Lucerne is cut and carried back to animals in feedlots. A typical farm may have three to five sheep, three pigs and sometimes cattle or a donkey for draught power. Animal production is important to local farmers for generating cash flow and the government is seeking ways to encourage livestock production. Lucerne can also play a valuable role in protecting soil resources when grown in rotation with crops.

BILL BELLOTTI

Production, new skills and a sustainable HOPE IN GANSU

Two projects are helping farmers from one of China's poorest regions get more from their soils, reports **Janet Lawrence**

Farmers in the Loess Plateau in the eastern part of China's Gansu Province grow wheat on tiny farms – only about 1.5 hectares. Their harvest goes into a storeroom, and that room basically feeds the family until the next harvest. There is not much of a surplus of anything, and farm families subsist on the equivalent of A$500 per year, mostly generated by raising a few sheep or pigs.

The traditional practices of subsistence farming have not adapted to loess soil, which is very prone to erosion. The Loess Plateau is a unique combination of soil type, slope and rainfall intensity. Practices of deep tillage and leaving the land under bare-fallow for the three months between harvest and crop planting have contributed to some of the worst soil erosion in the world. The high rate of erosion is the major cause of the heavy sedimentation that gives the Yellow River its unique colour, and name.

Believing that changes to these traditional practices could reduce erosion, two Australian research groups independently approached ACIAR in 1999. Each offered skills that could help the Loess Plateau's poor farmers become more productive and profitable, and increase long-term sustainability, by changing farming practices.

The University of Adelaide specialises in dryland (rain-fed) farming rotations between pastures and crops and the implications of soil water and nitrogen; New South Wales Department of Primary Industries has expertise in conservation tillage. The two groups had never worked together, but their complementary skills were ideal for combining into a single ACIAR project to benefit Gansu farmers.

Dr Bill Bellotti, from the University of Adelaide, became leader of the project, which began in 2000. The Chinese collaborators were from the Gansu Grassland Ecological Research Institute (which later merged with Lanzhou University) and the Gansu Agricultural University. The Agricultural Production Systems Research Unit of CSIRO's Sustainable Ecosystems Division also contributed its skills in modelling farming systems and their components.

Reducing erosion and lifting soil fertility

The project team believed that improved tillage and cropping sys-

Ms Li Lingling, a lecturer from Gansu Agricultural University, and Ms Sharna Nolan, an Australian Youth Ambassador for Development from the University of Adelaide, interview farmers on their attitudes towards adopting new technology.

Far left: Erosion on the Loess Plateau.

tems could reduce erosion, raise fertility and increase economic returns for wheat-based cropping. Two regions in Gansu were selected to test this. Trials were established at Dingxi, with 400 millimetres average annual rainfall and colder winters that permit only spring wheat, and further east, Xifeng with 560mm rainfall and warmer winters, allowing growth of winter wheat.

At the two sites the project team introduced conservation tillage, sowing new crops into the stubble left behind from the previous crop. This proven method of reducing soil erosion, while maintaining or increasing crop productivity, contradicted traditional deep ploughing. And because there is no need to plough, the method also reduces the physical effort need to establish crops and saves on fuel for tractors.

The team also looked to replace the three-month summer fallow with short-season legume crops such as soy beans, and to develop rotations around perennial forage crops such as lucerne. Replacing the fallow with a legume crop retains cover, gives an extra crop to harvest and provides nitrogen for the next crop. The practices had the potential to reduce erosion and increase whole-rotation productivity.

The Australians also established project sites at Wagga Wagga in New South Wales and Roseworthy in South Australia. In NSW, some farmers using conservation tillage complained of poor crop vigour, and the project scientists set out to discover the reason. One contributing factor was thought to be the changed spectrum of disease organisms that can develop in response to changes in tillage and stubble management. Trials to date have not provided any leads to explain the loss in crop vigour.

In South Australia, there was strong interest in the use of lucerne in cropping systems. Developments in system simulation using the Agricultural Production Systems Simulator (APSIM) provided an invaluable tool for analysis and interpretation of rotation experiments and rotations practised on-farm.

New approach to management

In China new ideas of management – integrating various factors to understand the system as a whole – have been informative for all scientists, extensionists and farmers. The Australian scientists introduced systems simulation modelling, using APSIM to evaluate current and 'novel' cropping systems being proposed to combat soil water erosion in the region.

The application of APSIM is dependent on its ability to accurately predict development and growth of different crops in the regions outside those in which they were developed. For instance, the APSIM lucerne module had been tested in Australia and New Zealand. But it required testing in the conditions of the two project sites before it could be used as a tool to evaluate relevant cropping systems and quantify risk associated with changing from traditional to new farming systems.

Dr Bellotti says: "The project has now completed its first four years, and after a positive review it received an extension to continue until the end of 2006. We have been really impressed with our Chinese partners. Together we have made good progress.

"All collaborators now have a much better understanding of the key processes – rainfall variability and fluctuations in plant-available soil water, and their effects on pasture/crop production and profit – operating in the Dingxi and Xifeng areas.

"APSIM proved itself once more as a valuable tool to integrate data gathered from different sources. The Chinese scientists grasped the usefulness of APSIM when they witnessed it in use, developing a framework to interpret data and predict various courses of action under differing environmental conditions.

"We now understand productivity of lucerne in this environment, its effect on soil water and on the wheat crop following the lucerne. We are addressing the issues of water/nitrogen dynamics and their effects on crop selection.

"We have undertaken an appraisal of conservation tillage, and while the project had not intended to progress so quickly to on-farm trials, the farmers came to us when they saw what we were achieving and wanted to get involved. There are now side-by-side demonstrations of conventional versus new practice on the farms."

Success with new practices

Some farmers have already shown that they can maintain and even increase crop yield with no tillage and complete retention of stubble. The Chinese farmers traditionally practised several runs of deep ploughing and removal of all stubble (which they completely put to use). So there was an opportunity cost of leaving stubble in the field.

In terms of yield, the conservation tillage compared favourably with traditional practice. Findings from this research will be valuable for local extension agencies as the central Chinese government embarks on an ambitious program to expand the area of crops grown under conservation tillage.

In the final two years of the project, scientists are targeting on-farm research. The project team wants to observe how farmers adapt the new practices to their situation. In December 2004, Australian team members conducted a workshop to discuss the principles of on-farm research with the Chinese scientists, for whom the concept of partnering with the farmers was quite new.

The presence of two Australian Youth Ambassadors for Development (graduates from Adelaide and Melbourne) will boost this on-farm adaptive research. They will work alongside the farmers for nine months in 2005.

Below: The farmer on the right is Mr Feng Jun, who approached the project team after seeing their experimental work and has now conducted on-farm research into conservation tillage. He is convinced that the new system has advantages in terms of less labour and higher yield.

BILL BELLOTTI

USING FORESTS TO SAVE THE SOIL

Soil erosion on sloping croplands gives the Yellow River its colour but threatens farmers' livelihoods. **Fiona Perry** reports

Two ACIAR projects under way in the Yellow River Basin in China's north-west are tackling land and water resource degradation that is threatening the social, economic and ecological sustainability of the region.

In the first project, Australian National University Professor Jeff Bennett is working in partnership with the China National Forestry Economics and Development Research Centre to evaluate the effectiveness of the Grain for Green (GFG) program, which encourages farmers to convert steep cropland into forest and perennial grasslands.

The practice of planting annual crops and grazing livestock on deforested lands with a slope of more than 25 degrees has led to accelerated rates of soil erosion in China, particularly in the Yellow River Basin.

The Chinese Government established the GFG program in 1999 on a pilot basis in Shaanxi, Sichuan and Gansu provinces, to help bring soil erosion and consequent problems – such as sandstorms and frequent flooding – under control. When the program was formally launched in 2002, its scope was extended to include 25 provinces and autonomous regions. It has involved more than 100,000 villages, more than 15 million farmer households and more than 60 million people. It is the biggest participatory forestry development program in China.

Under the program, farmers who volunteer to convert existing cropland into grassland or forests are paid in grain and cash. The duration of the payments depends on the type of conversion made: farmers who plant trees for ecological protection purposes (and at a higher density than commercial plantings) receive payments for longer than farmers who convert cropland to grassland, or who turn cropland into forest using commercial species of trees. Farmers are also encouraged to reforest areas that are not currently agriculturally productive but suitable for growing trees.

Disappearing soils: erosion in the Yellow River.

Professor Bennett says that in the first stage of the research – an investigation of the financial impacts of the program on farmers in the Ansai, Binxian, Gonghe and Minhe counties – preliminary data obtained in a household survey of participating farmers showed they were "financially much better off" through the program, both through the subsidies gained for conversion activity and because the new forest crops and grasslands represented long-term, more profitable income streams. In addition, previously barren lands are being brought into productive use, increasing crop yields and farmers' incomes, and tree crops are protecting existing crops, effectively forming buffer zones around them, he says.

Researchers will next undertake a social cost-benefit analysis of the program to investigate its impact on greater social wellbeing. This will involve estimating the 'off-site' environmental and social benefits (such as better air and water quality in 'converted' areas, as well as in distant cities such as Xi'an and Beijing) in an effort to determine the natural resource management outcomes preferred by the broader community and the price it would be willing to pay for them.

Using information obtained in the first two stages of the project, researchers will assess the policy mix and suggest alternative policy strategies, using a technique called Institutional Economics Analysis. For example, Professor Bennett says that at this stage it seems the Chinese Government could have adopted a more strategic approach, with some parts of northern China needing more funding than others.

Professor Bennett says the collaboration with the China National Forestry Economics and Development Research Centre is important on many levels, including providing a good avenue into government decision-making with the aim of making the research a policy reality.

The second ACIAR project is aiming to increase the productivity and sustainability of water use in Yellow River Basin irrigation systems by establishing equitable institutional arrangements, including water trading, that promote more efficient water allocation and management, as well as maintaining social cohesion.

Northern China is an important agricultural region and the site for much of the country's industrial production, but has a much lower per capita water endowment than in the south. There is rapidly increasing demand for water but an increasingly precarious supply, due in part to serious and growing water pollution, water misallocation and deteriorating irrigation systems.

In signing up to the World Trade Organization, China has relinquished trade barriers, putting pressure on farmers to lift productivity. The success of this endeavour demands that water be used most efficiently, on the right crops, in the right amounts and at the right time.

With China's move to a more market-oriented economy, farmers now have more freedom and significant opportunities to cultivate less intensive, horticultural crops that generate higher returns, such as sunflowers and vegetables.

Establishing an integrated water allocation system that is more flexible and responsive to these new developments, as well as being ecologically sustainable, has therefore become a priority.

Dr Stephen Beare, chief economist at the Australian Bureau of Agricultural and Resource Economics (ABARE) in Canberra, is working with the Centre for Chinese Agricultural Policy and the International Water Management Institute to develop a simulation model to evaluate the economic impact of alternative water trading and other allocation policies in the basin. This will enable the research team to provide recommendations on more effective water trading arrangements between villages and sectors, as well as policy tools to aid the sustainable management of water resources.

Dr Beare says the project is progressing well, with two additional resources – the Economic Research Service of the US Department of Agriculture and Professor Scott Rozelle from the University of California – agreeing to collaborate on the project. With their assistance, the first stage of the project has been completed.

Researchers have put together the most comprehensive data ever collected on the hydrological, physical, agronomic and socio-economic conditions existing in the Yellow River Basin. The international research partners have signed two memorandums of understanding with the Chinese Ministry for Water Resources, giving the project important backing at a political level.

Researchers will estimate the economic productivity of water uses by sector for different regions of the basin and a preliminary simulation model will be completed in May. Policy recommendations will follow in June.

Dr Beare says the project will provide the tools to evaluate policy options, and identify practical targets and opportunities to reallocate water with the aim of promoting economic, environmental and social sustainability in the region.