



A model project

RESEARCH THAT HELPS
AFRICAN FARMERS
UNDERSTAND AND COPE WITH
CHANGE IS ALSO BRINGING
BENEFITS TO AUSTRALIANS,
REPORTS **JANET LAWRENCE**

An ACIAR project that set out to improve African smallholder farming systems, has given rise to a new means of using computer simulations to aid thinking about risk and change.

The models proved valuable to researchers in Africa – and have led to a new approach that assists Australian farmers in their planning and decision making.

From 1983 to 1993, ACIAR funded research to address key challenges of farmers in the African and Australian semi-arid tropics. Scientists from Kenya and Australia focused on locations in eastern Kenya and Australia's Northern Territory – both regions known for infertile soils and low, erratic rainfall.

In Kenya, food security was under frequent strain due to a rapidly growing population and declining soil fertility. But the uncertainty of rainfall was a significant disincentive for farmers

to spend money on productivity investments.

The research team aimed to find ways to increase productivity that farmers judged to be both practical and affordable, and followed a 'farming systems research' strategy to work with farmers in this search.

Researchers sought to understand the constraints experienced in a typical farm household and how these affected farm management decisions.

After discovering that the project's original theme of using forage legumes to improve soil nitrogen was unfeasible due to small farm size and high cropping intensity, attention turned to the economics of modest amounts of nitrogen fertiliser.

Experiments within farmers' crops, supplemented by studies on research stations, focused on the economics of soil fertility enhancement.

The key challenge was the

A MODEL PROJECT IN SOUTHERN AFRICA

Maize is a staple crop in southern Africa and about 70 per cent comes from smallholder farms of less than five hectares, virtually all of which are rainfed. Erratic rainfall is a major constraint to the introduction of improved technologies for smallholder farmers.

This project was designed to develop and test a set of tools and methods that would improve farmers' understanding and adoption of crop management strategies for environments subject to climatic variability and risk.

The aim was to show farmers, through the use of simulation models and other information technology, the longer-term consequences and risks associated with continuing current practices compared to trying recommended alternatives.

The project employed the Australian-developed APSIM (Agricultural Production Systems sIMulator) for technology testing and farmer experimentation.

The design of the project was built around three principal tenets:

- methodology development in the integration of the APSIM systems modelling package to be integrated with farmer participatory research (FPR);
- climatic risk is the principal constraint on the adoption of new technology; and
- the potential of the project to link other CIMMYT maize activities in southern Africa.

The FPR work found that farmers' first priority was how to allocate scarce labour, capital and nutrient resources across different land types rather than worrying about how to adapt to climatic risk.

Central to the project was the application of APSIM, utilising the model in technology testing and farmer experimentation in Malawi and Zimbabwe (see story page 25). To achieve this the project had to assemble appropriate data sets, characterise the structure and constraints on smallholder maize systems, validate the principal elements of the model involved in simulating that structure and constraints, and apply the model against farm level data.

The project built on previous calibration work and secondary data sources to speed up the application. This approach was sound, but there are limits to utilising "representative" data sets in on-farm applications. A recommendation is that future work returns to developing a minimum data set to capture intra and inter-farm variability.

African farming is complex. However the on-farm research suggested that phosphorus and manure availability were key to farm constraints and farmers' decision making.

As the project focus shifted to farmer priorities on soil and resource management, new needs were identified, in particular the role of legumes in soil fertility management. The APSIM group extended the modelling into this area, although more validation is warranted, drawing on a wider array of existing data. ■

PROJECT:

SMCN/2001/028 Development and scaling out of targeted recommendations for smallholder maize systems in Southern Africa through integrating farmer participatory research and simulation modelling (Risk Management Project 2)

► fickle rainfall climate. For farmers it meant that low soil nitrogen prevented high yields in seasons of good rainfall, but household investment in fertiliser was risky because of the unreliability of the rainfall.

For researchers, the challenge was that experiments long enough to quantify risks and test options, greatly exceeded the likely duration of the project. So the researchers turned to computer simulation as a possible way of reducing this constraint.

ADAPTING A MODEL

The practice of crop modelling using computers was just beginning to show its usefulness back in the late 1980s. A computer software model called CERES-Maize had been developed for high-input agriculture in North America, where maize is farmed under relatively favourable and reliable conditions.

In the ACIAR project, the scientists set out to adapt the model to predict maize yields for the severe soil and climatic conditions of low input systems in the semi-arid tropics.

The scientists based their tests and modifications on data from both old records and new field experiments in Kenya. The result was a model named CMKEN (CERES-Maize for Kenya), the child of CERES-Maize.

This model could realistically simulate the yields of maize crops grown on soils with different water holding characteristics in response to daily rainfall (or irrigation) and to the addition of different amounts of nitrogen.

It could also show the relative performance of plants grown at different densities, and how

different maize cultivars would perform in each situation.

Development of the model gave the scientists a tool to make 'what if?' comparisons between a wide range of practices and strategies for growing maize at different locations, particularly with respect to returns on scarce household capital invested in nitrogen fertiliser.

It helped them to gain many insights into aspects of maize production in the Machakos and Kitui districts of Kenya.

Their simulations demonstrated that even in the highly risky environment of semi-arid Kenya, farmers could lift crop yields through water conservation and improved soil fertility, and this was affirmed by successful trials using the recommended practices.

Although risky in the short term, it was evident that nitrogen fertiliser was a good medium-term investment.

This finding was independently and impressively validated in the practice of a small number of farmers.

The impact of the project on African farming is not easy to gauge, but there is evidence of influence on the way research is now conducted by some of the Kenyan scientists and by some CGIAR centres. Certainly, it had a profound and enduring effect on the Australian research team.

The use of simulation as part of a farming systems research approach had shown its usefulness, and by the end of the project the scientists believed that it was ready to be applied more widely, wherever unpredictable rainfall constrained agriculture. In the ensuing years this has proven to be the case, as the Australian project leader, Dr Bob McCown, testifies. ►

► “Our participation in the modelling work in Kenya was an ideal opportunity for CSIRO scientists to discover the potential of simulation modelling as a tool for thinking about farming practices,” he said recently.

“Being able to simulate crop and cropland performance allows greater possibilities in ‘experimentation’, trying out ideas over periods of time much greater than the lifetime of a project and trying things that are simply not feasible in the field.

“And when you simulate situations together with farmers it increases the reality of representation, and the involved farmers are more ready to recognise the simulation output as meaningful to their thinking and actions.”

MODELS AS RESEARCH TOOLS

The CSIRO team’s modelling work has progressively evolved in Australia, augmented by collaborative research in India, Zimbabwe, and South Africa.

“But it was the ACIAR project that reinforced our need for models as research tools, provided support for their development and gave us a vision of the potential of this approach to help Australian farmers,” Bob McCown says.

In 1990 this team was part of a joint initiative of the Queensland Departments of Primary Industries (DPI) and Natural Resources (DNR) and CSIRO Tropical Agriculture in creating APSRU (the Agricultural Production Systems Research Unit). Its purpose was to benefit Australia, its northern region in particular, through innovative systems approaches to research and development (R&D) in rural industries.

APSRU’s core expertise and research technology is in crop and soil management and in the computer simulation of farming systems.

Central to the Unit’s activities is APSIM (Agricultural Production Systems sIMulator). The APSIM modelling framework has many advantages.

It has a modular framework, whereby any logical combination of modules can be simply specified by the user ‘plugging-in’ required modules and ‘pulling out’ any modules no longer required. The original modelling work concentrated only on maize. Now many other crops can be studied, as well as a much expanded suite of environmental constraints and management interventions.

ACTION RESEARCH WITH FARMSCAPE

APSRU has engaged farmers in relevant R&D by direct action with them and indirect action via advisers and consultants.

The FARMSCAPE (Farmers, Advisers, Researchers, Monitoring, Simulation, Communication, And Performance Evaluation) action research program evolved to learn if and how simulation can be useful to farmers and farming consultants.

FARMSCAPE is about agricultural knowledge – both practical and scientific.

These two sides meet in FARMSCAPE when a farmer ‘does an experiment’ using a scientific model made to look like an actual paddock of his or her farm and, as a result, either alters their practice or decides not to.

FARMSCAPE is an approach to farming systems research that comprises: ►



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'SIMULATIONS DEMONSTRATED THAT EVEN IN THE HIGHLY RISKY ENVIRONMENT OF SEMI-ARID KENYA, FARMERS COULD LIFT CROP YIELDS THROUGH WATER CONSERVATION AND IMPROVED SOIL FERTILITY, AND THIS WAS AFFIRMED BY SUCCESSFUL TRIALS USING THE RECOMMENDED PRACTICES.'



- ▶ ■ on-farm monitoring to ensure local relevance;
- computer simulation to feasibly explore alternative management possibilities; and
- discussion to explore possibilities informed by the different perspectives of farmers, advisers, and researchers.

FARMSCAPE represents a shift in systems thinking. Formerly, computers were seen to compensate for shortfalls in managers' understanding and consequent decision-making. Now, computers aid the construction of new understanding that opens up new possibilities for farm management.

'TOYS' TURNED TO FARMERS' TOOLS

Farmers on Queensland's Darling Downs were at first sceptical and dismissive of models as 'toys for scientists'.

But after working in league with the scientists and advisers they have come to realise that the 'toys' can be tools that uncover new possibilities relevant to certain farming challenges.

The farmers started to take computer simulations seriously when they could relate them to the climate, soil and management situations with which they were dealing. The models passed their tests of credibility by adequately simulating events they had experienced.

They undertook a process of yield benchmarking – why the crop behaved as it did and how a different outcome could have been achieved through altered management actions.

Farmers know that their crop performance will vary from year to year. Until recently, they could

only know the outcome of a poor season through painful experience, but with modelling, the odds can be quantified. A significant number of farmers are now aligning their plans with simulation-based forecasts.

What is now understood about the Southern Oscillation Index (SOI), which greatly influences Australia's rainfall patterns, has helped the scientists to refine their models and increase the accuracy of predictions.

But they are adamant that farmers must realise that their soil is the central focus of their enterprise. They hope that information they provide about soil type, and how weather and crops influence the soil, will contribute to farmers' understanding of what drives farming systems and open them to new ways of increasing water capture and use.

After 12 years of research to create an approach to computer-aided planning and decision-making that 'works' in farm management practice, current research focuses on developing (1) sustainable institutions for delivery of FARMSCAPE tools and services; and (2) better theoretical understanding of the interface between systems research practice and farm management practice.

APSIM, with its user-friendly interface, flexible graphics tool and database tool for storing, manipulating and sharing soil properties data, has developed from a single-crop simulator into a comprehensive simulator of farming systems. Its portfolio of applications grows as new needs arise.

Farmer clients now come from Queensland, northern NSW, Victoria and Western Australia. They meet in groups on the internet, where they can see

**Widening
their
decisions:**

farmers from the Hwedza district in Zimbabwe inspect a tropical legume, Lablab purpureus, used as an improved fallow.

Photo: **Bruce Pengelly.**



► screens, discuss possibilities and do experiments.

Simulation modelling is providing a unique bridge between the knowledge of agricultural science and the know-how of farming practice. APSIM's starting point was crop and soil process research, now its major focus is on mobilisation of human learning and planning skills.

APSIM and FARMSCAPE represent progress in new capabilities that has received global recognition, prompting other major agricultural and farming systems research institutions to re-engineer their models from the ground up and trial new ways of using them.

Bob McCown believes that it would not have happened without the ACIAR project that began in 1983, with its major focus on farming in eastern Kenya – together with a project philosophy in ACIAR that allowed space for project transformation as learning took place. ■

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'AN AUDACIOUS THING TO DO'

Using cropping systems models with commercial farmers in Australia is one thing, but could these same tools be applied with smallholder farmers in southern Africa?

"It was an audacious thing to do," says APSRU leader Peter Carberry, when a group of computer simulation modellers teamed up with participatory researchers (agronomists, economists and social scientists) and local researchers to use the FARMSCAPE approach with smallholder farmers in Zimbabwe.

The group worked with 30 farmers in the village of Mkhubazi, Tsholotsho for three days. Many of the farmers had never even seen a computer before, let alone used a cropping systems model. Hand-drawn diagrams on flip charts were used to help describe a computer model. A notebook computer was displayed to the group and the idea of using the computer to ask 'what if' questions was proposed. If maize was planted in a field with a small amount of manure and yielded two bags, what yield would the computer suggest with more manure? Or with inorganic fertiliser?

Actual rainfall and simulated crop yields for a number of crops in past years were presented as hand-drawn graphs. Immediately after the graphs were presented, Sevi, a female farmer, asked the question: "Why is the sorghum yield in a year with more than 800 millimetres rainfall less than the yield in a year with only 480mm?" This broke the ice for discussion about a range of issues.

Selected case studies were conducted for four farmers. In the first case, results were simulated for growing maize, with no manure or fertiliser and then with application of manure.

When a farmer commented that the variety used was not suitable for their area, Carberry was able to run the model again using the preferred variety. The new runs were completed within minutes and the changes in bags per acre were presented on flip charts. Good discussion followed.

While new simulations were being run, farmers were asked to nominate what change they would expect from, for example, application of manure or inorganic fertiliser; many started debating among themselves the likely outcome. Once the farmers could see their experience reflected in the simulated output for a change in maize cultivar, for example, the model gained credibility and they were willing to proceed with further simulations.

As a result of the workshop, farmers identified recordkeeping of yields and rainfall as something important they had learnt. They also asked for access to seed and fertiliser so they could increase productivity in the ways discussed.

The farmers in Mkhubazi subsequently implemented and managed trials investigating manure and inorganic nitrogen interactions, legumes and their responses to phosphorus.

At the beginning the researchers were sceptical that simulation could be directly relevant to smallholder farmers, but by the third day they were enthusiastic about the opportunities to use this approach. ■

PROJECT:

SMCN/1999/003 Integrated nutrient management in tropical cropping systems: Improved capabilities in modelling and recommendations