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Virtual solutions for real problems
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Women with brooms made from grass collected in the Mafungautsi State Forest, Zimbabwe. © Ravi Prabhu

User-friendly computer simulation can help rural communities identify which tree-crop combinations and farming strategies are most productive in their location. It can also inform governments on how economic policies affect agroforestry and forest conservation.

Virtual solutions for real problems

Mrs Mabhena is a widow living on the fringes of the Mafungautsi State Forest in Zimbabwe. Like other women in her community, Mrs Mabhena collects an annual grass from the forest to make brooms. During lean times, when all the farm crops have been sold, these brooms are Mrs Mabhena's only source of income.

Historically, the Zimbabwean government controlled the exploitation of forest products such as broom grass. Now, times have changed and local communities can dictate how to manage natural resources on their doorstep. For Mrs Mabhena and other women in the area, the question is, how should broom grass be managed to ensure sustainable harvests and income in the future?

Questions like these are most comprehensively addressed through computer simulation, which is now critical to scientific research into the sustainable management of the earth's natural resources. For example, marine ecologists routinely use models to predict the impact of fishing on oceanic fish populations. These models provide crucial information to the EU Common Fisheries Policy. Likewise, computer simulation of agroforestry systems can inform land-use strategies and economic policies that are both environmentally sustainable and beneficial to small-scale farmers like Mrs Mabhena.

In order to provide computer models that can be readily used by land managers and policy makers in the developing world, the Forestry Research Programme (FRP) of the UK Department for International Development (DFID), with parallel contributions, especially from the French Agricultural Research Centre for International Development (CIRAD), funded a series of research projects. These projects were led by the Natural Environment Research Council (NERC) Centre for Ecology and Hydrology, the University of Wales, Bangor, the Center for International Forestry Research (CIFOR) and the University of Edinburgh.

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Projects conducted by the Centre for Ecology and Hydrology, the University of Wales, Bangor, the University of Edinburgh and the Center for International Forestry Research

The computer modelling systems provided by the FRP-funded research have been adopted by academics, development workers and local people in Africa, Asia and South America to test policies and land-use strategies before investing in field research or implementation on the ground. The research therefore contributes to Goals 7 and 8 of the UN Millennium Development Goals; namely to "ensure environmental sustainability" and to "develop a global partnership for development".

Developing computer models

The FRP-funded research comprised a two-strand approach. Firstly, the NERC Centre for Hydrology and Ecology (formerly the Institute of Terrestrial Ecology) at Edinburgh co-ordinated a collaborative effort amongst 26 institutes to develop computer models for examining interactions between different trees, crops and soil types. This research involved an evaluation of existing crop models and field experiments[1], the creation of an agroforestry model known as HyPAR[2] from the PARCH model for grain sorghum, and the development of a library of soil, tree and crop parameter values. This library has been used in the local calibration of HyPAR and also for the WaNuLCAS (Water, Nutrients and Light Capture in Agroforestry Systems) model developed by the World Agroforestry Centre (ICRAF).[3]

"The thing about modelling is that it throws up scenarios that get people thinking. It acts as a catalyst."

Ravi Prabhu
Adaptive Collaborative Management programme leader, CIFOR

In the second strand of the research, the University of Edinburgh created the unique modelling framework software, Simile. This software can visually display models like HyPAR, thus aiding discussion about trade-offs in environmental management. Simile can be used by researchers, policy-makers and farmers alike, thereby providing a level playing field for development negotiations.

CIFOR used the Simile software to aid the creation of FLORES, the Forest Land-Oriented Resource Envisioning System, which works from the household scale upwards and produces landscape simulations. The original FLORES model was developed by an international group in Indonesia using research data collected by ICRAF.[4, 5] The University of Wales, Bangor, then worked with the University of Edinburgh, Southern Cross University, Australia and Worldforests in creating the FLORES Adaptation and Calibration (FLAC) package. FLAC was designed as a toolkit for building local simulation models, and was initially tested in Zimbabwe.[6]

Providing a tool for researchers, policy makers and farmers

The agroforestry computer models HyPAR and WaNuLCAS are important tools for agronomists, agroforesters, land-use planners and food security specialists. The models help identify which tree-crop combinations are most sustainably productive and most worthy of field trial research, thereby ensuring high returns on limited research budgets. As a result, there are around 300 registered users of the HyPAR and WaNuLCAS models in at least 35 countries across the world. Components of the HyPAR model have been used by the EU-funded research programme Silvoarable Agroforestry for Europe (SAFE) for its adapted model HySAFE.

In contrast to HyPAR and WaNuLCAS, the FLORES modelling system through its framework software, Simile, takes account of both socio-economic and ecological factors. FLORES also displays "pictures" of real life situations to show the outcome of particular land-use or policy changes. This means that, with careful facilitation, policy

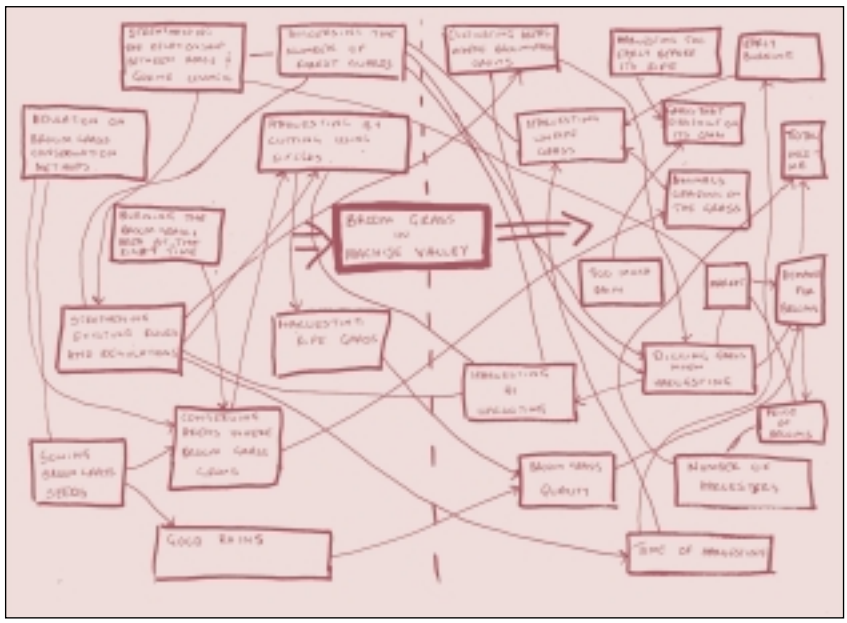

Diagram created by Mafungautsi women and facilitators for conversion into a Simile computer model. © Broomgrass User Group, Batanai RMC

makers and farmers with no previous experience of modelling can use the software to explore land-use and policy scenarios for themselves.

The FRP-funded research has stimulated organisations in Africa and Indonesia to develop FLORES-type computer models.[7, 8, 9] For example, in the Lumut Mountain Forest of East Kalimantan, CIFOR has used a FLORES-based model to help the Indonesian government make informed policy decisions on forest management. The government aims to reduce forest degradation as well as improve the livelihoods of local people but these objectives can involve conflicting interests. CIFOR's forest management simulations therefore provide a scientific basis for some difficult policy decisions. And, because the modelling system is accessible to non-specialists, it facilitates equitable negotiations between the logging company, Telaga Mas, and local forest-dependent people.

The Simile software used to frame and display FLORES models is being further developed and promoted by the Edinburgh-based company, Simulistics Ltd[10] and is now used by more than 1,000 institutes worldwide. For example, in Zimbabwe, WWF supported a research project that used Simile to model the relationships between fuel prices, fuel demand and deforestation around Harare.[6]

Empowering rural communities

Following on from the FRP-funded work on FLORES, CIFOR used the Simile software in a series of low-cost participatory modelling exercises in Zimbabwe.[11] During these exercises, Mrs Mabhena and her neighbours analysed the way in which broom grass is harvested and processed. The complex ecological and social interactions (see diagram) were translated into Simile to produce a visual computer model, which helped the women test the feasibility of different management scenarios.

The computer model led the women to devise various strategies, such as fining those who uproot rather than cut broom grass, to reduce destructive harvesting.[11] But the modelling process was more than a useful analytical tool; it was also a key technique for involving communities in taking responsible control of natural resources in their local area. This participatory approach to agroforestry modelling has been further developed in Central America as part of the EU-funded project, FRAGMENT.[12]

Creating sustainable livelihoods

The FRP-funded research on agroforestry computer modelling adheres to the core principles of the Sustainable Livelihoods Approach (SLA) advocated by DFID. Firstly, the research is **people-centred**, focusing on empowering smallholder farmers to improve agroforestry systems, and developing world governments to make informed policy decisions.

Secondly, the research is a **response** to the need of non-academics for user-friendly tools to help them decide on appropriate land-use strategies. Thirdly, the projects involved the **participation** of local people who developed and tested models and provided important feedback.

The FRP-funded modelling projects are **multi-level**, providing development tools for users ranging from academics in international research institutes to local village representatives. By working with non-governmental organisations such as WWF, international research institutes such as ICRAF, and government bodies such as the Zimbabwe Forestry Commission, the researchers also took a **partnership** approach.

Sustainability is central to the agroforestry models, which aim to identify tree-crop combinations that can provide long-term yields for local people. Finally, the research takes account of the **dynamic** and complex web of relationships between ecological, social and economic factors in developing countries. By taking a systems rather than a piecemeal approach, computer modelling paves the way for informed and appropriate land management decisions that provide long-term benefits for local communities.

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