest cocoa hybrids from the international breeding program of the Cocoa and Coconut Institute Ltd (CCIL) of PNG. These hybrids were tested at multiple sites across tropical Australia, performing best in far-North Queensland, where they now provide the basis for growing commercial production by companies such as Daintree Estates.

Most of the world's cocoa production is in developing countries with much lower labour costs than Australia's. If they are to be competitive in this global market, Queensland's producers must harness the latest innovations in breeding, crop nutrition and orchard management. They gain access to such innovations and help to generate new technologies through participation in ACIAR projects. New varieties and on-farm selections of highly productive, disease-resistant cocoa continue to become available through ongoing work with CCIL (in PNG) and through a partnership with Mars Inc. and local research and development partners in Indonesia; these partners are also working with Australian universities and Q-DAF to optimize fertiliser regimes and other soil management options for cocoa.

A particularly promising production innovation is the use of trellising. The idea of using this approach for tropical fruits arose from collaboration between Q-DAF and local tropical fruit producers in Queensland, in the wake of Cyclones Yasi in February 2011 and Larry in March 2006. Training the trees along trellises can increase productivity per unit of area and open the way to at least partial mechanisation, as well as reducing the vulnerability of cocoa and other tree crops to cyclone damage. This innovation has been trialled with cocoa in Indonesia and with other crops in the Philippines and is now being adopted by Australian cocoa producers such as Mackay's and Charley's Chocolate Factory. ACIAR and Q-DAF will continue to evaluate and promote the use of trellising with partners in the smaller Pacific islands such as Vanuatu, as part of a broader effort to increase the resilience of the region's economies in the face of extreme weather and climate change.

Given the potential increase in destructive cyclones in the Pacific as a result of climate change, trellising of cocoa and other tropical fruit crops deserves additional research. In far north Queensland the jury is still out for many growers because of the high upfront cost of trellis construction and additional pruning costs. However, a number of key players have embraced trellising as a form of cyclone insurance and hopefully as a means to an end for higher yields and improved quality.

Australia's chocolate makers are relatively small by global standards but have increased their competitiveness and profitability by developing 'single origin' products – a trend pioneered in wines and coffee and now being pursued in chocolate and other cocoa products. Australian bean-to-bar manufacturers such as Daintree Estates and Charley's Chocolate Factory have promoted their own products in this way but have also started to purchase cocoa from suitable producers in neighbouring countries, such as Samoa and Fiji, to produce single-origin bars.

Two cocoa producers from Queensland and one each from Fiji, Solomon Islands and Papua New Guinea were among those to receive prestigious 'Cocoa of Excellence' awards at a recent competition in Paris, helping to establish the place of the Australia-Pacific region in global high-quality markets. Photo: Grant Vinning

For those producers in developing countries who can meet the necessary quality standards, participating in fine-flavour and single-origin chocolate markets, can greatly improve the returns to smallholder producers, as well as contribute to their country's trading position. Through participation in ACIAR projects, Australian high-end chocolate makers Haigh's, Zokoko and Bahen & Co have helped small-scale producers in Vanuatu and Solomon Islands to improve their quality and gain higher prices by exporting to these markets in Australia. This growing trade in an increasingly valuable commodity brings benefits to all partners in the Australia-Pacific region.

Mangoes in Pakistan

Traditionally, Pakistan mango retailers included street hawkers, fruit and vegetable shops, supermarkets, roadside stalls and food service outlets. Most mangoes in

Pakistan are sold by street hawkers, who purchase daily requirements from local wholesale markets. Specialist fruit and vegetable shops are uncommon, but are found in larger cities. Very few supermarkets operate in Pakistan but multinationals are expected to open in 2-3 years. Roadside stalls in mango production areas sell fourth or reject grade fruit at low prices. Food service outlets include better quality hotels, which may include mangoes in fruit baskets in guests' rooms, and restaurants that serve mangoes in season. The major export destinations for Pakistan mangoes are the Middle East, the United Kingdom and Europe.

ACIAR established two complementary projects in Pakistan to address issues for production and marketing of mangoes. Working with local partners, integrated crop management practices were researched and improvements in the mango value chain sought. The focus of the first project was on instituting nursery best practice and improved management of established orchards, reducing the incidence of disease and postharvest losses. The second project took an integrative approach on the whole value chain from farm to consumer.

Small grower Pakistani farmers working cooperatively for direct marketing. Photo: ACIAR

Significantly increased yields and improved fruit quality through adoption of canopy management and control of pests and diseases were achieved, providing higher returns to farmers. Successful commercialisation of controlled atmosphere sea freight of mangoes from Pakistan to the European Union/United Kingdom and improved domestic marketing strategies involving smallholder growers was developed. The consequence was that village-based opportunities to produce and market value-added products emerged with the potential to increase household income by 50%.

A group of small growers was trained under the project in best practices for production of quality mangos. An aspiring young grower from the group was encouraged to apply for a six week pro-poor market development course at Queensland University, under the Australian Awards short courses funded by DFAT. Upon return, leader Mr Sadaqat assembled a group of small growers who are willing

to work cooperatively for direct marketing. A small sale outlet in the main city was established while two young men were hired for home delivery.

The inclusion of an Australian commercial mango grower to the project team added tremendous value to the study as Pakistan growers related better to a grower and the grower was able to give a commercial perspective. The practical approach of the project, that is the development of some new model supply chains, rather than a pure analysis with policy and high level recommendations, has been well received.

Pakistan mangoes on the wharf awaiting loading. Photo: ACIAR

A significant benefit to Australian mango producers has been the opportunity to capitalise on the production of out-of-season mangos from Pakistan to ensure continuity of supply from Australian producers to their customers. Looking forward, there could be arrangements where Australian and Pakistani mango growers become the partners with each handling their part in their respective countries. A mango grower from Queensland, John Morton has shown keen interest in such and arrangement with Pakistan. A former Chairman of the Australian Mango Industry association recently visited Pakistan and also shown interest in the potential of such an arrangement.

The activity demonstrates the benefits of a value chain approach for small growers. In addition to more earning, the group created jobs at the local level. The Australian assistance has proven its effectiveness in improving small income, job creation at local level and quality produce for consumers. It has also demonstrated the usefulness of a whole-of-government approach where linkages of developmental activities brought great results.

Disease-resistant mungbean

Mungbean is one of the most important food legumes in Asia and the most important summer legume in northern Australia. Australian mungbean crop will benefit from cooperation in a plant breeding project being undertaken by ACIAR and from increased knowledge of the partner countries' mungbean industries.

The project is addressing major constraints to mungbean productivity by bringing together the World Vegetable Centre and the Australian mungbean breeding program based at the Queensland Department of Agriculture, Fisheries and Forestry. Building on available genetic material allowing for a fast start of activities, co-funded by the Grains Research and Development Corporation and ACIAR. The project will identify key areas for germplasm enhancement and use available genetic resources to study resistance to three biotic stresses.

Water-efficient sorghum benefiting global cropping systems

Sorghum grown in India in the post-rainy season (Rabi), and within Australia's cropping systems, relies on residual soil moisture, and the crop is commonly exposed to terminal drought stress. But there is a ready market for its high-quality grain and stover (used as fodder on dairy farms). Steps to improve productivity while maintaining quality offer an attractive opportunity for sorghum farmers to improve incomes and farm profitability.

Genetically improving the efficiency of using stored soil moisture is a prime target to maximise grain/stover production and quality of sorghum. ACIAR's support to international research partnerships is achieving this through the application of DNA sequences known as quantitative trait loci (QTLs). The project scientists will introduce marker-assisted introgression of stay-green QTLs into sorghum lines, enhancing both the quality and the quantity of grain/stover of postrainy sorghum.

The partnership will also use modelling to identify the key physiological traits involved in a higher, more stable yield across water-limited environments of India and Australia, and the key stay-green QTLs contributing to these traits.

Forestry

Australia has a large, and growing, appetite for imported forest products including solid and reconstituted wood, wooden furniture, pulp and paper. Much of this comes from South East Asian countries – Indonesia, Vietnam and China - and much of this has been aided by ACIAR projects either via improved germplasm and site management (Eucalyptus and Acacia) or improved wood production and manufacturing processes, and more recently, activities to reduce costs of demonstrating legality (now required by law for all forest products imported to Australia).

Balsa Wood Enhancement in PNG

ACIAR is supporting a research project - *Improving the PNG balsa value chain to enhance smallholder livelihoods* - to improve the value, value recovery and international competitiveness of the PNG balsa industry and, by doing so, optimize benefits for smallholder growers in East New Britain Province.

The PNG Forest Authority aims to build a sector that is sustainable and highly profitable, while recognising the importance of promoting community forestry activities to empower rural communities and alleviate poverty. The established balsa industry in East New Britain (ENB) is the best example nationally of a successful value-adding forest industry involving smallholder tree growing.

PNG is the world's second largest balsa supplier after Ecuador, with an export value of approximately PGK11.2million in 2008. Balsa cultivation is an attractive and competitive land use option for both large and small-scale landowners with few barriers to entry.

Smallholders engage in balsa growing both individually and, increasingly over the past decade, as groups working collaboratively. Currently, around 75% of the planted area is smallholder plantation, and almost all of this is managed as blocks of >20 ha by landowners who have pooled their resources to maximise their returns.

One byproduct of this project is research being undertaken by Nathan Kotlarewski, a PhD student from Swinburne University, who is developing new balsa products for the PNG balsa industry to enhance the livelihoods of smallholders who rely on balsa production for financial returns in conjunction with ACIAR's project.

Nathan Kotlarewski demonstrating his balsa wood panel with Jaupo Zavivi Minimulu, ACIAR PNG Project Officer. Photo: ACIAR

Nathan was part of an undergraduate project team who worked on supplying of balsa wood to Swinburne for student projects and the utilisation of balsa as the raw

material for product design and business development. Nathan accompanied the ACIAR project leader to PNG to see balsa as a crop and it was there that the link between the benefits to the smallholder farmers and use of balsa became apparent. The result has been the production of a novel new product with a broad range of benefits to the Australian building sector. It is a light weight fit for purpose panel used in high-rise residential developments and/or as a partition in open plan offices. The weight benefit is significant to savings in the cost of a building. The panel has an inner balsa core and an outer skin of appearance grade products

Nathan has been working with a number of Australian companies and it is possible that the outcomes of the project will generate a range of opportunities for Australia's private sector and has published a number of papers on the properties of balsa wood.

Nathan recently won the 2015 International Green Interior Awards. The International Green Interior Awards are a platform created by Australian Living in 2011 to inspire interior designers and architects to realise the beauty and benefits of integrating green interior products into projects. These Awards also encourages manufacturers and innovators to design and make interior products that are healthy for us and our environment.

The commercialisation of the product must be underpinned by evidence as any investor would undertake due diligence and seek evidence. This requirement reinforces the importance of ACIAR project technical outputs such as reports and publications and papers.

Australian import businesses now have additional products to import, promote and supply to customers. The part processed balsa wood could also be imported from PNG with the final manufacturing undertaken in Australia. Alternatively, and possibly preferably due to transport costs, the finished product could be manufactured in PNG, where there are a number of potential partners to take on the product. This could be with an Australian or PNG company or consortia.

Plantation forestry improvements in Indonesia and Australia

Between 1987 and 2006, ACIAR invested in twelve forestry projects in Indonesia with the aim of improving plantation forestry in both Indonesia and Australia. These projects focussed on the domestication and silviculture of Australian trees and other multi-purpose trees such as sandalwood. They also undertook research on genetic improvement of plantation trees, control of fungal diseases and insect pests and on policy instruments for sustainable plantation management.

An independent impact assessment calculated benefits worth AUD 11.914 billion from the 12 projects. For the cluster of projects on Australian trees, evidence of impact was only found in Indonesia, associated with the expansion and improved productivity of *Acacia* and *Eucalyptus* industrial pulpwood plantations.

Conversely, for the agroforestry and multi-purpose trees cluster of projects, the study found evidence of impact only in Australia, related to the development of the Ord River sandalwood plantation industry, with estimated to be worth AUD 766.48 million.

Product of ACIAR forestry projects in Indonesia. Source: Tony Bartlett, ACIAR

Dr Eko Hardiyanto, University of Gadja Mada, measuring an Acacia tree in Indonesia. Source: Tony Bartlett, ACIAR

This program of research has generated very high returns and benefits to both Indonesia and Australia. In Indonesia most of these benefits relate to the large expansion of short rotation plantations of *Acacias* and *Eucalyptus* that produce wood for Indonesia's pulp mills – which produce paper that Australia buys. In Australia it led to the development of the sandalwood industry around Kununurra.

Conclusion

ACIAR makes a unique contribution to the development and deployment of technology to increase agricultural productivity in developing countries and in Australia. Independent studies show benefits that have flowed to Australia to exceed $2.5 billion, and Australia's contribution to international agricultural research centres delivering annual benefits to Australia estimated at more than $100 million a year.

Future increases to agricultural productivity in Australia, through improvements in the efficiency of agricultural practices due to new technology, emerging technology relevant to the agricultural sector, and overcoming barriers to the adoption of emerging technology, will continue to have both direct and indirect impacts on the export of Australian agricultural products, technology and knowhow. Innovation, along with adaptability and flexibility, are essential to ACIAR's work, and these are built into the way in which ACIAR works with our in-country collaborators.