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IN RESEARCH FOR DEVELOPMENT

CLIMATE CHANGE

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RESTORING CHINA'S GRASSLANDS

Coping with climate change

Agriculture depends on the sustainable use of natural resources and, for this reason, will be more directly and significantly affected by climate change than other sectors of the economy. Agriculture is also a significant contributor to climate change. Developing countries are more likely to be affected by climate change because they rely more on agriculture for employment and contribution to their economies.

And the poorest farmers—who are often located on the more marginal production areas—could be expected to bear the brunt of climate-change impacts first. They are also generally the first to feel the effects of seasonal climate variability.

Agricultural research plays a central role in helping farmers, farmer communities and policymakers develop strategies to adapt to, or lessen the effects of, climate change. In the first instance, ACIAR funds several projects that address *seasonal* climate variability. Some of the tools that are developed to make decisions on seasonal variability can then be applied to longer-term shifts in climate associated with global warming.

Improving the reliability of seasonal forecasts is a key tool for reducing farmers' exposure to risk. One project in Lombok (eastern Indonesia) is applying the knowledge of seasonal climate forecasting to the management of irrigation systems, while another in the Philippines is looking at potential economic benefits of seasonal forecasts and how they can be used in setting policies (see 'Profiting from the climate prophets').

Reducing carbon emissions and other greenhouse gases that contribute to climate change is another focus for ACIAR. Examples covered in this issue of *Partners* include assessments of carbon sequestration in Indonesia, where economists and scientists are working out ways to pay farmers for planting forests, or for leaving forests standing; the 'Happy Seeder' project in the Punjab state of India, which addresses the environmental and public health benefits derived from sowing seed directly into the soil without the need for burning off stubble from the previous crop; and management of nitrogenous fertilisers in the North China Plain, where scientists have shown that, by reducing the amount of fertiliser used on rice crops, not only is there reduced wastage and improved profits for farmers, but also less emissions of nitrous oxide—one of the most potent greenhouse gases.

Most of ACIAR's climate-change work is concerned with adaptation—helping build the capacity of farmers to respond to climate change, through the development of more sustainable, resilient agricultural systems. This can be achieved by identifying and developing new crop varieties—for example breeding for better water-use efficiency, tolerance to drought and water-logging, and resistance to pests and disease that may become more prevalent in a changed climate. An important aspect of this work is the collection of data and material for international gene banks.

> Each of these climate-change projects is driven by the need to improve smallholder productivity.

Another way that more resilient agricultural systems can be achieved in the face of shifting climates is by changing farming practices. In a China grasslands project, for example, reducing livestock numbers was shown to increase yields and profits for smallholder farmers, at the same time reducing soil erosion and methane production.

Each of these climate-change projects is driven by the need to improve smallholder productivity while at the same time addressing climate change and environmental protection. If new practices and products can be shown to be cost-effective, and to improve agricultural profitability and sustainability, there is a good chance they will be adopted by farmers. And any benefits to the environment, in terms of reduced greenhouse gas emissions and land degradation, will follow.

partners
IN RESEARCH FOR DEVELOPMENT

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Features

PHOTO: NICOLAI DZYUBENKO

ACIAR-supported projects have involved the collection of genetic material from ancient and wild forms of crops in Central Asia. Shown here are oxen threshing wheat in the Bardakashan autonomous province of Tajikistan.

Plant breeders prepare for climate change

Crop breeding is proving a viable tool to assist in adapting to climate change

BY DR TONY FISCHER

Well before issues such as rising carbon dioxide levels and altered weather patterns began filling newspaper headlines, ACIAR crop researchers were laying the groundwork for a response to climate change.

It is not that we have been better than others at predicting the future but, through good scientific judgement and a bit of serendipity, many projects within ACIAR's Crop Improvement and Management Program already contain key aspects relevant to changing climate and weather patterns.

Consider ongoing ACIAR work, for example, to strengthen crop breeding in developing nations, much of which involves understanding and screening for traits that confer adaptations to drought and other climate constraints, conducting yield testing and releasing suitable varieties.

A critical part of this work has been to build local scientific breeding capabilities and engage farmers through on-farm testing. If you can help build the agronomic infrastructure in these nations and encourage farmers to shift from a subsistence existence towards a more commercial approach and stand on their own feet, they will be better able to cope with the effects of climate change. You cannot be sustainable or have crops that are resistant or tolerant in the face of climate change if you are struggling to survive under normal conditions.

Breeding projects range according to the needs of the collaborating country. Some have involved the introduction, testing, selection and, ultimately, release of improved crop varieties. Other projects have introduced the latest biological 'tools', such as molecular markers and transgenic approaches, to encourage specific traits.

The key effect of these projects is to be found in improved varieties in farmers' fields. But the identification of better genetic material, the use of smarter methods of breeding and/or the development of more skilled breeders are other important outcomes from ACIAR projects.

Particularly successful has been the work of ACIAR/AusAID with the Ministry of Agriculture, Forestry and Fisheries (MAFF) in East Timor to produce new varieties of the country's staple crops—maize, cassava, sweet potato, ground nut and rice—for farmers' fields.

In 2002, straight after the former Indonesian province achieved independence, extensive testing began on introduced improved cultivars. This led

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PHOTO: CLIVE FRANCIS

Farmers and their families inspect a field demonstration of a new lentil cultivar in south-eastern Nepal.

to MAFF naming and releasing seven new varieties early this year, which have already being planted by hundreds of farmers. These are the first varieties ever released by MAFF.

This work will mean more food available for a country whose agriculture currently barely feeds its own farmers and is always threatened by El Niño drought.

Afghanistan is another country where drought is already a big climatic factor. Here farmers are benefiting from new varieties of the major food crop—wheat—released in recent years under an ACIAR/AusAID-supported project conducted by Mexico's International Maize and Wheat Improvement Center (CIMMYT).

Drought is also a major climatic factor limiting production-crop breeding elsewhere in many of ACIAR's partner countries and so it is common for projects to deal with developing resistance to this.

Recent ACIAR peanut projects in India built on earlier work that assessed and analysed crop performance under drought in three key areas: water use, transpiration efficiency and harvest index (which indicates grain yield). Substantial genetic variation for these traits showed relationships to yield. As a result, a major

PHOTO: SHU FUKAI

Efforts to strengthen crop breeding in developing countries include work in Cambodia on drought-resistant varieties of rice.

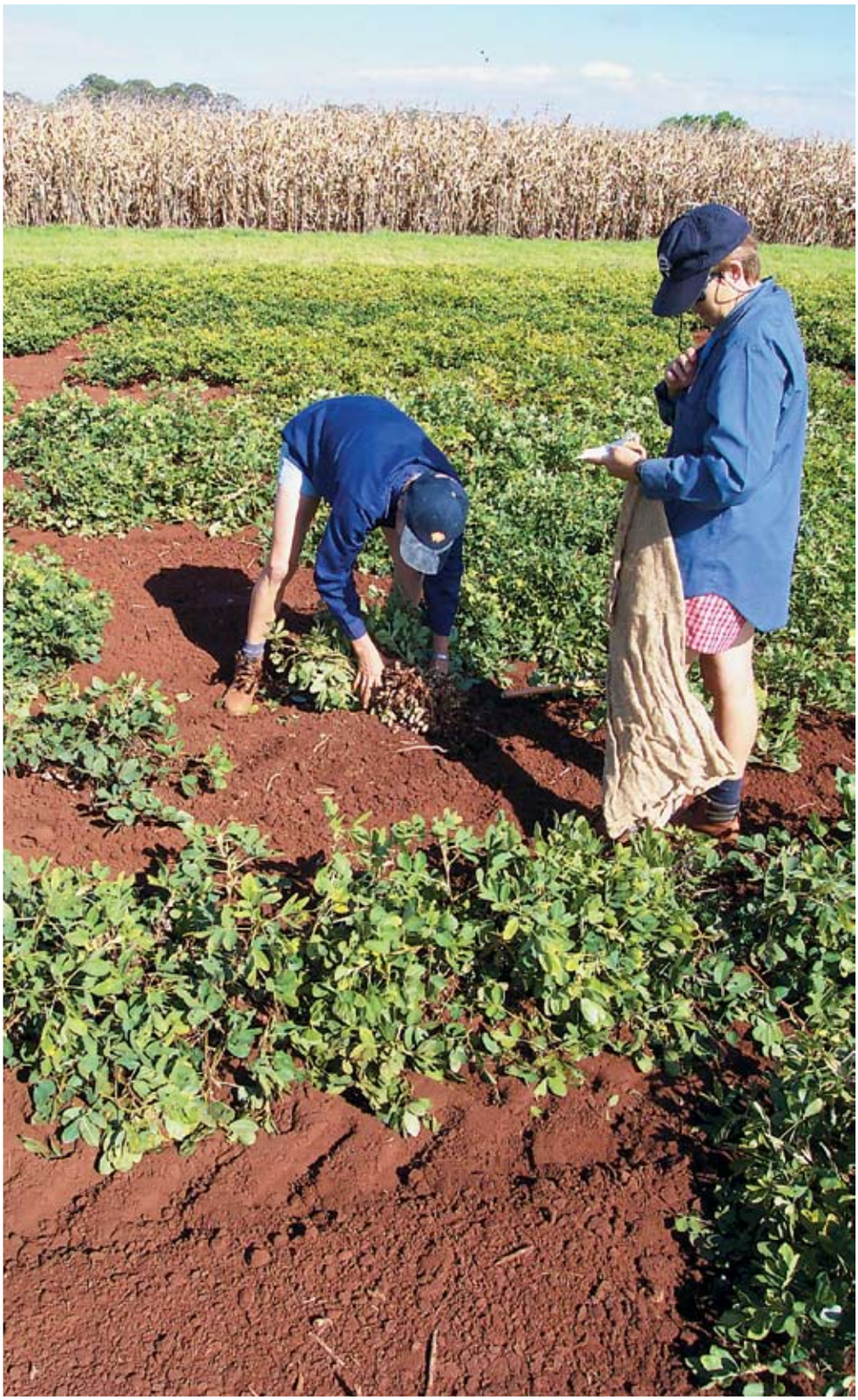

PHOTO: NO NAME SUPPLIED??

Harvesting peanuts and testing yield samples from different breeding lines at the Department of Primary Industries and Fisheries Research Station in Kingaroy, Queensland.

targeted breeding effort based on these followed and involved many institutions across India, including the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The first variety from the project, which was recently released in southern Andra Pradesh, has brought much excitement from farmers.

ACIAR-funded projects in Bangladesh and Nepal to improve lentils have also been significant. Lentils are grown on residual monsoon moisture in these countries by very poor farmers. Drought and warm-climate diseases are the major constraints of this crop, which is normally grown in temperate winter rainfall environments at higher latitudes.

The project has linked local and Australian institutions with the world centre for lentil breeding, the International

Germplasm catalogues could become particularly valuable for identifying genes adapted to conditions that may emerge as climate change progresses.

Center for Agricultural Research in the Dry Areas (ICARDA). Much new genetic material has been introduced for testing and crossing, and superior new varieties have been released in both countries, leading to significant lentil production increases. One variety, Barimasur-4, released in 1996 in Bangladesh, adds an estimated 40,000 tonnes annually to local production. Improved varieties have also been recently released in Nepal.

Again, an important feature of these projects has been to train local breeders, which means they will be better able, when needed, to adapt to climate change.

Rainfed lowland rice comprises a major agricultural production system in the central Mekong basin, in north-eastern Thailand, and is another crop constrained more often by drought than other climate factors. ACIAR support has had a major effect on the breeding capacity and strategy used there. As a result, variety production time has been shortened by 30%, with drought-screening and wider testing likely to further improve efficiency, and promising high-yielding lines being produced.

Soybean is an important new crop in Vietnam and an ACIAR project has helped local breeders introduce genetic sources of adaptations to this country's seasonal climatic conditions. One variety—DT21—was released in 2006 and is now grown on several hundred hectares in the Red River delta region. It is adapted to winter and spring plantings, but will produce under summer planting as well, providing fresh seed for the next winter, important because soybean seed does not keep well over tropical summers. Other promising varieties are in the pipeline.

ACIAR-supported projects carried out during the past decade through ICARDA have also been laying important groundwork relevant to changing climatic conditions. These have involved the ↳

PHOTO: BRAD COLLIS

Australian researcher Dr Clive Francis searching for ancient pulse and legume varieties in Armenia as part of the ACIAR-supported germplasm collection work undertaken by ICARDA.

extensive collection, description and storage in gene banks of genetic material from ancient or wild forms of crops from Central Asia and the Caucasus (Eurasia). The genes they contain could be useful for introducing adaptations, such as heat resistance, into crops in response to climate change.

This work has also been valuable because climate change could be accelerating the extinction of some potentially important species, such as those that now exist only in unique mountain-top refuges, but which may disappear forever from the wild as conditions warm. The genetic diversity contained within these old varieties is sometimes called upon by plant breeders and this may now be particularly important in the face of new climate stresses.

Many of the world's major crops originated in Central Asia and the Caucasus, including wheat, barley and other cereals, grain legumes such as chick peas, lentils and peas, and forage legumes such as lucerne and clover. To date, more than 3000 new accessions of these and other agricultural species have been collected under ACIAR projects.

Germplasm catalogues are stored safely within their respective countries of origin as well as with ICARDA and are available to researchers throughout the world. These sorts of databases could become particularly valuable for identifying genes adapted to conditions that may emerge as climate change progresses. Similar ACIAR work in China has focused on gathering germplasm from old varieties of grain legumes, such as adzuki beans, faba beans and peas.

One way breeders can search for useful material in such collections is to match the climate of the location where the germplasm was acquired to that of the region they are targeting. This is significantly helped by good databases.

An excellent example is the database of tropical forage genetic material, developed as part of a recently completed ACIAR project involving CSIRO, the International Livestock Research Institute (ILRI) and the International Center for Tropical Agriculture (CIAT). This comprises the best available information on the adaptation and potential use of 180 tropical forage species. It is accessible via the internet and already receives thousands of enquiries every month.

ACIAR has supported similar projects through CIMMYT. These have made important contributions to databases such as the International Crop Information System (ICIS), Systemwide Information Network for Genetic Resources (SINGER) and International Wheat Information System (IWIS). Such databases will be important for successful plant-breeding programs for major crops worldwide and could prove to be crucial tools in building protection against climate change. ■

Dr Tony Fischer is a former ACIAR research program manager in the areas of Crop Improvement and Nutrition, and Land and Water Resources. Regarded internationally as one of the world's leading crop physiologists, he is the 2007 recipient of the prestigious Farrer Memorial Medal (see page 26).

CHALKY RICE

As higher temperatures affect rice quality around the world, researchers are developing DNA markers to produce more heat-tolerant varieties and stop rice grain turning to 'chalk'

BY GIO BRAIDOTTI

Rice that breaks or powders during milling due to a defect called 'chalk' affects growers across all socioeconomic scales—from villagers who grow rice for home consumption to large-scale farmers servicing export markets. The trait becomes more prevalent with high temperatures, a fact that leaves rice breeders in no doubt that climate change will bring quality and yield losses to rice growers unless counter-measures are developed.

The problem of chalky grain has been around for a long time and, despite considerable research, nobody has succeeded in breeding chalk out of rice. With a temperature rise of just 2° C sufficient to trigger the trait, researchers have noted that a 4° C increase could ruin entire crops, except for particular uses such as risotto, paella and sake.

In the past, research efforts focused on starch biochemistry, since loosely packed starch granules characterise chalky grain. But starting in 1997, Dr Melissa Fitzgerald, a Philippines-based researcher with close ties to the Australian rice industry, has overturned that conventional wisdom about chalk.

Dr Fitzgerald heads the Grain Quality, Nutrition and Postharvest Centre at the International Rice Research Institute (IRRI) in the Philippines. About 18 months ago, she had a 'scientific moment' during a seminar that helped her redefine chalk's underlying causes.

The seminar related to using a nitrogen isotope to trace where new growth occurs during rice development. The study found that during grain-filling, rice plants are able to switch resources away from making seed and into developing more stems or tillers.

"That means rice is not a true annual—it is actually a weak perennial," Dr Fitzgerald says. "I then realised chalk has nothing to do with how starch is made. Rather the panicle—the plant's branched flower-head where seed develops—has no control over the amount of time available to fill grain. There is a cut-off time. So what we call chalk is simply grain that did not mature in time."

This new perspective allowed Dr Fitzgerald to make sense of an earlier observation involving panicle architecture. Previously she had noted that panicles form primary branches during early stages of seed development and secondary branches later in development. Given that late-developing grain is more susceptible to the cut-off in seed production, Dr Fitzgerald suddenly understood why grain located on secondary branches is often much chalkier than on primary branches.

> Climate change will bring quality and yield losses to rice growers unless counter-measures are developed.

"When I went to IRRI, I realised how much variability there is in panicle architecture in different rice varieties," she says. "There were varieties in the Philippines that were rarely chalky. When I looked at their panicles, they had very few secondary branches, indicating that panicle architecture is under genetic control and these genes play a role in chalk."

While this amounted to a new way of thinking about chalk, Dr Fitzgerald needed to connect the new mechanism to heat stress. Experiments quickly followed where she compared plants grown at 26° C and 33° C. She found that at the higher temperature, plants had only half as many days in which to make grain (14 compared with 30).

"Because of the shorter time available for grain-filling, there is more immature grain at higher temperatures, with immaturity expressing as chalk," she explains. "So overall, rice is a weak perennial with a limited amount of time devoted to grain production and that time is reduced by high temperature."

With the focus still on heat stress, she also found that different rice varieties, with different underlying tendencies to chalk, also mount different stress responses. At one extreme, the plant attempts to fill all grain, resulting in high yields of low-quality, chalky rice. At the other end, the plant sacrifices half the grain, resulting in low yields of high-quality grain. Variation in this stress response was also found to be under genetic control.

"The work immediately suggested a number of ways to reduce the occurrence of chalk," Dr Fitzgerald says. "What we need to do is minimise secondary branching in the panicle, extend the time available for grain-filling, and select for a heat-stress response that avoids chalking."

Towards that goal, Dr Fitzgerald's IRRI team is using ACIAR funds to map newly discovered genetic variation for chalk traits onto discrete regions of the rice genome. DNA markers can then be developed to facilitate selective-breeding efforts that could deliver rice varieties less prone to chalk at high temperature. ■

PARTNER COUNTRY: The Philippines

PROJECT: CIM/2006/176: Develop molecular markers for rice breeders to reduce the occurrence of low-quality 'chalky' grain

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PHOTO: CAT MURRAY

A typical goat and sheep farm on the low-altitude steppes of Inner Mongolia.

Restoring China's grasslands

An ACIAR project in western China aims to improve farmers' livelihoods while encouraging the rehabilitation of degraded ecosystems and reducing greenhouse gas emissions

BY KAREN McGHEE

Dust storms have long been a part of life in Beijing. China's capital can be blanketed during the northern spring by layers of dirt and grit up to two centimetres thick, as winds dump hundreds of thousands of tonnes of eroded soil across the city.

This airborne pollution is carried from the extensive native grasslands that stretch for some 3,000 kilometres across the nation, from the west to the north-east. As these ecosystems have become increasingly degraded, China's infamous dust problem has worsened, drawing complaints from as far away as Japan and Korea.

Dust storms are a consequence of increasing human and livestock populations on China's grasslands, large expanses of which are now characterised by low-income households and deteriorating ecosystems. "Studying dust problems independently of the way livestock are managed will not bring sustainable solutions," explains Professor Nan Zhibiao, dean of the College of Pastoral Science, Lanzhou University.

At the invitation of the Chinese Government, Professor David Kemp, one of the world's foremost scientific experts on temperate grasslands and chair of farming systems at Charles Sturt University in western New South Wales, travelled through China's north-west, speaking to farmers and officials, and quickly realised that ACIAR-supported work in the area could have a truly monumental impact.

The result was a $1 million farming-systems project headed by Professor Kemp, which is set to improve the incomes of millions of very poor farmers while simultaneously tackling environmental issues of global concern.

The grasslands in China are used to graze cattle, sheep, goats and yaks, and are diverse environments that range from the high-altitude seasonally frozen plains of the Qinghai-Tibetan plateau to the low-altitude steppes of Inner Mongolia.

They cover roughly the same area as Australia's grasslands—about 400 million hectares—but are considerably harsher environments from which to make a living. Across much of this pastureland, for example, temperatures range from –40° C in winter to summer highs of 40° C, plants grow for only three out of every 12 months and, at higher altitudes, upper soil layers remain frozen for much of each year.

PARTNER COUNTRY: China

PROJECT: LPS/2001/094: Sustainable development of grasslands in western China

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Despite the hardships, an estimated 40 million people in northern and western China, in some of the world's more impoverished communities, rely directly on these grazing lands for survival. And life is getting harder. About 80% of China's ↳

PHOTOS: DAVID KEMP

Top: Xu Zhu and Tian Qingsong at the Grassland Research Institute Field Station, Taipusi, examining the meadow steppe in August.
Above: David Kemp (centre) and Hou Fujiang, of the Gansu Grassland Ecological Research Institute (second from right), with farmers and local Animal Husbandry Bureau officials in the mixed cropping and grazing farms at Huanxian in eastern Gansu.

grasslands are considered degraded to some degree and the desert areas they abut in the west have been expanding annually by 2,500 square kilometres, although this phenomenal rate seems to have now slowed due to efforts to ameliorate the problem.

"You can sometimes be near the Gobi Desert and almost watch it [advance] towards you!" Professor Kemp says.

As one herder in Inner Mongolia commented recently: "Forty years ago we had trouble seeing the cattle; now we can easily see the mice."

ACIAR's response has been to take a highly collaborative, holistic approach to the problem. Professor Kemp found in 2002 that many ecological and agronomic aspects of the grasslands had already been well researched and documented by scientists and institutions within China. But little had been done to bring the results of this work together to develop practical and effective solutions.

ACIAR's resultant farming-systems study has been drawing on experience and expertise from six different research institutions throughout the country: the Gansu Grassland Ecological Research Institute, Gansu Agricultural University, Inner Mongolia Agricultural University, the Grassland Research Institute of the Chinese Academy of Agricultural Sciences, Research Centre for Rural Economy, and the Institute of Environment and Sustainable Development for Agriculture.

Using four study villages linked to different grassland environments, ACIAR has been identifying areas where farm management can be improved.

In Australia, the University of Queensland and New South Wales Department of Primary Industries are providing support for the project.

"We've spent a lot of time talking to the herders in China about what they do and how they manage through the year, and from that we're building a picture of what a typical farm does in each of the villages we've been studying," Professor Kemp explains.

His colleague Dr Xu Zhu, deputy director of the Grassland Research Institute, says: "A strength of the project has been the emphasis on finding economic solutions, while paying attention to grassland improvement."

Results from these explorations are being combined with known ecological, biological and agronomic information to build computer models that analyse the current practices of Chinese herdsmen and explore how altering these could improve financial and environmental outcomes. It is already clear that answers will require shifts in cultural practices that have been adopted over thousands of years.

Professor Wu Jianping, vice-president of Gansu Agricultural University, agrees the project has given their research a better scientific basis and helped generate new ideas that can be tested in the field.

One of the big issues is the number of animals grazing these environments. Compared with Australia, China's grasslands presently carry considerably more livestock.

"Our estimate is that there would be three to four times the number of animals in China as there would be in Australia on similar grassland types," Professor Kemp says, explaining that there is consensus that China's grasslands are being considerably overgrazed.

It is a phenomenon that began to appear during the past few decades, as ↳

PHOTO: CAT MURRAY

Goats are tagged for identification and their weight and health monitored during the life of ACIAR's China grasslands project.

PHOTOS: DAVID KEMP

Inner Mongolian herders take livestock out to graze every day, regardless of the conditions. These sheep were photographed in early December, on a –20 °C day.

stock numbers on the grasslands have more than doubled in response to human population growth and government policies and programs. The problem has been exacerbated by the conversion of some grasslands into croplands.

Traditional herd-management practices, largely born of social and community behaviours, can be counter-productive. For example, although the grasslands are green for only three months a year and covered with frost and dead plant remnants for the rest of the time, herdsmen typically graze their animals every day, no matter how inhospitable the weather or sparse the feed supply.

"The energy costs that animals expend just walking around are often greater than any nutrition they ever get out of the pastures, and they typically lose 25 to 30% of their bodyweight through autumn, winter and spring before regaining it over summer," Professor Kemp says.

As a result it takes cattle, for example, four to five years to reach the size of 18-month-old animals in Australia.

There are huge opportunities to make improvements by adjusting stock levels and the way grassland herds are being managed.

The group has been re-analysing data from stocking rate experiments conducted over the past 20 years by Professor Han Guodong at Inner Mongolia Agricultural University. His work shows the benefits of reducing stocking rates in summer, and how animal growth rates stop and they then lose weight as soon as the grass is frosted.

An option that Professor Kemp and his colleagues are advocating is a reduction in herd sizes by as much as half, and the grazing of animals only in summer months. For the rest of the year they should be kept in sheds, or other outbuildings that protect them from the elements, and hand-fed.

By streamlining production in this way, farmers should receive better returns for the efforts they put in, even though they have fewer animals. The remaining animals would have twice as much fodder available per head, which would result in much higher rates of meat, milk, wool and cashmere production. This should improve farmer incomes while reducing grazing pressures on the grasslands, so they have the chance to rehabilitate naturally.

The project is encouraging a far more cooperative approach among farmers, not only in the way they care for and manage their herds, but also the way they market them. This should give them better bargaining power to achieve premium prices for the products they produce from their grassland herds.

> Perhaps most importantly, given that traditionally their wealth is measured by herd size, these farmers now recognise that the quality of their animals is more important than how big their herd is.

A decline in dust storms is one eagerly awaited long-term outcome, but it is inevitable there will also be other big environmental spin-offs relevant to climate change. The return of more verdant grasslands will, for example, also be a sign that these ecosystems are removing more carbon dioxide from the Earth's atmosphere and locking it away in plant cells and tissues.

Good news is also expected about methane production: as declines in herd sizes should reduce livestock emissions of methane, a greenhouse gas that is considerably more potent than carbon dioxide, ACIAR's grasslands project is being partly funded by the Australian Greenhouse Office.

"If we can reduce animal numbers by 50% and get those remaining animals to grow faster so they reach marketable size quicker, we know that will reduce the total amount of greenhouse gases they produce over their lifetimes," Professor Kemp says. According to ACIAR's work, a reduction in methane production by 50% is likely to be reasonably easy to achieve by improving the efficiency of livestock production.

Rehabilitation of China's grasslands is likely to produce other significant outcomes. More grass will slow the flow of water over these landscapes, which will not only contribute further to cutting back

the soil-erosion problems that underlie some of Asia's worst dust storms, but also reduce siltation in watercourses such as the Yellow River.

To ensure government and bureaucratic policy is used to best effect, and that it supports the types of changes Professor Kemp and his colleagues are advocating, ACIAR is drawing on expertise within the University of Queensland's School of Natural and Rural Systems Management, which has been working in China for more than two decades.

"We're involved in the policy and institutional side of things," explains economist Dr Colin Brown, a senior lecturer in the school. "So we're looking at China's mix of plans, regulations, and programs that impact herder livelihoods and grassland degradation, not just specific grassland measures but also those in the marketing and organisational-structure area."

Dr Brown and his colleague Scott Waldron are investigating the formation, design and direction of relevant policies at the highest level of government in China. But their work on the ground with local-level officials, herders, enterprise managers, traders and others means they can also observe and investigate how the directions being set hundreds and even thousands of kilometres away in Beijing are affecting herder livelihoods and grassland degradation.

"By working with the Research Centre for Rural Economy based in Beijing, which has an extensive network of contacts throughout China, we are trying to understand how national policies are being implemented as you come down through the different layers of government in China," Dr Brown says.

As well as improving outcomes for China's animal herders and contributing to the resolution of major environmental problems, the sorts of lessons being learnt and the tools being developed in China are likely to have wider application in other Asian nations facing similar problems, as well as Australia.

Already the computer models being developed in this project are being adapted for Australian circumstances and should, by next year, begin helping local grassland farmers achieve more sustainable outcomes, both economic and environmental. ■

Siziwang herders

Genden smiles and says one of the best things about being a herder is "my freedom".

Living near Siziwang Banner, about 90 kilometres north of Hohhot, Genden is a herder in a scattered village community of the desert steppes in Inner Mongolia.

Along with his wife and son, Genden manages about 507 hectares of grazing land. Of this, Genden has a state leasehold for 440 ha and rents a further 67 ha. They have 200 sheep and 100 goats—about average for the area.

Genden says the most difficult or challenging part of being a herder is the fact that it has been so dry in recent times and his herd is starving. He says they have had no real rain for three years.

He and five other herders from his community have been selected to assist with the development of ACIAR's grasslands project. The village vet Alatensuhe helps Genden with work related to the research. This involves counting and tagging stock for identification, and monitoring the animals' weight and health during the life of the project.

Genden's neighbours wish they could also be officially involved in the project and have their animals monitored too. Generally the herders feel they know pretty much all there is to know about animal health: "We only go to a doctor for people illness."

They appreciate the advice they receive on land management from Chinese extension workers and research personnel, but recognise they have much to learn about how the right nutrition is essential to improving their herds. Watching, and participating in, this project gives them the opportunity to learn new farm-management skills.

The herders understand they will need to change their traditional feeding and fodder-production regimes, but are concerned at the lack of rain to enable this. They have also come to appreciate the value of checking for older and sick animals in their herd in order to improve the overall quality of their stock—something they do not usually do.

Perhaps most importantly, given that traditionally their wealth is measured by herd size, these farmers now recognise that the quality of their animals is more important than how big their herd is.

The herders say they hope that as a result of this project their animals will get bigger and have more weight, and that they are keen to get rid of older and sick animals. As Genden says: "We know there are markets out there willing to pay premiums for bigger and better animals; we hope to learn how to improve our animals to take advantage of that."

Siziwang herder Genden and his wife.

PHOTO: CAT MURRAY

Farm forests seen as commercial carbon sinks

A new carbon-sequestration study in Indonesia could pave the way for farmers to be paid for re-planting and maintaining forests

BY ROBIN TAYLOR

The concept of developing carbon markets to help lower greenhouse gas emissions by placing a tradable value on practices that offset emissions is gathering momentum around the world.

Of particular interest for agriculture is the role it can play in carbon sequestration—the process of removing carbon dioxide (CO_2) from the atmosphere and 'storing' it in plants that use sunlight to turn CO_2 into biomass and oxygen.

As far back as 1999, ACIAR initiated a carbon sequestration project that looked at its potential in Indonesia, addressing questions related to infrastructure, bioeconomic models and skills required.

That initial interest brought together Dr Oscar Cacho, an environmental economist at the University of New England (UNE), NSW, with expertise in developing market solutions to environmental problems, and a team at the Centre for Economic and Social Research in Forestry (CESRF) in Indonesia, led by Dr Erwidodo. CESRF had been discussing opportunities for carbon-emissions-trading research with ACIAR so, between the then ACIAR project manager Dr Ken Menz and the two groups, a second project to explore the economics of smallholder agroforestry in Indonesia to offset carbon emissions was developed.

Dr Cacho says the objective of this project is to find a way to encourage smallholders in Indonesia to plant trees and gain the multiple benefits of reducing deforestation, reducing CO_2 emissions from slash-and-burn agriculture, and reducing health problems from smoke inhalation.

Within the Kyoto Protocol, the clean development mechanism (CDM) is an arrangement that already allows industrialised countries with a commitment to reduce greenhouse gases to invest in emission-reducing projects in developing countries as an alternative to more costly emission reduction in their own countries.

Smallholder agroforestry systems, which address smallholders' livelihood needs and store large amounts of carbon, are viable

PHOTO: BRAD COLLIS

Smallholder farmers are starting to be encouraged to adopt practices that do not require deforestation, such as this, and instead start to replant trees to be part of future commercial carbon trading.

project types under the CDM, with its dual objective of emissions reduction and sustainable development.

The Intergovernmental Panel on Climate Change has identified change from cropland and grassland to agroforestry as the land-use change with the most potential for carbon sequestration globally.

The team from UNE worked with researchers from the CESRF (part of Indonesia's Forest Research and Development Agency) to examine the merits of different agroforestry systems for smallholder farmers and, on the policy side, to investigate how to link farmers with the international carbon market.

The focus was on large areas of

↳

Indonesia

PARTNER COUNTRY: Indonesia

PROJECT: PLIA/2002/066: Economic potential of land-use change and forestry for carbon sequestration and poverty reduction

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Carbon trading

Over millions of years, the Earth has managed to regulate concentrations of greenhouse gases through a system of sources and sinks. Carbon, in the form of carbon dioxide (CO_2) and methane, is emitted by volcanoes, rotting vegetation and other organic matter (collectively called 'sources'), and CO_2 is sequestered or absorbed by trees (the so-called 'sinks').

In modern times, the burning of fossil fuels combined with accelerated land clearance has led to unprecedented levels of greenhouse gas emissions. Carbon sinks cannot keep up and concentrations of greenhouse gases in the atmosphere have risen dramatically. Most scientists say that, as concentrations of these gases continue to rise, there will be a general and very rapid warming of the world's climate.

Carbon-emissions trading is seen as a way of cutting concentrations of atmospheric greenhouse gases and, at the same time, promoting reforestation. Carbon markets function by placing a cost on carbon emissions and a value on emissions reductions, and enabling trade of the resulting allowances or credits.

There are two ways to measure the amount of carbon sequestered in trees. The most accurate is to fell a tree, measure its total biomass and analyse all tree parts for carbon content. While this is not a practical method for calculating carbon stored in whole forests, it provides measures that can inform more general estimates. The second method is based on allometrics, the relationships between certain tree attributes—such as height and stem diameter—to the amount of carbon stored in trees. Groups in Australia, such as CSIRO and the Cooperative Research Centre (CRC) for Greenhouse Accounting, are working out these relationships for different species in different environments.

Additionally, the Australian Greenhouse Office, the CRC for Greenhouse Accounting, the Australian National University and others have developed methods to measure greenhouse gas emissions from activities such as soil cultivation, fire and electricity generation. These methods are evolving and improving.

Through this market-based approach to the problem of reducing emissions, participants buy and sell permits for emissions or credits for emissions reductions through regulated or voluntary markets.

More information: www.greenhouse.crc.org.au/tools/calculators/treecarbon

previously forested land in three regions—Jambi, East Kalimantan and Sulawesi. The researchers estimated the flow of carbon fixed by trees above ground and flows in soils and roots.

"We basically came up with a set of spreadsheet models that allow economic analysis of different agroforestry systems and also allow us to estimate how much carbon could be produced," Dr Cacho explains. "We looked at 26 different agroforesty systems. Some were complex, with more than five or 10 different species—trees that produce fruits, timber or resin—whereas others were just individual tree species."

Dr Cacho says the researchers found that some of these agroforestry systems could be quite profitable in certain areas of Indonesia and have already been developed by various farmers who would be well placed to earn carbon credits—in theory.

The researchers also identified a number of problems that were preventing smallholders from planting trees, the main one being a lack of credit. It costs money to establish trees and takes some years before income is generated. Another hurdle is a lack of technical expertise. It is, for example, easier to grow cassava than to manage a complex forest system.

Another problem for millions of smallholder farmers in Indonesia is lack of security over land tenure because of conflicting land claims. Farmers are unlikely to plant a long-term crop, such as trees, if they do not have secure tenure.

The researchers found that project viability is also sensitive to transaction costs (the costs of doing business), the trees' carbon-sequestration potential and the size of the participating farms. Transaction costs are quite substantial in projects where there are a large number of smallholders, compared with planting one large forest.

The researchers studied comparative transaction costs for marketing carbon from smallholder operations. They concluded that smallholders operating on an individual contract basis would require certified emission reduction prices ranging from $12 to $18 per tonne of CO_2 to profitably participate in carbon trading.

But by forming farmer groups and pooling land resources they could improve the viability of the project. For example, where a two-hectare farm requires $18 per tonne of CO_2 to be viable, if several farms are concentrated into 20-hectare units the project becomes feasible at a price of $10 per tonne of CO_2.

The project results also show how factors such as tree growth rates and the baseline condition of sites affect the project's viability. Carbon credits are measured relative to a baseline (business as usual) scenario. Only carbon captured above the baseline (that is, additional carbon absorbed) is eligible for credits.

Results from the project suggest that the best strategy for success with tree planting is to concentrate on degraded lands, which have low profitability and low carbon stocks (that is, a low baseline) relative to an agroforestry enterprise.

"Indonesia has millions of hectares of *Imperata* grasslands that may be ideal candidates for CDM projects," Dr Cacho says.

It is expensive (in terms of labour and materials) to clear these lands and establish trees. Carbon credits could provide the funding. In addition, the incentive to participate would be enhanced if communities and individuals were offered tenure of degraded state land that they restore. According to the project's findings, technically smallholders could be competitive with other activities in terms of carbon sequestration, but institutional constraints make it difficult.

Potentially, money from carbon-credit funds could be used to help farmers establish agroforestry and provide them with training, with a positive impact for poverty alleviation and the environment. ■

TreeSmart

For people wanting to plant trees for carbon credits, timber or other purposes, a useful output of the ACIAR project is a database called 'TreeSmart', which contains 110 Australian species with agroforestry potential in medium to low-rainfall areas (less than 600 millimetres) and data on tree growth, soil type and climate from various trials. The database can be adapted to include other species for other climates or geographic areas, making it a useful tool for forestry researchers in many countries.

TreeSmart is being prepared for public access through the internet. Management of the program and distribution will occur through the NSW Department of Primary Industries.

Agroforestry systems may have many uses, such as the collection of resin.

PHOTOS: OSCAR CACHO

A young agroforestry system in Malang, Java.

INDIA'S BURNING RICE BOWL

Stubble burning is a serious problem in the intensive-agricultural state of Punjab. Although new technology could stop the need to burn stubble, there are barriers to its adoption

BY REBECCA THYER

For up to 25 days each year, a vast cloud of smoke engulfs the Indian state of Punjab as farmers burn the stubble of freshly harvested rice.

Punjab, which straddles India's border with Pakistan, is often referred to as the country's 'bread basket' because it produces two-thirds of the country's food grains.

The size of the crop area also makes stubble burning a serious problem—more than 17 million tonnes of rice stubble is burnt each year. Widely practised in the mechanised rice–wheat systems of south Asia because it is fast, cheap and allows for a quick turnaround in crops, stubble burning has serious side-effects. It is detrimental to soil, human and animal health, other crops and remnant vegetation, and generates heavy atmospheric pollution.

In Punjab, more than 90% of the rice is harvested using combine harvesters, leaving loads of up to nine tonnes a hectare of rice stubble in the fields. This has to be dealt with before the next crop, usually wheat, can be planted.

Seeding machinery that can sow directly into rice stubble has been developed, but its uptake has been constrained. Many farmers lack the capital or economic impetus to invest, while other social or institutional issues have hindered its adoption.

Called the Happy Seeder, the machine was developed through a previous ACIAR project. It cuts and collects stubble in front of the sowing tynes, depositing it behind the seeder as mulch. The technology offers farmers a way to drill wheat directly into rice stubble without burning, thus eliminating smoke pollution and arresting nutrient and organic carbon loss.

One of the researchers behind the Happy Seeder is Dr Harminder Singh Sidhu, a research engineer with Punjab Agricultural University's Department of Farm Power and Machinery. With Australia's Charles Sturt University and machinery manufacturer Dasmesh Mechanical Works, the university has continually worked to improve the seeder.

Dr Sidhu says its adoption could also mitigate greenhouse gas emissions.

"It could be the answer to our burning problem, saving our environment and improving our soil health," he says.

However, critical to realising these benefits is the extent and rate of adoption. ACIAR commissioned a scoping study to assess the range and scale of policy-related issues relevant to Happy Seeder take-up, with a view to developing a project to overcome limitations identified.

PARTNER COUNTRY: India
PROJECT: PLIA/2006/180: Happy Seeder policy linkage scoping study
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The project, led by policy economist Phillip Pagan from the NSW Department of Primary Industries, considered a range of issues, from government and economic policies and reforms to specific agronomic constraints, and their impact on adoption. For example, some policy settings, such as those related to electricity and groundwater, mean that farmers may not financially benefit from adopting the Happy Seeder.

"Both electricity and groundwater are significant, but free inputs," Dr Pagan said. "Once supplies are connected to farms, at considerable capital expense, their use is unregulated, with no ongoing access or unit pricing."

These free inputs mean that many of the economic benefits of Happy Seeder adoption are less apparent: "The costs of following conventional farming practices are not borne by those farmers."

However, Dr Pagan expected that policy reform in this area would change farmers' circumstances and, as costs were felt more directly, the relative profitability of water-intensive rice production in comparison to other crops would decline.

Dr Pagan expected this would change the Happy Seeder's primary purpose—sowing wheat into rice stubble—and it would be adapted to other crop rotations. "It increases the potential for the Happy Seeder to be flexible in its ability to sow alternative crops into other types of heavy stubble loads."

Other constraints identified included design, agronomy, alternative technologies, low policy-maker awareness of these technologies' limitations, and government and private impediments to its manufacture, such as patenting issues, training and extension, and credit availability. Dr Pagan said that there should be a focus on alternative potential policy instruments and intellectual property protection options to help address these constraints. ■

ACIAR is sad to advise readers that Dr Phillip Pagan passed away on 1 September 2007. The results of Dr Pagan's study will be published in a forthcoming report and have provided a basis for further ACIAR projects, which he stood to lead. Our thoughts are with his family.

Targeted fertiliser lifts income and lowers waste

Although nitrogen deficiency is a major yield constraint for food crops in many parts of Asia, overuse of fertiliser can cause financial loss to farmers and problems for their environment

BY KELLIE PENFOLD

In smallholder-dominated farming communities in rural China, being able to increase a family's annual income by between $50 and $109, through educating people not to overuse nitrogen fertiliser and irrigation water, is not only a gain for those families but a bonus for their environment.

ACIAR has been funding an Australian research project working with wheat and maize growers on the North China Plain (NCP) to improve water and nitrogen-fertiliser efficiency, and reduce nitrate leaching and greenhouse gas (nitrous oxide) emissions. This region produces more than 30% of China's total grain, and its economy is largely based on small family farms. Even though the Chinese agricultural sector is expanding, Australian researchers have found farmers have little access to agronomic advice but can use cheap irrigation water and fertiliser, which is about a fifth the price of fertiliser in Australia because of indirect government subsidies.

Irrigated crops in China receive, on average, a massive 400–500 kilograms of nitrogen per hectare for a wheat and maize rotation, but in some areas more than 900 kg/ha. Only a third of this is used by the crop, so there is a loss of more than 1.7 million tonnes of nitrogen (worth some $1.3 billion) each year in the NCP.

Work done in a previous ACIAR project, completed in 2003, found as much as 120 kg/ha excess nitrogen was applied each year, and 30% of all irrigation water was lost because of poor practices. Overall, it found 25% of nitrogen and 30% of irrigation water could be saved without reducing the yields of wheat or maize, but with a substantial reduction in the nitrate leaching and the emission of nitrous oxide (N_2O) into the atmosphere as a greenhouse gas.

In cooperation with the Australian Greenhouse Office (AGO), ACIAR has now funded a second project, which will develop (using Australian and Chinese research sites) best management practices for water and fertiliser-use efficiency. The AGO has come on board to support research that may aid Australian farmers to best manage fertiliser use to reduce on-farm greenhouse gas emissions.

Project leader Associate Professor Deli Chen, from the University of Melbourne, says the approach to educating farmers in the NCP is "back to basics".

"It is very simple," he says. "The majority of farmers do not measure the water that is going onto their crop because they don't have to pay for the water they use. They just turn on the pump and, after two hours, turn it off. The decision on watering the crop is based on whether it is their day to water, not whether the crop needs it. As for fertiliser, the belief is that, the more you apply, the higher the crop yield."

The NCP is intensively farmed, with the average farm being about half a hectare. Traditionally, farms operate a double-cropping system of winter wheat and summer maize. There is limited opportunity for farmers to increase the size of their holdings, so the focus is on increasing production with water and fertiliser.

In the second project, researchers are investigating the effect of variables such as fertiliser rates, rainfall, irrigation and soil type on crop yield, water and nitrogen-use efficiency and environmental impacts. In Australia, these will be assessed on dryland wheat, irrigated maize and pastures, and in China on irrigated wheat and maize. The data will be used to test and validate the Geographic Information System (GIS)-based Water and Nitrogen Management Model (WNMM).

PARTNER COUNTRY: China

PROJECT: LWR/2003/039: Improving the management of water and nitrogen fertiliser for agricultural profitability, water quality and reduced N_20 emissions in China and Australia

CONTACT: Dr Deli Chen, delichen@unimelb.edu.au

PHOTOS: DELI CHEN

Professor Cai Guixin of the Institute of Soil Science, Chinese Academy of Sciences, setting up the equipment used to measure ammonia gas released from a wheat field at the Fengqiu experimental site, North China Plain.

A savings snapshot

In the North China Plain's (NCP) Fengqu County, the traditional nitrogen fertiliser rate is 500 kilograms a hectare per year, compared to Australia's 100 kg/ha/year. The average farm size is 0.53 ha with the county's 29,000 ha devoted to double-cropping of wheat in winter and maize in summer. Average farm income is about $1,890.

ACIAR-funded research on the NCP showed most nitrogen loss occurring as ammonia gas from maize. Nitrate leaching from over-watering was also a major issue, especially in growing maize, where up to 40% of a single water application was wasted.

The project recommendations for Fengqu County were to change the fertiliser application method to either direct drilling or surface broadcast followed by watering, reduce the rate of application, reduce the amount of water used and change the timing of flood irrigation during the course of the growing season, and retain and mulch the straw by-products into the soil.

Field results suggested that an annual fertiliser reduction of 115 kg/ha (23%) could be achieved without any effect on yield. Irrigation applications could be reduced by 30%, reducing electricity use by 35 kW and saving the farmer more money. If those recommendations were followed, a Fengqu County farmer with a 0.53 ha farm could expect an extra $50 of income annually, from $53 in cost savings less $3 from reduced grain output.

What is a greenhouse gas?

Atmospheric gases that absorb incoming energy and warm the lower atmosphere are known as greenhouse gases.

About 75% of the natural greenhouse effect is due to water vapour. The next most significant greenhouse gas is carbon dioxide, followed by methane, nitrous oxide, ozone, synthetic halocarbons (such as chlorofluorocarbons and hydrofluorocarbons) and sulfur hexafluoride—all of which are influenced by human activities.

Higher concentrations of greenhouse gases in the atmosphere will lead to increased trapping of infrared radiation. Scientists say the lower atmosphere is then likely to warm, changing the weather and climate.

The two greenhouse gases most linked to agricultural activity (other than CO_2 from stubble burning) are methane and nitrous oxide. The main sources of methane are cattle, rice growing and leakages in natural gas production. Nitrous oxide results from fertiliser use and other agricultural activities, such as land clearing and cultivation.

More information: www.greenhouse.gov.au

Mr Liu from the Chinese Academy of Agricultural Sciences with an automated chamber for measuring nitrous oxide emissions from irrigated maize at Yuci, Shanxi.

A separate socioeconomic model will be developed and linked to the biophysical model. Based on this, a farmer-friendly and site-specific decision-support system (DSS) for irrigation and fertiliser application will be developed. The DSS will help farmers and extension and government officers consider financial returns and environmental objectives such as reductions in nitrate leaching and emissions.

The research is now more focused on what happens to nitrogen fertiliser and irrigation water after being applied, and on building on the computer modelling system developed during the first project. This involves interpreting complex data in a simple visual-graphic computer demonstration that shows farmers the impact of decisions, such as timing, method and rate of fertiliser application.

This GIS-based WNMM model has already been used in Australia in the Victorian dairy industry and with irrigated maize in Griffith, NSW, and dryland wheat at Rutherglen, Victoria.

"In China, there is a lot of information on what happens with fertiliser, what happens with water, what happens with soil, but not what happens when you put them all together," Dr Chen says. "In China, we are simulating hundreds of different management scenarios with hundreds of different outcomes and hundreds of different financial returns and hundreds of different impacts on nitrate leaching and greenhouse emissions. Sometimes the results are dramatic—for a mere 5–10% in crop yield there can be two to three times more nitrate leaching into the groundwater and double the greenhouse emissions."

Emeritus Professor Robert White from the University of Melbourne, who was involved in the first project and is advising on the current project, sees the role of researchers now as educating the middle management of Chinese agriculture—the village elders—about the benefits of gaining efficiencies in water and nitrogen use. ■

Profiting from the climate prophets

Making seasonal climate forecasts available to farmers in Indonesia and the Philippines is contributing to better water-resource management

BY JANET LAWRENCE

Talk of climate change seems to focus on the headline grabbers—the high sea levels in several decades' time, or temperature rises between now and 2050. Far less emphasis is given to the season-to-season variations that are the reality of farming and can mean the difference between famine and plenty.

Many Australian and Asia–Pacific farmers grow their crops and raise their livestock in a climate of uncertainty, marked in particular by large variations in rainfall. Over the past 20 years scientists have gained a clearer understanding of the mechanism driving these seasonal swings.

It is an ocean-atmosphere interaction in the tropics that gives rise to the El Niño-Southern Oscillation (ENSO), a seesaw of climatic conditions near the equator in the Pacific Ocean. It leads to the El Niño effect that causes the Pacific air pressure patterns to periodically reverse. During this phase, a high-pressure system predominates over Australia and a low-pressure system occurs in the eastern Pacific. The consequence is drought in Australia, Indonesia and other South-East Asian countries.

Scientists studying the El Niño phenomenon, from actual and historical perspectives, now have models on which to base predictions of changing weather and rainfall patterns associated with ENSO.

With global warming, the concern is that El Niño events could be more frequent and more intense. Thus the study of these seasonal fluctuations is important in the overall context of learning more about climate trends and developing practical tools for farmers.

An irrigation channel in Lombok, one of many included in a climate model of water availability designed to help farmers make cropping decisions.

PHOTOS: BRONYA ALEXANDER, SARDI

ACIAR has been supporting research on the effects of ENSO on both climate and agricultural productivity. A project in the late 1990s involving Australia, Indonesia, Zimbabwe and India adapted the RAINMAN software package (designed to help Australian farmers construct their individual seasonal forecasts) to produce an international version. This made the tools for seasonal forecasting available to help agriculture in developing countries. The challenge was to demonstrate to farmers the model's reliability.

PARTNER COUNTRIES: Indonesia, the Philippines

PROJECTS: SMCN/2002/033: Seasonal climate forecasting for better irrigation system management in Lombok; ASEM/2003/009: Bridging the gap between seasonal climate forecasts and decision makers in agriculture

CONTACTS: Dr Yahya Abawi, yahya.abawi@dpi.qld.gov.au; Dr Peter Hayman, hayman.peter@saugov.sa.gov.au

Transplanting rice in Lombok.

Dr Yahya Abawi, from the Queensland Climate Change Centre of Excellence in Toowoomba, is the Australian project leader of the ACIAR-funded study on how seasonal climate forecasting can lead to better irrigation-system management in Lombok, Indonesia.

Dr Abawi says that social, cultural and policy issues often need to be addressed before the science of seasonal climate forecasting is acceptable to farmers and water managers. Educational levels may also influence their ability to adopt such innovations.

One of the issues that researchers hope the RAINMAN model will help address is the ability to predict stream flows during the irrigation season. This is important for effective water-allocation decisions, especially in regions where there is virtually no water storage.

Lombok has three distinct geographical zones. The western zone gets the most water, but has little agricultural land. The central zone, with moderate rainfall, has the most agricultural land, while the southern and eastern area is dry. Water for the drier zones comes from irrigation channels out of the river in the west, with seasonal and inter-annual rainfall influenced by ENSO. In normal years this system is sufficient, but in El Niño years there is virtually no flow in these channels.

To help provide the region with seasonal forecasts, Dr Abawi and his Australian team have worked with Indonesian project leader Professor Mansur Ma'shum, from the University of Mataram in Lombok, and his Indonesian team to develop models of water availability throughout the irrigation system, taking into account different climate, water, land and institutional constraints.

Dr Abawi says the research has provided the tools on which to base optimal cropping decisions, but other considerations also influence decisions, such as rice growing being an enduring tradition. There are social as well as commercial factors underlying rice production.

The Indonesian team members have introduced the project outputs to farmer groups, field officers and government agencies in parts of Lombok. They are well aware that farmers are reluctant to change cropping patterns solely on the basis of climate forecast information, since having to rely on crops grown on quarter-hectare farms (the average size in Lombok) makes them very vulnerable to any crop failure.

Nevertheless, they concur with Dr Abawi, who believes it is worth persevering to change this hesitation. "Significant economic gains can be realised through water-allocation and cropping decisions at a scale that suits the characteristics of these smaller farms," he says.

> "Significant economic gains can be realised through water-allocation and cropping decisions at a scale that suits the characteristics of these smaller farms."
>
> – Dr Yahya Abawi

A similar set of issues is confronting the ACIAR team undertaking a Philippines-based project looking at the economic value of seasonal climate forecasts (SCFs) and the gap that exists between such information and decision-makers in agriculture.

The team is working with the Philippine meteorological service (PAGASA) to develop and implement strategies to better match forecasts with decision-makers' needs. The project involves a series of farm-level and policy-level case studies to determine how people can integrate forecasts into risk-management strategies. ↪

PHOTOS: BRONYA ALEXANDER, SARDI

Team members speak with farmers in the Philippines, about better ways to match climate forecasts to the needs of agricultural decision-makers.

The team found International RAINMAN a useful tool to convey when and where to expect a strong ENSO signal, and when to use climatology as an appropriate guide to the approaching season.

Project leaders Dr Peter Hayman, from the South Australian Research and Development Institute (SARDI), and Dr Celia Reyes, of Leyte State University, report that the ongoing drought in Australia and typhoons in the Philippines, combined with a high level of media coverage regarding climate change, has ensured strong interest in the results of the project. PAGASA has benefited from the collaboration, lifting its capacity to deliver SCFs for the regions in the case studies. PAGASA in turn has partnered with the Philippine Institute for Development Studies (PIDS) and Visayas State University. Together the three institutions are finding ways to better link climate science with the community.

Joint project leader Peter Hayman (right) in a discussion session with project members from PAGASA, PIDS and LSU in Quezon City.

A typical case study in the Philippines involved corn farmers in the Visayas region. Team members compiled a brief description of dominant cropping patterns and corn production practices in the study area, then reviewed and presented a valuation framework for estimating the economic benefits of SCF information under various assumptions of risks and uncertainty.

Their task was then to quantify the potential economic value of SCFs to corn farmers in Leyte. These data, along with the findings of another study of corn farmers in Isabela, helped them draw up policy implications on the usefulness of SCFs to corn farmers throughout the Philippines.

Surveys showed that farmers held a high degree of concern about climate risk and were well aware of El Niño, but they only made moderate use of the information in decision-making. As part of the project, the team refined an Excel-based game that allows participants to work out the best decisions for their situations, based on forecasts that are more than guesswork but fall short of perfect information.

PIDS is the lead agency in another project initiative, in which researchers developed a national policy paper examining how SCFs can affect rice policy decisions made by the National Food Authority, particularly with regard to rice importation. The paper argues that imports have played an important role in the rice supply–demand situation of the country since 1990. The study found that inaccurate forecasts of the volume, as well as timing, of rice imports, especially during El Niño years, resulted in substantial economic costs. These costs could be variously manifested as rice shortages, higher rice prices, or excess rice leading to higher storage costs.

Thus policy decisions—such as how much rice to import into the Philippines, what variety of corn, and how much fertiliser to use in certain regions—are intrinsically linked with issues of seasonal forecasting and climatic risk.

Dr Hayman has found that engaging decision-makers in these diverse contexts is helping them to realise the challenges of using climate information while teaching them how to rate the value of seasonal climate forecasts for different situations. ■

OVERSEEING A RURAL RENAISSANCE

A group of motivated young economists in China, led by Dr Huang Jikun and Dr Shang Linxiu, are tackling environmental issues as part of a broader rural development platform

BY GIO BRAIDOTTI

Agricultural economists Dr Huang Jikun and Dr Shang Linxiu head a unique research centre in China that is promoting sustainable and equitable agricultural and rural development. As director and deputy director respectively of the Centre for Chinese Agricultural Policy (CCAP), the two economists are overseeing research on a broad range of subjects affecting rural outcomes, including environmental and gender issues.

Established in 1995 in the Chinese Academy of Agricultural Sciences, CCAP moved to the Chinese Academy of Sciences in 2000 and is one of the first to be awarded the distinction of 'Innovative Research Group' by China's National Natural Science Foundation. Its research focus is on the analysis of policies related to food, agriculture, natural resources and environmental issues.

Over the years, CCAP has helped formulate practical and feasible policies for the development and modernisation of rural China in ways that engage environmental impacts, household food security, land tenure issues, forestry property rights and rural poverty.

Dr Huang obtained his PhD from the University of the Philippines, Los Baños, in 1990 and his expertise covers agricultural R&D policy, rural development, price and marketing policy, international trade, resource and environment economics, food security and poverty, and economic modelling.

Deputy director Dr Shang has a PhD in Agricultural Economics from the University of Reading, obtained in 1995. She is in charge of the Rural Development and Poverty Research Program, which covers policy relevant to land tenure and the effects of law reform on resource degradation and gender inequity.

"CCAP firmly believes that China can, through its own hard work, satisfy its growing demand for agricultural goods in an increasingly efficient and sustainable way," Dr Huang says. "China must also effectively reduce poverty and realise a balanced rural and urban growth and development that benefits all. In addition to this, CCAP believes that the modernisation of agriculture will contribute to China's economic development."

CCAP has recruited a group of motivated and vibrant young economists dedicated to pursuing the centre's aims in a collaborative and integrated fashion. International collaborations are encouraged and CCAP actively participates in national and international forums. Domestically, CCAP has been collaborating with more than 20 research institutes and universities on various research programs.

"The centre is unafraid to focus its efforts on difficult questions regarding the development of China's agricultural and rural sector," Dr Huang says. "To achieve this goal, CCAP has a number of unique characteristics that have evolved into its own research culture."

Apart from the novel administrative, management and personnel characteristics that set it apart from other research groups in China, CCAP also seeks to base its research and modelling activities on the latest theories and methods. Because all of CCAP's research is empirically based, the researchers have had a big impact in both academic and policy-consultancy circles. Many of CCAP's policy recommendations have been submitted to and approved for action by China's top governmental bodies.

While Dr Huang emphasises that all CCAP's work is expected to contribute to China's economic development, environmental and gender issues are considered high research priorities.

"The Natural Resources and Environmental Policy Research Program is committed to carrying out economic analysis on China's major policy challenges regarding sustainable development so as to help improve the nation's policy-making process," he says.

Given the rate of reform in rural practices, especially with the implementation of a new land-contracting law in early 2003, Dr Shang has been particularly concerned by research findings indicating that women are likely to be excluded. The work is part of a broader initiative to alleviate rural poverty and help vulnerable groups share in China's rapid economic development.

"Evidence shows that women are losing land during this process," Dr Shang says. "Given the importance of land as a resource for securing the livelihood of rural households, hidden problems under the new contractual land arrangement without gender sensitivity will result in significant social impacts if the problems are not properly addressed." ■

PHOTO: CCAP

Dr Huang Jikun, Centre for Chinese Agricultural Policy.

Australian team leader Rob Williams and UNTL lecturer Adao Barbosa introduce Janette Howard to the new peanut variety Utumua during her visit to the 'Seeds of Life' project in Timor-Leste.

Prime Minister's wife visits Dili projects

DILI: On 26 July, Mrs Janette Howard, the wife of Australian Prime Minister John Howard, had an opportunity to view some ACIAR-associated projects during an official visit to East Timor. Staff from the Australian Embassy invited Mrs Howard to visit a 'Seeds of Life' (SOL) trial site in Hera, near the East Timor capital of Dili. Seeds of Life, which receives support from both ACIAR and AusAID, is a program within East Timor's Ministry of Agriculture, Forestry and Fisheries (MAFF) that addresses the country's food-security issues.

Mrs Howard learnt of the program's ongoing research and on-farm trials with farmers in their fields. In addition, she met students and staff working at the University of Timor Loro Sa'e Laboratories (UNTL). The laboratory building and experimental farm had been restored, and university researchers and lecturers trained, under a second ACIAR project that ran from 2001 to 2005. Mrs Howard then had the opportunity to taste the SOL-tested peanut variety Utumua, comparing for herself its larger, sweeter properties with those of the local variety.

The visitors later checked out the university's sweet potato testing site, where three high-performing sweet potato varieties recently released by MAFF were awaiting harvest.

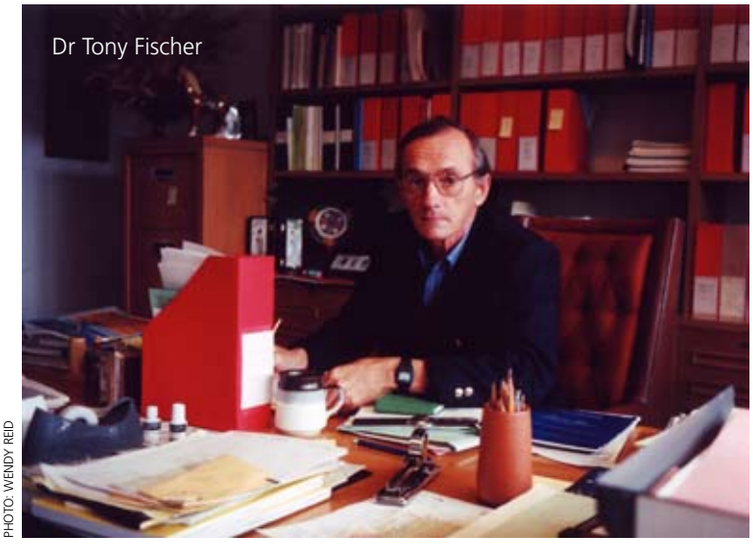
Tony Fischer wins 2007 Farrer Memorial Medal

CANBERRA: Former ACIAR research program manager Dr Tony Fischer has won the 2007 Farrer Memorial Medal, an annual award established in 1911 to perpetuate the memory of famous Australian wheat rust researcher William Farrer and to encourage and inspire agricultural scientists.

In announcing the award, Farrer Memorial Trust Chairman Barry Buffier described Tony as the pre-eminent Australian crop physiologist of his generation. Tony's main interest throughout his career has been wheat yield under both dry and well-watered conditions, with the goal of applying physiological knowledge to wheat improvement through breeding and agronomy. He has published more than 120 scientific publications, including several papers drawing on data from his own property in southern NSW where he kept crop, soil and climatic records for more than 40 years.

Tony received his medal in August at a ceremony in Canberra held to coincide with the Crawford Fund 2007 Conference.

He then delivered the 2007 Farrer Memorial Oration.



Dr Tony Fischer

PHOTO: WENDY REID

Fisheries leaders meet in Townsville

TOWNSVILLE: The biennial ACIAR Fisheries Program meeting was held at James Cook University, in Townsville, Queensland, on 28 and 29 August 2007. It was coordinated by the Fisheries Program team—Barney Smith, Geoff Allan, Leonie Jenkins and Helena Heasman—with ACIAR deputy CEO John Skerritt, and Liz Clarke and Georgina Hickey from the ACIAR Communications Unit also participating. More than 30 Australian project leaders attended, along with representatives from key collaborating organisations such as the Department of Agriculture, Fisheries and Forestry (DAFF), the Network of Aquaculture Centres in Asia–Pacific (NACA), the WorldFish

ACIAR Fisheries program manager Barney Smith talks with project leader Dr Stephen Blaber of CSIRO at the Fisheries program meeting in Townsville, August 2007.

Center and the Secretariat of the Pacific Community (SPC).

The meeting provided a chance for all project leaders to become better acquainted with the broader work of ACIAR, to exchange ideas and, in some cases, to examine opportunities for linking projects to capture synergies. An important focus of the gathering was the exchange of lessons learnt in project implementation and management with a view to coming up with new solutions to common problems.

A large part of managing a project is the socio-cultural element. Individual project leaders repeatedly affirmed that ACIAR projects are not just about delivering scientific results, but involve the development of close friendships and a new understanding of life in developing countries.

The end point for ACIAR research is not research outcomes alone, it is making a difference in the community, and that spirit of intent was alive and well at the meeting.

ACIAR hosts Cambodian VIP

CANBERRA: In June 2007 ACIAR hosted a visit by His Excellency, Mr Chan Tong Yves, Secretary of State for the Ministry of Agriculture, Forestry and Fisheries in Cambodia. Dr Men Sarom, the director of the Cambodian Agriculture Research and Development Institute (CARDI), accompanied Mr Chan.

After an initial briefing from ACIAR staff in Canberra, where he gained an overview of ACIAR's program in Cambodia, Mr Yves met representatives from the Department of Foreign Affairs and Trade, Department of Agriculture, Fisheries and Forestry, and AusAID. Then he and Dr Men travelled to Tamworth to visit a zero-till farm. While in Tamworth they also met with Barry Buffier, the Director-General of the NSW Department of Primary Industries, and other representatives, before travelling on to Western Australia.

(Left to right) Chan Tong Yves of MAFF Cambodia, ACIAR project leader Dr Bob Martin and Dr Men Sarom of CARDI meet farmer Neil Barwick on his zero-till farm in Tamworth, NSW.

Farewell Ken and Bill

CANBERRA: Two long-time research program managers were farewelled recently when they retired from ACIAR.

Dr Ken Menz led the Agricultural Systems Economics and Management Program from July 1987. The program recognises the need for researchers drawn from both the social and biophysical sciences to work with each other—and with research users—to develop effective agricultural production and marketing practices and resource management strategies. Ken had a particular focus on Papua New Guinea, Cambodia, Laos and the Philippines, and for one year during the 1990s took a 'sabbatical' from ACIAR to work at the Australian National University as a project leader for an ACIAR project in the Philippines.

Dr Bill Winter led the Livestock Production Systems Program from January 2000. He encouraged research to improve the welfare of smallholders owning pigs or cattle, helping them to move from being 'keepers' to being 'producers', more engaged with markets, through research that increased livestock growth, reproductive performance and work capacity through better nutrition and management. In this regard he focused on projects in Indonesia and Vietnam, as well as East Timor and parts of China. He also took particular pride in the outcomes of project work in South Africa, where emerging African cattle farmers were learning to set their own priorities to develop and manage business enterprises that competed favourably with larger commercial undertakings.

Current and former colleagues were able to wish Ken and Bill all the best for their futures beyond ACIAR at a function held at The Old Canberra Inn on 12 July 2007.

Bill Winter and Ken Menz cut their farewell cake at a function held in their honour.

Crawford Fund seminar considers the future of biofuels

PHOTO: COURTESY CRAWFORD FUND

Above: IFPRI's Dr Joachim von Braun was the keynote speaker at this year's Crawford Fund conference, held in August 2007 in Canberra. Below: Biodiesel made from canola oil.

CANBERRA: The Crawford Fund held its annual agricultural development conference at Parliament House, Canberra, on 15 August 2007. Entitled 'Biofuels, Energy and Agriculture: Powering Towards or Away from Food Security?', it was opened by The Hon. Alexander Downer, Minister for Foreign Affairs.

Keynote speaker Dr Joachim von Braun, Director General of the International Food Policy Research Institute (IFPRI), declared that world agriculture is at a turning point, with energy and climate change redefining the global food situation. In this new world, biofuels could help supply the rapidly growing market for liquid transport fuel, while at the same time moderating greenhouse gas emissions and creating employment opportunities and income growth for farmers. However, biofuels also pose challenges, especially for the poor in developing countries. Current plans for biofuel production could divert land and water away from the production of food for humans and feed for livestock and increase food prices by 5–15% for various crops.

Other speakers picked up these themes. Lord Ron Oxburgh (Chairman of D1 Oils, a UK-based biodiesel producer, and a former Chairman of Shell Transport and Trading) believes that in the longer term biofuels have a crucial—and sustainable—role to play. Mr Michael Taylor (Secretary, Department of Transport and Regional Services) summarised the public policy instruments and interventions that could be used to guide the development of biofuel industries nationally or globally. Dr Steve Schuck (Manager, Bioenergy Australia) outlined the processes used to produce so-called 'first generation' biofuels (mainly ethanol derived from sugar, molasses or grain, and biodiesel derived from vegetable oils and animal fat).

Three speakers described the biofuel industries in Brazil, India and Australia. His Excellency Fernando de Mello Barreto (Brazilian Ambassador to Australia) described the biofuel industry in Brazil—a country that already derives almost half its total energy requirements from renewable sources. In contrast, Dr Alok Adolheya (The Energy and Resources Institute, India) described an embryonic biofuel industry in India—a country committed to producing biodiesel from non-edible oilseed crops such as jatropha to supply a significant share of rural energy needs. In the case of Australia, Dr John Wright (Director, CSIRO Energy Transformed Flagship Program) described a highly industrialised nation with a biofuel industry growing from a small base towards a modest initial target (350 megalitres by 2010), using a diversity of mainly 'first-generation' feedstocks, and with a range of future options for transport fuels.

ACIAR Chief Executive Officer Peter Core identified some future priorities for research focused on the needs of developing countries. He named four research areas: improving the productivity of crops used in 'first-generation' technologies (including, for example, sweet sorghum, which can grow on marginal cropping land); better quality public policy to guide the development of biofuel industries; unlocking 'second-generation' technologies; and demonstrating the production of 'second-generation' biofuels. He cautioned against excessive diversion of scarce international agricultural research resources away from food production. "From a development perspective, more productive food crops and better quality public policy will provide a platform for biofuels," he said.

NEW APPOINTMENTS

Budi has worked for 10 years throughout Indonesia, and gained field experience with NGOs to implement integrated pest management programs with farmers in central Java. She will implement Component 2 of ACIAR–SADI, evaluating ways to improve approaches to agricultural technology assessment and approaches to knowledge exchange between researchers and extensionists.

DR CAROLINE LEMERLE

Dr Caroline Lemerle has commenced as research program manager, Agricultural Systems and Economic Management. She brings to the position a wealth of experience and expertise with a multidisciplinary, extension-oriented and management background. Since early 2004 she has been a general manager of the National Rural Issues Portfolio (and before that the Sustainable Systems Program) at the Rural Industries Research and Development Corporation.

Before that she worked for 11 years as a senior executive within the NSW National Parks and Wildlife Service and a senior manager in NSW Agriculture. In the 1980s Caroline worked as a researcher with what is now the Victorian Department of Primary Industries, and in the late 1970s worked in Papua New Guinea in agricultural extension and teaching.

BUDI CHRISTIANA

Ms Budi Christiana joined the ACIAR–SADI office in Makassar in July. SADI, the Smallholder Agribusiness Development Initiative, aims to improve rural sector productivity and growth in four eastern Indonesian provinces—East Nusa Tenggara, West Nusa Tenggara, South-East Sulawesi and South Sulawesi.

NGUYEN THI THANH AN

Nguyen Thi Thanh An is ACIAR's new Assistant Country Manager in Vietnam. An joins ACIAR from the Public Diplomacy Unit of the Embassy in Hanoi. An has been the Public Affairs and Media Liaison Officer since 2004, and has been involved in the area of public affairs for over six years. She has a degree in English and also held jobs as an office manager and an earlier career teaching English. An has particular skills in understanding different audiences, and appropriate methods to convey key messages to each group of audience. An's skills will help the Vietnam office communicate ACIAR's work and research results more effectively.

ROBYN DOUGLAS

Robyn Douglas is the new program assistant for the Crop Improvement and Management research program area, assisting research program manager Dr Paul Fox. Robyn has just returned to the workforce after raising her four boys. Her interests and skills are diverse, ranging from flying light aircraft (she is the winner of three air races) to coordinating ACT Junior Squash.

JANET WILLIAMS

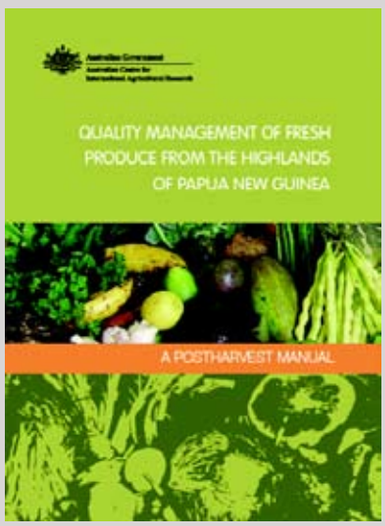
Janet Williams is the new program assistant for the Agricultural Systems Economics and Management program area, assisting Dr Caroline Lemerle. Janet has a Masters degree in communications from Deakin University, which included cultural and policy studies. Before coming to ACIAR, Janet worked as an administrative assistant in Aboriginal Health Services in Vancouver, Canada.

NEW PROJECTS

ADP/2007/044	Scoping study on impacts and policy implication of plausible futures for Indonesia and Australia
AH/2005/086	Best practice health and husbandry of cattle, Cambodia
ASEM/2006/060	Lao Agricultural Research Fund (LARF)
ASEM/2006/091	Enhancing tree seedling supply via economic and policy changes in the Philippines nursery sector
CIM/2006/040	Diversification and intensification of rainfed lowland cropping systems in Cambodia
CIM/2006/176	Developing molecular markers to enable selection against chalk in rice
FIS/2003/059	Sea ranching and restocking sandfish (*Holothuria scabra*) in Asia–Pacific
FIS/2005/078	Culture-based fisheries development in Lao PDR
FIS/2006/099	Capacity building and technology transfer in applied population genetics of aquatic species in the south of Vietnam
FIS/2006/144	Strengthening regional mechanisms to maximise benefits to smallholder shrimp farmer groups adopting better management practices (BMPs)
FIS/2006/172	Winged oyster pearl industry development in Tonga
FIS/2007/029	Support for antibiotic residue testing in fisheries products
FIS/2007/045	Evaluation of production technology, product quality and market potential for the development of bivalve mollusc aquaculture in the Philippines
FST/2004/054	Improving value and marketability of coconut wood
HORT/2004/030	Control of Asian honeybees in the Solomon Islands
HORT/2005/077	Integrated crop management package for sustainable smallholder gardens in the Solomon Islands
HORT/2006/053	Evaluation of the impact of Dasheen mosaic virus and other viruses on taro yield
HORT/2007/032	Detection surveys for mango seed and pulp weevils in Sarangani and Davao del Sur, Mindanao, the Philippines—Phase 2
LPS/2005/094	Improving the profitability of village broiler production in Papua New Guinea
LPS/2005/129	Mineral response in Tibetan livestock
LPS/2005/132	Improving dairy production in Pakistan through improved extension services
LPS/2006/149	Using local feeds to reduce the cost of pig and poultry production in Tonga
PLIA/2006/136	Economic and policy constraints affecting the development of small-scale dairy farmers in Pakistan
PLIA/2006/153	Evaluation of catchment filter pilot study in Shanxi, China
SMAR/2005/074	Improving cocoa production through farmer involvement in demonstration trials of potentially superior and pest/disease-resistant genotypes and integrated management practices
SMAR/2006/011	Enterprise development, value chains and evaluation of non-timber forest products for agroforestry systems in West Timor, Flores, Sumba and Savu, eastern Indonesia
SMAR/2006/061	LPS: Building capacity in the knowledge and adoption of Bali cattle improvement technology in South Sulawesi
SMAR/2006/080	West Timor integrated timber–forage–livestock agroforestry (scoping study)
SMAR/2006/096	LPS: Scaling-up herd management strategies in crop-livestock systems in Lombok, Indonesia
SMCN/2003/035	Improving the utilisation of water and soil resources for tree crop production in coastal areas of Vietnam and New South Wales
SMCN/2004/067	Soil fertility management in the Papua New Guinea highlands for sweet potato-based cropping systems

NEW PUBLICATIONS

MONOGRAPHS



Quality management of fresh produce from the highlands of Papua New Guinea: a postharvest manual

This spiral-bound postharvest manual is a valuable reference for farmers, marketers and extension personnel as they seek to improve the management and marketing of highlands-based fresh produce. *By Vincent Haguluha and Ernest Natera, edited by John Spriggs, 2007, ACIAR Monograph 128, $40.00 GST inclusive (plus postage and handling).*

PROCEEDINGS

Integrated rural development in East Nusa Tenggara, Indonesia

These proceedings report on an international workshop held in Kupang, in April 2006, to identify opportunities and constraints to improving livelihoods in East Nusa Tenggara using an integrated rural development approach, and to discuss directions for future activities. *Edited by S. Djoeroemana, B. Myers, J. Russell-Smith, M. Blyth and E.I.T. Salean, 2007, ACIAR Proceedings 126, $45.00 GST inclusive (plus postage and handling).*

IMPACT ASSESSMENT SERIES

Mite pests of honey bees in the Asia–Pacific region

Mite pests of bees are one of the major production constraints facing the apiary industry throughout the world. In most countries, the mites are present and have a significant impact on productivity and production costs. In Australia, the only country in the world without these mites, the maintenance of effective quarantine strategies against them is a major aim. ACIAR has funded research on these pests for about 15 years, which has made a significant contribution internationally to a better understanding of the mites, especially *Varroa* species, and their host conditions. *By Michael Monck and David Pearce, 2007, ACIAR Impact Assessment Series 46.*

Improved Australian tree species for Vietnam

Australian tree species are being used extensively throughout the world because of their rapid growth and adaptability to many (harsh) environments. This study looks at the impact on Vietnam of some past ACIAR research activities. It shows that, through adaptation, significant improvements in productivity can be achieved by selecting tree provenances that are best suited to specific environments. *By Hayden Fisher and Jenny Gordon, 2007, ACIAR Impact Assessment Series 47.*

Assessment of capacity building: overcoming production constraints to sorghum in rainfed environments in India and Australia

This project uncovered new sorghum plant material with characteristics of considerable potential benefit to Australia. Through other Australian funding, this was subsequently developed into a new variety. Although no new sorghum varieties were developed in India, it markedly enhanced the capacity of the Indian collaborators in some new biotechnology research techniques. This enhanced capacity aided successful application for funding from other sources. *By Chloë Longmore, Jenny Gordon and M. Cynthia Bantilan, 2007, ACIAR Impact Assessment Series 48.*

Minimising impacts of fungal disease of eucalypts in South-East Asia

Eucalypt species are relatively free of pests and diseases when introduced into new environments, which has led to large areas under plantation throughout the world. However as the plantation areas increase so does the threat of pest and disease introduction. This ACIAR project found new genetic material with enhanced disease resistance. It also used climatic modelling to identify high disease-risk regions. *By Hayden Fisher and Jenny Gordon, 2007, ACIAR Impact Assessment Series 49.*

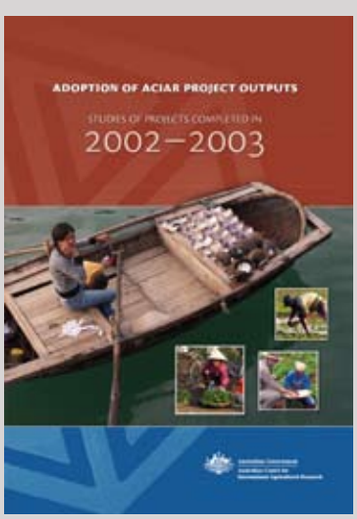
Improved trade in mangoes from the Philippines, Thailand and Australia

This impact assessment focused on two ACIAR mango projects, looking at production cycles and quarantine requirements in export markets. The production cycle project was a high-risk project in a very complex area and it did not have direct impacts, but it did initiate further research. The quarantine requirement project was a lower-risk project and it generated significant returns on investment. *By Michael Monck and David Pearce, 2007, ACIAR Impact Assessment Series 50.*

Growing trees on salt-affected land

Salinity and waterlogging are significant problems in a wide range of agricultural areas throughout the world. It has been found that some Australian species, including species in the genera *Eucalyptus* and *Acacia*, have adapted to thrive in these conditions. Bioremediation using such trees has often been suggested as a potentially lower-cost alternative to physical methods, however adoption has not been high. This is probably due to the development costs and relatively long investment periods before seeing a return. *By James Corbishley and David Pearce, 2007, ACIAR Impact Assessment Series 51.*

Adoption of ACIAR project outputs: studies of projects completed in 2002–2003



Adoption studies are undertaken three to four years after a large project is completed to assess the level of uptake and the legacy of the project. They provide valuable insights into the uptake of project results and the impact on local communities. This adoption study looks at projects completed in 2002-03. *Edited by Jenny Gordon and Jeff Davis, 2007.*

ACIAR'S DISTRIBUTION POLICY

ACIAR provides complimentary copies of its publications to developing-country libraries, institutions, researchers and administrators with an involvement in agriculture, and to any scientist involved in an ACIAR project. For enquiries about complimentary copies, please contact ACIAR's communications unit, comms@aciar.gov.au.

For other customers, please use our online ordering facility at **www.aciar.gov.au**, or direct enquiries to our distributors, National Mailing & Marketing, PO Box 7077, Canberra BC ACT 2610, Australia, phone 61 2 6269 1055, fax 61 2 6260 2770, aciar@nationalmailing.com.au.

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ACIAR'S VISION

ACIAR looks to a world where poverty has been reduced and the livelihoods of many improved through more productive and sustainable agriculture emerging from collaborative international research.

The Australian Centre for International Agricultural Research (ACIAR) operates as part of Australia's international development cooperation program, with a mission to achieve more productive and sustainable agricultural systems, for the benefit of developing countries and Australia. ACIAR commissions collaborative research between Australian and developing-country researchers in areas where Australia has special research competence. It also administers Australia's contribution to the International Agricultural Research Centres.

Back cover: An East Timor farmer working with ACIAR-supported researchers helping farmers to switch to an improved yellow maize variety.
PHOTO: BRAD COLLIS

Front cover: Efforts to strengthen crop breeding in developing countries include work in Cambodia on drought-resistant varieties of rice.
PHOTO: SHU FUKAI