# 42. INSIGHTS FROM A SYSTEMS VIEW: HOW MODELLING CAN INFORM REFORM

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Participatory modelling is one of several techniques that can help communities to share and test ideas, and to agree on the 'best bet' for improving the triple bottom line for individuals and for the community. Two case studies from Africa illustrate how participatory modelling can assist in this way, by informing communities, by providing an objective way to conduct 'risk-free' experiments and explore scenarios, and by helping people to gain the confidence needed to make changes. Progress towards a better triple bottom line often depends on having the confidence to take action, and modelling is one of several techniques that can help to build this confidence. The resulting model is not an endpoint, but a disposable 'stepping stone' in the developing this confidence. Thus for many models, success means being momentarily inspirational in the search for solutions, rather than being a permanent monument to a static concept.

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## INTRODUCTION

Attempting to improve the triple bottom line of a rural enterprise is a noble and worthwhile objective, but it is not always obvious how to achieve these diverse goals of improved social, economic and environmental outcomes. The history of development assistance is littered with examples of projects that have not just failed to improve the triple bottom line, but have failed to create any improvements, because of ill-conceived projects and unforeseen site-effects (Easterly 2001). Fortunately, there are also many examples of great success, and it is instructive to examine why and how these examples came to be successful. This is not the place for a comprehensive review of the successes and failures of development assistance projects, so this paper confines itself to one technique that can help to explore possible consequences (beneficial or otherwise) and avoid unforeseen dangers.

*Systems Thinking* embraces a range of techniques that can help to provide a careful and systematic examination of a project, and this paper presents two examples in which systems modelling helped to expose development strategies that were not initially foreseen. The two examples rely on the Simile visual modelling environment (as described by Muetzelfeldt and Massheder 2003, Vanclay 2003), a package which makes advanced modelling tools accessible and relatively easy to use. With Simile, a model is not hand-crafted with hundreds of lines of computer code, but is assembled using intuitive icons to create a model diagram that is not merely an image of the model, but is a working model able to complete simulations and explore scenarios.

## A MODEL OF URBAN FUELWOOD USE IN HARARE

The first example relates to a study of fuelwood in Harare, the capital of Zimbabwe, where fuelwood accounts for 88% of total wood consumption, and 52% of total energy needs (Chambwera 2004). Up to 40% of households in Harare rely on fuelwood for cooking, with low-income households spending up to 9% of household income on fuelwood purchases (Chambwera 2004). In 1989, the annual fuelwood harvest was 93,000 tons (Attwell *et al.* 1989), primarily of indigenous species, leading to excessive harvesting in forests surrounding the city.

In 1999, Muyeye Chambwera of the WWF Southern Africa Regional Program Office initiated a research project on urban fuelwood demand, and presented some preliminary findings to a CIFOR modelling workshop with which the author was involved. The preliminary model constructed by Chambwera during the workshop was a simple one that concentrated on a limited number of variables, primarily relating to woodland dynamics, fuelwood pricing, and household size. The Simile representation of this model is presented in Figure 1. Variable names used in the model indicate the concepts considered influential at the time, notably woodland dynamics (top left of Figure 1), fuelwood prices (bottom left), and number and size of households (right). This simple model was never fully calibrated, but it was sufficient to stimulate interest, provoke discussion about a wider range of related issues, and to kindle further research effort. The author has subsequently developed the concept further with various groups of students in Harare and elsewhere, and used it to demonstrate some of the insights that may be gained from such models (Figure 2). Muyeye Chambwera has continued researching a broader range of fuelwood issues as part of his PhD studies (Chambwera 2004, Chambwera and Folmer 2007).

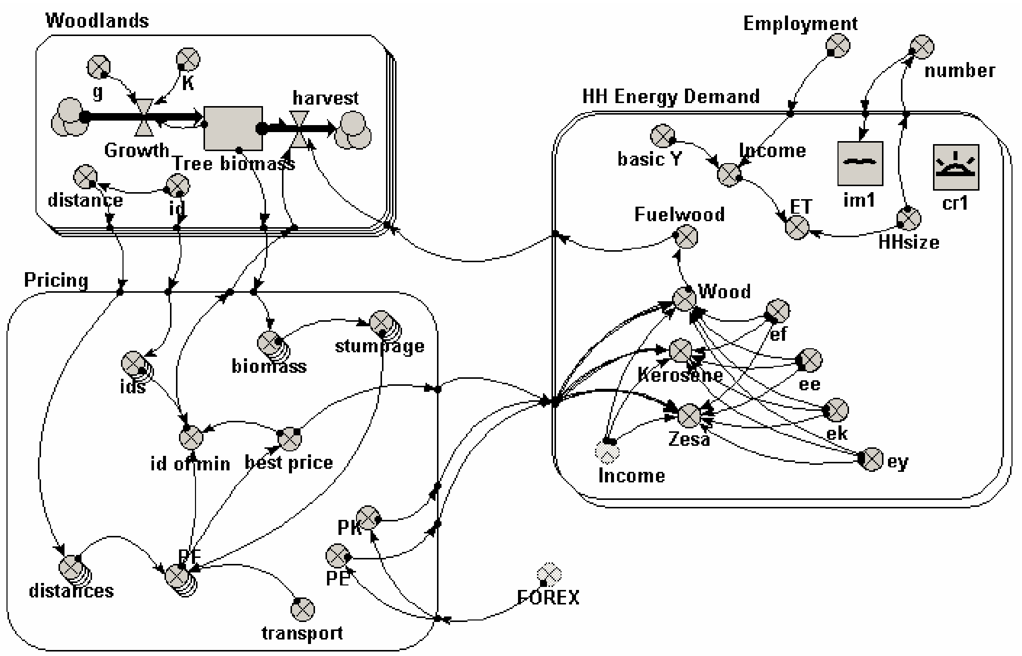


**Figure 1.** The first version of the Harare fuelwood model, devised by Muyeye Chambwera. The model deals with the dynamics of several patches of woodland (top left), with fuelwood pricing (bottom left), and with the number and size of households (right).

Many modellers advocate a problem-oriented approach to systems modelling, but the author's experience suggests that a solution-oriented approach may be more effective (Vanclay *et al.* 2006). Thus, in moving from the first version of the model (Figure 1) to the version used for teaching (Figure 2), students have been urged to focus on ways to test and demonstrate their 'best bet' for strategies that could help solve the fuelwood dilemma in Harare. Several approaches are evident in Figures 2 and 3 (the latter presenting an illustration of model output). Participants have focused on the ecological dynamics of forests (the 'Woodlots' submodel in Figure 2), on economic issues (the 'Harvesting and pricing' submodel in Figure 2), on alternative fuels and decisions made by individual households (the 'Switching decisions' submodel in Figure 2), and on 'policy levers', incentives and impediments that governments could use to alter behaviour (Figure 3). This way of thinking about the issues and 'best bets' informed the development of the model and influenced the model design and layout as reflected in Figure 2.

Parts of this model appear complicated, but attention to the layout and naming conventions can make it possible for participants to retain an adequate overview, even when they do not comprehend all the specific details of a submodel. For instance, the 'Switching decisions' submodel in Figure 2 is cluttered with model constructs, but it is easy for participants to realize that this submodel estimates the number of households making the investment to obtain and maintain the infrastructure needed to use liquid fuel (kerosene) or electric appliances. All active participants needed to – and were able to – understand the role of this submodel and to satisfy themselves about the reliability of its predictions, and it did not matter that relatively few delved into the specific details about how this submodel functions.

For participants engaged in the discussion about the Harare fuelwood situation, the model in Figure 2 was a means to an end, not an end in itself. The model was part of a greater effort to stimulate and inform discussion, and the desired endpoint was to obtain new insights about the efficacy of a diverse range of initiatives.

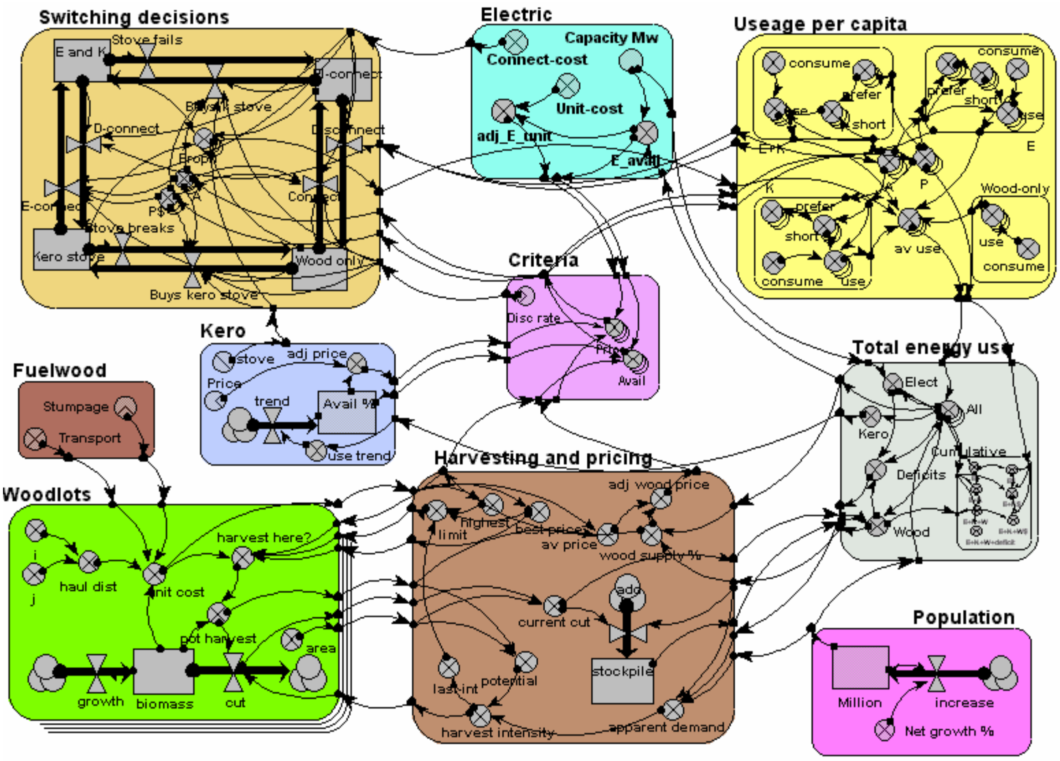


**Figure 2.** A more refined fuelwood model used for teaching and demonstration

Figure 3 illustrates some of the outputs possible from the model, and reveals some of the long list of issues that participants wished to explore. Issues revealed in Figure 3 include *sliders* (Figure 3, left) to vary stumpage price, transport costs, urban population growth, and costs of alternative fuel (kerosene and electricity). The model offered a range of graphs, but one of the more popular outputs has been the 'lollypop' diagram, an abstract indication of how forest condition is expected to vary with increasing distance from Harare. With this highly simplified representation of the real world situation, participants quickly gained new insights about the opportunities to influence fuel choices, and of the efficacy of various instruments. For instance, the model predicts that increased stumpage prices are relatively ineffective at halting the forest degradation, but that low-cost micro-loans to assist households to connect to the electricity grid could be extremely effective, and that ultimately the fate of the forest is inexorably linked to urban expansion.

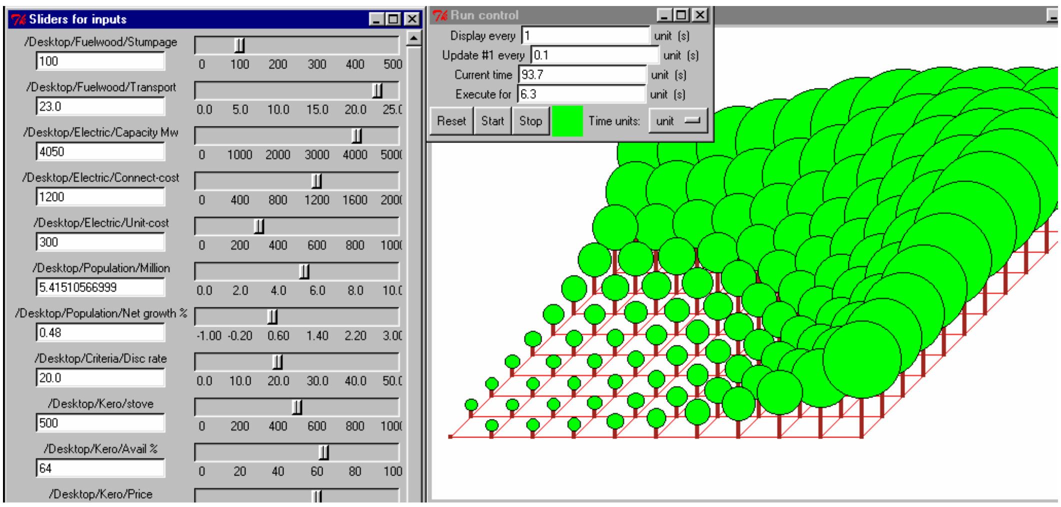


**Figure 3.** Example of output from the Harare fuelwood model

Note: Sliders at left allow users to explore possible policy interventions. The image at right symbolises the condition of the forest with increasing distance from Harare (located at front left corner of grid).

Participatory models used to explore scenarios are usually disposable, because the model is not the product, but a mere stepping stone along the path to new insights. A model has served its purpose once participants have gained new insights, after which they move on to other issues or change the model substantially. The model illustrated in Figure 2 survives not because of its relevance to the Harare fuelwood situation, but because it useful in the teaching of Simile at Southern Cross University, where it has been the basis of several class exercises. Muyeye Chambwera used the initial model (Figure 1) to clarify his thinking and inform his data collection at an early stage of his analysis before moving on to more sophisticated techniques (Chambwera 2004, Chambwera and Folmer 2007). For many models, success means being momentarily inspirational in the search for solutions, rather than being a permanent monument to a static concept.

## THE BROOMGRASS MODEL

The previous example reflected a team effort, but participation was limited initially to a small group of experts and lobbyists who had a particular interest and specific expertise, and later to students learning Simile. Participatory modelling (Hare *et al.* 2003, Standa-Gunda *et al.* 2003) extends the approach to embrace greater participation to engage and inform stakeholders in natural resource issues. One example of this deals with broomgrass harvesting from communal lands near the village of Batanai in central Zimbabwe. Brooms made from this grass make a substantial contribution to household income in this region, so management of the *vlei* where this grass grows is an important issue involving ecology, equity and social justice.


**Figure 4.** Batanai broomgrass workers with handcrafted brooms (Photo: Ravi Prabhu).

The people of Batanai village knew that their broomgrass harvest was not sustainable, but could not devise a more sustainable alternative – there were few other ways to earn a cash income, and many difficulties in dealing with common-property resources. Engaging the community through structured learning and participatory modelling helped them to gain a new understanding of the resource and of the opportunities for marketing their products. Guided by Richard Nyirenda and other members of CIFOR's Adaptive Co-Management team, the broomgrass workers (Figure 4) developed a shared vision, formulated a model that allowed them to explore their options, brainstormed to find innovative options, and devised a strategy to realize their vision. Together they gained the confidence to put these ideas into practice, and empowered themselves to create and adhere to new communal rules to achieve fair and wise use of their communal resources. As a result, the broomgrass on the common is now more productive, people are making better brooms, reaching new markets, and are earning more money. In Batanai, structured learning through participatory modelling has been the catalyst that has helped the community to change its destiny.

The full story of the Batanai broomgrass is told elsewhere (Mutimukuru *et al.* 2006, Vanclay *et al.* 2006); this paper merely highlights some insights from the discoveries arising through the participatory modelling approach. Like many models, the broomgrass model started from humble beginnings, with discussions in the field in the shade of a tree. A later brainstorming session led to a 'flipchart' model (Figure 5) that was the basis for a series of models implemented in Simile. The flipchart image illustrates an early stage of the model-building process, and reflects the outcome of brainstorming rather than critical reflection. It reveals the issues that were under discussion, including some that were omitted along the way (e.g. 'good rains', bottom left of Figure 5), some that required more development before they could be implemented in Simile ('Strengthening the relationship between RMCS and Gokwe Council', top right of Figure 5), some that proved ineffective ('Increasing the number of forest guards', top centre of Figure 5), and some that reflected 'best bets' that subsequently showed promise ('broomgrass quality', 'Number of harvesters', 'Time of harvesting', bottom right of Figure 5).

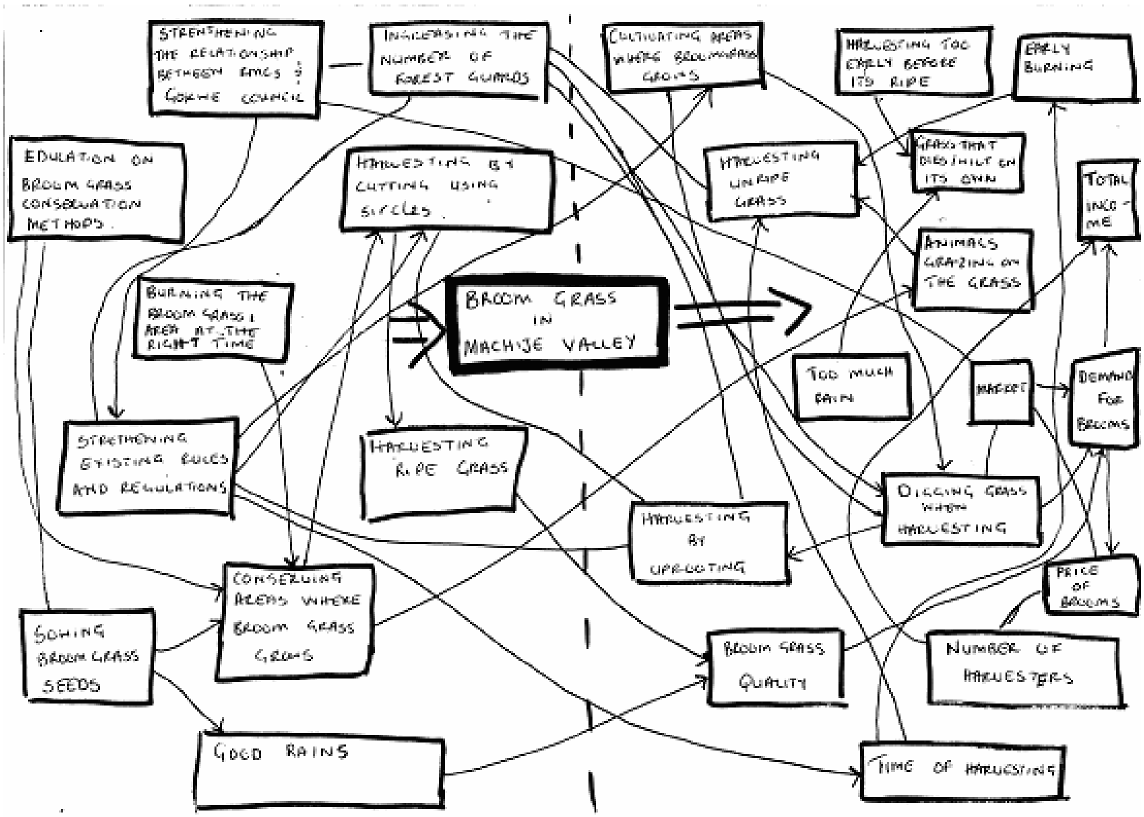


**Figure 5**. The initial flipchart model of the broomgrass resource

The flipchart model gradually evolved through a series of Simile models that explore various alternative ways to express the issues and frame potential solutions. Participants discovered the way forward while the model was still in a relatively crude state (illustrated in Standa-Gunda *et al.* 2003), and by the time experienced modellers had 'tidied up' the model to make it appear more elegant and accessible, the broomgrass workers had no further use for it. The model illustrated in Figure 6 was never used by the broomgrass workers, and was created merely to allow others an insight into the conclusions that participants reached. It was the process of building and testing the model, not the model itself, that gave the participants the insights and confidence they needed to put new management practices into place on their common lands.

Some of the findings of the participatory modelling process seemed counter-intuitive to people not intimately involved in the process. The broomgrass workers wanted to increase the number of households involved in cutting grass on the commons. To the foreigners involved in the exercise this seemed illogical: more harvesters must surely mean more harvesting and lead to overexploitation.

But the broomgrass ladies (and it was the women who had many of the innovative ideas) realized that greater participation in this money-making enterprise would lead to greater adherence to community codes of practice, to fewer stray cattle trampling the grass, and to a reduction in waste, and would provide more opportunities for mutual assistance. Collectively, their new code of practice would lead to sustainable harvesting and increased household incomes (Figure 7).

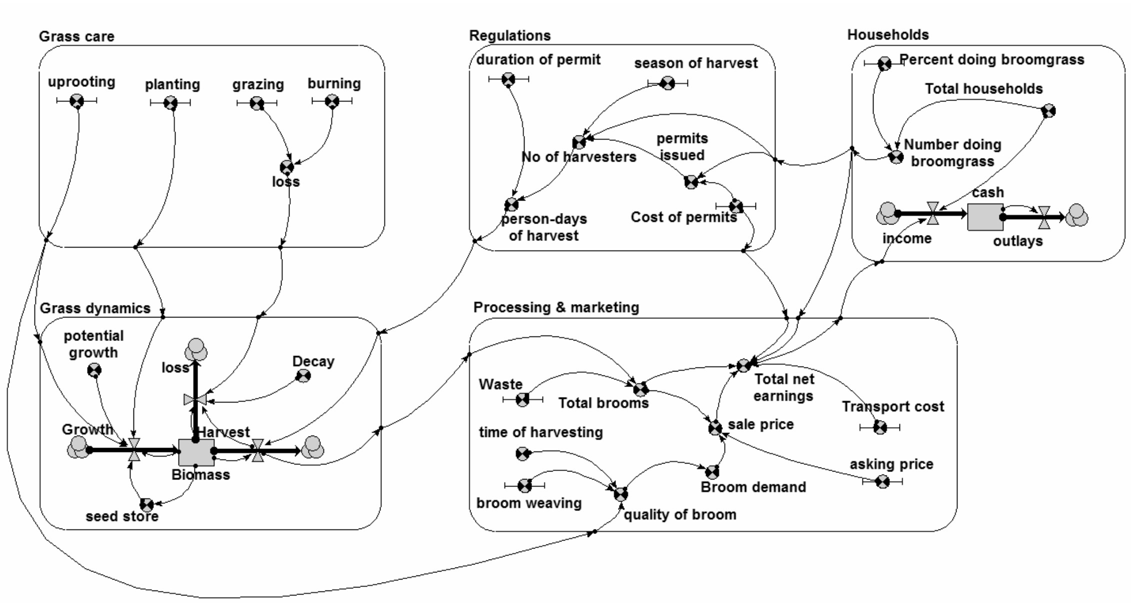


**Figure 6.** The presentation version of the broomgrass model (Vanclay *et al.* 2006). Model constructs have been labelled clearly, grouped into submodels that reflect function, and components have been arranged for clarity by minimizing the ‘criss-crossing’ of lines.

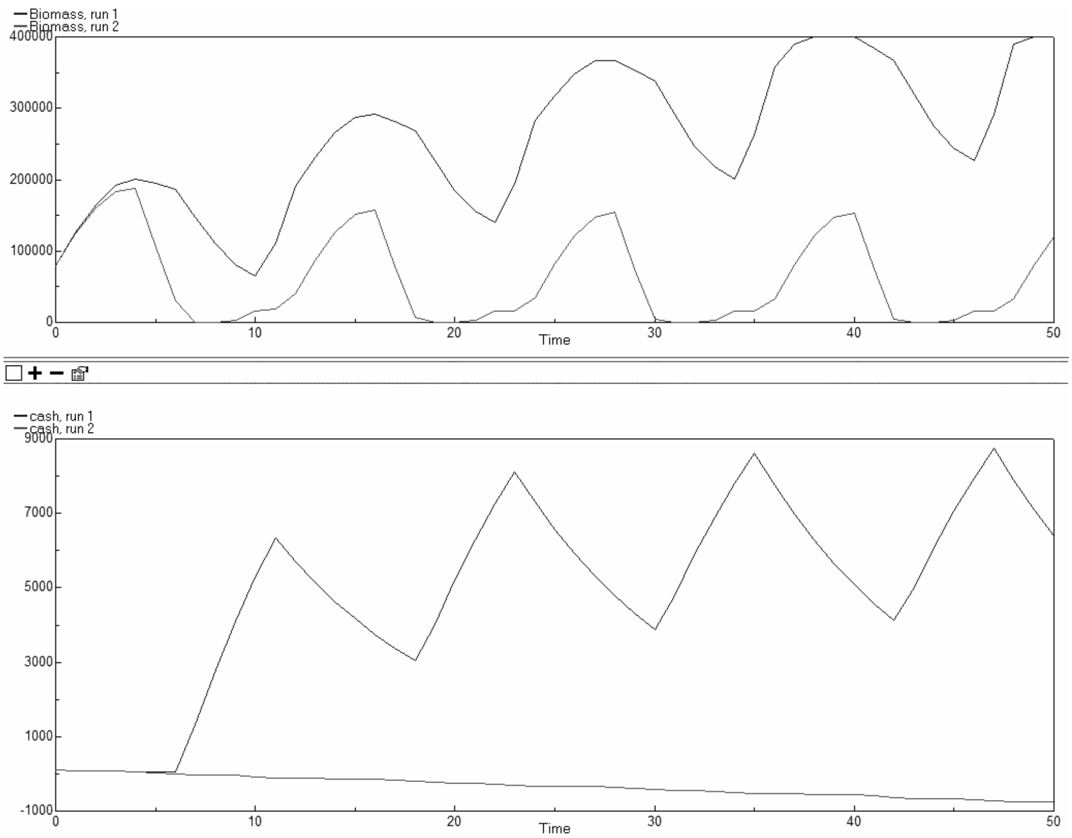


**Figure 7.** Simulation output from the broomgrass model, showing how the new initiatives (top line in both panels) increase both the grass biomass (top panel) and the household income (bottom panel).

The broomgrass ladies also realized that a change to the triple bottom line would require consideration of all three components of this bottom line, which they modelled and explored through simulation. They examined, modelled, and included in their code of practice, issues relating to ecology (season of harvesting, cutting with a sickle versus uprooting; Figure 6, top), economics (quality of broom, transport cost; Figure 6, bottom left) and social aspects (patch harvesting, with harvesters only allowed to move to a new patch after completing the previous patch, to allow widows, orphans and other slow harvesters to participate without fear of losing access). All of these aspects can be, and were examined with the Simile model.

## CONCLUSION

Participatory modelling cannot solve a problem, but it can inform, offer new insights, and allow experiments to be simulated and scenarios evaluated. Together, these may give communities the confidence needed to adopt new initiatives to improve the triple bottom line. Exploring the options and building confidence may mean building and testing many versions and variants of a model, but this is part of the learning process. Modellers should resist becoming attached to their models, because with participatory modelling, the model is simply a stepping stone along the path to enlightenment. Success in participatory modelling means being momentarily inspirational in the search for solutions, rather than providing a monument to a static concept. Facilitators of participatory modelling exercises must inspire confidence, so that participants are willing to propose diverse scenarios for evaluation and simulation. A focus on 'modelling the best bet' rather than 'modelling the problem' can be an effective way to progress towards viable solutions.

## REFERENCES


Attwell, C.A.M., Campbell, B.M., Du Toit, R.F. and Lynam, T.J.P. (1989), *Patterns of fuelwood utilization in Harare*, Zimbabwe, Report to the Forestry Commission of Zimbabwe and the World Bank.

Chambwera, M. (2004), Economic Analysis of Urban Fuelwood Demand: The Case of Harare in Zimbabwe, PhD Thesis, Wageningen University, Wageningen, Netherlands.

Chambwera, M. and Folmer, H. (2007), 'Fuel switching in Harare: An almost ideal demand system approach', *Energy Policy,* 35(4), 2538–2548.

Easterly, W. (2001), *The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics*, MIT Press, Cambridge MS.

Hare, M., Letcher, R.A. and Jakeman, A.J. (2003), 'Participatory modelling in natural resource management: A comparison of four case studies', *Integrated Assessment,* 4(2):62–72.

Muetzelfeldt, R. and Massheder, J. (2003), 'The Simile visual modelling environment', *European Journal of Agronomy,* 18(3–4):345–358.

Mutimukuru, T., Kozanayi, W. and Nyirenda, R. (2006), 'Catalyzing collaborative monitoring processes in joint forest management situations: The Mafungautsi Forest case, Zimbabwe', *Society and Natural Resources,* 19(3):209–224.

Standa-Gunda, W., Mutimukuru, T., Nyirenda, R., Prabhu, R., Haggith, M. and Vanclay, J.K. (2003), 'Participatory modelling to enhance social learning, collective action and mobilization among users of the Mafungautsi Forest, Zimbabwe', *Small-scale Forest Management, Economics and Policy,* 2(2):313–326.

Vanclay, J.K., (2003), 'The one-minute modeller: An introduction to Simile', *Annals of Tropical Research,* 25(1):31–44.

Vanclay, J.K., Prabhu, R. and Sinclair, F.L. (2006), *Realizing Community Futures: A Practical Guide to Harnessing Natural Resources*, Earthscan, London.