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Jerome K. Vanclay
Southern Cross University

Mandy Haggith
WorldFOrests, Inverness

Carol J. Pierce Colfer
Center for International Forestry Research, Bogor, Indonesia

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Participation and Model-building: Lessons Learned from the Bukittinggi Workshop

Jerome K. Vanclay[1]
Southern Cross University, PO Box 157, Lismore NSW 2480, Australia

Mandy Haggith
Worldforests, 95 Achmelvich, Lochinver, Sutherland, Scotland IV27 4JB

Carol J. Pierce Colfer
Center for International Forestry Research, Bogor, Indonesia

FLORES (the Forest Land Oriented Resource Envisioning System) was initially constructed by 50 people during a multidisciplinary workshop in Bukittinggi, Sumatra, in 1999. It proved that a model of a complex system could be constructed in a participatory way by a diverse team; that it could be done with a graphically-based package such as Simile; and that the resulting model could remain reasonably accessible to all participants, and could run on an ordinary notebook computer. Many useful insights can be gained through building such a model, and subsequent experience has demonstrated that modelling in this way can foster continuing interdisciplinary collaboration. Participants founded the FLORES Society, a loose collective open to all researchers interested in pursuing the development and use of such models. The Society conducts an e-mail discussion group on FLORES@cgnet.com (subscription requests to JVanclay@scu.edu.au).

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INTRODUCTION

The idea of simulating land use at the landscape scale for informed decision-making was articulated in 1995 (Vanclay 1995), but further development of the concept awaited advances in computer technology (e.g. Muetzelfeldt and Taylor 1997, 2001). A prototype constructed in 1997 (Muetzelfeldt *et al.* 1997) was influential in helping to attract funding from the British Department for International Development (DFID) to convene a workshop to prove the concept. The workshop was held in Bukittinggi (Sumatra, Indonesia) in early 1999, and this paper reports on the workshop process, the outcomes and the lessons learned.

This paper has been compiled from a journal maintained during the workshop, from e-mail bulletins sent to virtual participants, reports prepared by workshop participants, and from digital photos taken during the workshop of flipcharts, whiteboards and other materials. Although (at the time of writing) three years has elapsed since the workshop, it continues to influence the continuing development of the FLORES approach to modelling and to inspire a group of researchers known as the FLORES Society. Thus it is useful to re-examine the workshop experience, including the original objectives, workshop process and the resulting achievements. This analysis highlights some shortcomings, the successes, and many lessons arising from the experience.

THE FLORES CONCEPT

FLORES was articulated as part of the research programme of CIFOR, the Center for International Forestry Research, the motto of which is 'Science for People for Forests'. CIFOR is a member of Future Harvest, a consortium concerned with food security, rural poverty and the conservation of biodiversity. These concerns are, of course, inexorably linked to land-use decisions made by local communities and absent landlords, whose decisions can be influenced by incentives and policies made in cities far from the forest frontier. Most decision-makers have an adequate basis for decisions taken in a stable environment, but changing circumstances, whether natural (e.g. droughts and floods forming part of the ENSO[2] cycle) or imposed (e.g. development, transmigration), may lead to situations where people are ill-equipped to anticipate consequences of their decisions. Many researchers have addressed these issues in part, but there is limited synthesis of such work, and FLORES sought to provide a decision-support system able to influence land-use decisions both locally and at the national level.

A prototype, pFLORES (Muetzelfeldt *et al.* 1997, Haggith and Colfer 1999), had demonstrated the technical feasibility of FLORES, but it was in many ways (quite deliberately) an empty shell, awaiting stakeholder input to animate it fully. These inputs would not merely populate a template with parameters, but were needed to turn a technical demonstration into a tool for social learning. It was envisaged that a multidisciplinary workshop to formulate, calibrate and test a full version of FLORES could:

[2] An El Niño Southern Oscillation is a disruption of the ocean-atmosphere system in the tropical Pacific causing increased rainfall in the eastern Pacific (Peru, south-east USA), and drought in the West Pacific, sometimes associated with devastating fires in Australia.

- Stimulate discussion about decision-making processes in forest-dependent communities, and how these may change with circumstances;
- Reveal weaknesses in the FLORES concept and offer a better logical framework for thinking about land-use issues; and
- Offer new insights into data structures, and lead to efficiencies in field data collection procedures.

Workshop proponents recognised that any initial version of FLORES was unlikely to provide a practical decision support system. Such a decision-support system would require several iterations of calibration, testing and refinement. However, it was anticipated that efforts to design an appropriate user interface would:

1. Encourage potential users to join in discussions, to contribute to system design, and to participate in the conduct of related research;
2. Stimulate interaction between a range of researchers, practitioners and other clients; and
3. Offer potential users an insight into new technology and an understanding of how it may help their advocacy activities.

Proponents anticipated that workshop participants would work with local people, researchers and other data owners to identify activities critical to land-use decisions and community welfare. Productivity and economic data for each of these activities would be gathered subsequently so that suitable sub-models could be formulated and incorporated into FLORES. Several iterations of model reformulation, calibration and testing subsequent to the workshop were envisaged to provide a satisfactory representation of the biophysical processes and social interactions in the system. Even if the initial version of FLORES was unable to provide 'the answers', it was expected to deliver tangible benefits by enabling researchers and advocates to ask better questions.

Workshop outputs were envisaged to include a preliminary FLORES setup for a hypothetical (composite) situation, and user guidelines for any researchers interested in using the model, including specific advice on how to calibrate the model for other sites. Follow-up activities were expected to include sensitivity analyses identifying critical parameters in the model and research papers reporting achievements and further research needs. It was expected that rural communities would ultimately benefit from this research through increased food security, through the provision of a decision-support system that could be used to evaluate alternatives and explore consequences.

The original intention was that the workshop should involve 20 people, selected to ensure a broad representation of technical and disciplinary skills. Invitations were circulated to prospective participants three months prior to the workshop (in October 1998), and stated concisely the objectives and planned process for the workshop:

> The workshop seeks to bring together twenty experts from various disciplines to synthesise existing knowledge of forestry, land-use and policy issues within the FLORES framework. This exercise will foster interdisciplinary collaboration, force participants to focus pragmatically on key policy issues, and produce a model and related publications making this information more widely available in a useable form.

In doing so, it will promote the use of FLORES as a flexible platform for empirical hypothesis testing, and create a user group to foster further development of FLORES.

Participation in the workshop will be restricted to those with specialist skills in relevant disciplines, modelling or facilitation. Five teams will be formed to work on sub-models relating to agronomy and the physical environment, forest dynamics, non-timber forest products and environmental services, biodiversity and ecology, and socio-economics and household decision-making. Each team will comprise three or four individuals, with at least two disciplinary specialists, and at least one person with modelling experience. …

The workshop is expected to deliver two main tangible outputs: a working model that can be adapted to specific situations; and documentation of the process and outcomes that will guide subsequent iterations and assist others planning similar exercises. The workshop is also expected to foster commitment towards on-going development, implementation and use of the resulting model by participants and other researchers.

WORKSHOP PREPARATIONS

Preparations for the workshop represented a compromise between the desire to initiate some discussion before the workshop so that the workshop itself could make rapid progress, and the recognition that thorough discussion, considered decisions, and a sense of 'ownership' required full participation that could only occur during the workshop proper. Nonetheless, e-mail exchange was initiated to stimulate thinking about the scope and detail of the model by formulating a series of questions that potential users eventually may wish to ask of FLORES (two months before the workshop, November 1998). These questions included:

1. What effect will a change in access rights (or access to credit, better education, fuel subsidies, marketing cooperatives, price controls, transport costs, etc.) have on biodiversity (or food security, income distribution, land-use patterns, quality of life, endangered species, water quality, etc.)?
2. How will it affect biodiversity (or food security, etc.) if the new infrastructure (bridge, factory, plantation, pulp mill, resort, road, etc.) is placed here instead of there?
3. We have articulated our vision for the future, and experts have helped us formulate a strategy: will it work? Which aspects of the strategy are the most critical? How will we know if we get off-track? When can we expect to see progress?
4. What should we do with the illegal squatters within this conservation reserve? Present land-uses are not sustainable and are degrading the land. Should we move them, offer them tenure, or regulate land-uses? How can we choose the best solution?
5. Imperata grasslands can be rehabilitated with our new techniques: are there any socio-economic factors that may hamper our efforts to restore these lands?
6. Where can we locate a new settlement so that it will be sustainable, provide adequate incomes, and avoid undesirable environmental effects?

The response was limited. There was some discussion about the possible use of FLORES in optimization studies, leading to the general consensus that it was unwise to assume that a theoretical optimum would be realistic or useful. However, the process did eventually generate some discussion about specific model details. One suggestion (Robert Muetzelfeldt, 29 December 1998) was that participants should subscribe to a model with a 1-week time step; 3 villages each with 10-20 households; 0-5 patches of land (each about 0.5 ha) per household; a community forest of three times the cultivated area; with land represented as polygons (not rasters) and boundaries remaining fixed throughout the simulation.

This elicited three helpful responses:

- *A wise caution*. Whilst it is tempting to try to sort out the basics in advance, I would caution against this. From what I have seen, these modelling groups work best when there is a real sense of shared ownership of the emerging model. By keeping the slate as clean as possible at this stage, it allows the shared ownership to develop during group sessions in which all can participate. All the basic issues – objectives, issues, outputs, scale, structure (sub-models) etc. – are best handled in this way. Otherwise much of the knowledge of the assembled group will be left out, and motivation may lapse. This doesn't mean to say that the suggestion isn't the best one – it may well be. If so it will easily prevail (Martyn Murray, 30 December 1998).
- *A plea to be more inclusive*. It is difficult for a non-modeller to comment on the nuts-and-bolts of the model per se. I'm interested in refining our objectives with regard to what kind of questions and insights we are going to focus our initial efforts upon – we clearly have a wide choice … some guidance and consensus is needed. I can see that the detail required within any model element depends very much on the level (within the landscape hierarchy) of the issues we are hoping to come to grips with. Won't our model choices be largely defined by the scale of the questions we choose to focus our primary efforts upon? Can some initial discussion be 'question' oriented rather than 'model element' oriented? Can anyone define what characterises a reasonable question for FLORES (Doug Sheil, 12 January 1999)?
- *A reminder of the importance of conceptualising*. Maybe now is a good time to remind people who consider themselves "non-modellers" that there are two processes at work when creating a new model: conceptualisation and representation. I like and strongly support the focus on household decision-making as a key element in the FLORES analysis. It's less clear to me whether current effort should be focussed on representation as opposed to conceptualisation. My hope is that the fieldwork will have opportunities for discovery. Issues of scale may well fall into place. Maybe the evidence will force us all to rethink – re-conceptualise – our mental models of decision-making. Participants with no background in coding models may lead us to that end, so their involvement in FLORES is crucial. Representing the new models should be less difficult than their conceptualisation and testing (Bob Caldwell, 13 January 1999).

With these contributions, the e-mail discussion gradually petered out, and the issues lay dormant until the workshop commenced, when they were re-addressed more fully. In hindsight, it is interesting to observe that the e-mail correspondence seemed to empower participants to make brief 'nit-picking' comments on technical details, but did not draw them into the more important philosophical discussion about conceptualising the model and the issues that it needed to encompass. This may be due in part to the fact that sporadic text-oriented e-mails are not well-suited to discussion and 'brain-storming', which seem to flow better when they are immediate, spontaneous and focussed (cf. a facilitated break-out group around a whiteboard).

Perhaps the major visible effect of the e-mail discussions was the arousal of widespread interest in the workshop. Invitations were circulated to prospective participants well in advance of the workshop, and an impressive list of participants was soon settled. However, requests to join the workshop kept coming, reaching a peak during the e-mail discussions in January, just days before the workshop, and culminating in a hundred applications. Because of this enthusiasm, workshop plans were expanded to include 50 participants, with a further 40 people participating in a virtual way via daily e-mail bulletins throughout the workshop. A web site was also maintained throughout the workshop, but efforts to effect daily updates were hampered by technical difficulties and other commitments.

WORKSHOP PROCESS

The Bukittinggi workshop drew inspiration from the Adaptive Environmental Assessment and Management (AEAM) workshops pioneered by Holling (1978). However, there were some important differences in workshop objectives and expected outcomes. Holling's (1978) book is directed largely at 'the person charged with preparing an assessment of the environmental consequences of some proposed action. … responsible for gathering together and coordinating a team to examine the problem, analyse the possible consequences, and prepare a report that will be used as an aid for decision' (Holling 1978, p. 38). While there was much in common, the Bukittinggi objectives were much broader: to synthesise knowledge, engender participation, and foster commitment to continuing interdisciplinary research into land-use issues. Nonetheless, the Bukittinggi workshop generally followed the following steps adapted from the AEAM approach:

1. identify issues;
2. identify indicators of performance (outputs);
3. define policy levers;
4. establish purpose of the model (= indicators + levers);
5. define overall model characteristics;
6. form groups to deal with particular issues;
7. agree on interfacing between groups;
8. design sub-models;
9. test sub-models as stand-alone models;
10. synthesise sub-models to form a consolidated model;
11. test the consolidated model; and
12. explore implications for management.

Workshop participants were drawn from diverse backgrounds, so the first three days of the workshop followed a different agenda. The first day provided introductions, offered a broad overview of the concept (and of the contractual commitments made to the donor, DFID), and built team spirit and a sense of common purpose, in part, by playing Fishbanks (as developed by Meadows 1996). It also included basic training in modelling with Simile, then known as AME (Muetzelfeldt and Taylor 1997) and a brief introduction to the FLORES prototype (Muetzelfeldt *et al.* 1997) to develop confidence that the task was possible. This was followed by a 2-day field trip to see the issues and context first-hand. Thus, by the time participants sat down together in a meeting room in Bukittinggi, considerable progress had already been made without the formal adoption of these 12 steps.

To foster ownership of the emerging model by workshop participants, workshop proponents stood aside from the formal leadership role from Day 4 of the workshop (the commencement of model-building activities in Bukittinggi, Table 1), and arranged for the process to be led by a professional facilitator experienced in the AEAM approach.

Table 1. Planned agenda for Bukittinggi workshop

Day	Date	Activities
	Fri 22 Jan, 1999	Arrival in Jambi, icebreaker
1	Sat 23 Jan, 1999	Introductions, issues, Simile, pFLORES, Fishbanks
2	Sun 24 Jan, 1999	Field trip: lowlands, peneplain, industrial deforestation
3	Mon 25 Jan, 1999	To Bukittinggi: foothills, smallholder deforestation
4	Tue 26 Jan, 1999	Specific objectives, issues, policy levers, form teams
5-8	Wed - Sat, 1999	Teams discuss, design and construct sub-models
7	Fri 29 Jan, 1999	(Prototypes available to plan consolidation)
8	Sat 30 Jan, 1999	(Final sub-models available for consolidation)
9	Sun 31 Jan, 1999	Recreation (white-water rafting), while experts consolidate model and get it running
10	Mon 1 Feb, 1999	Demonstrate consolidated model, test feasible scope
11	Tue 2 Feb, 1999	Postmortem: utility, applicability, way forward
12	Wed 3 Feb, 1999	Future plans, documentation, publication
	Thu 4 Feb, 1999	Depart

The facilitator led the group methodically through the 12 steps of the AEAM process. This was a difficult time for the workshop. Some participants clearly felt that there had been enough discussion of these issues during the field trip, and they wanted to get on with the business of model-building. Some participants who had read the background material and participated in the e-mail discussion, showed some impatience at going back over 'old ground' to identify issues (i.e. Step 1 above). This was a testing time for the facilitator, who needed to control the agenda, to ensure all the participants shared a common understanding of the issues, and needed to maintain the confidence and enthusiasm of those who wanted to press on. Despite some frustration, the group persevered with the AEAM approach and agreed on issues and purposes on some indicators and levers and on overall model characteristics. As it happened, the model structure previously canvassed via e-mail was adopted with only minor modifications, and the sub-groups adopted were essentially those proposed at the outset by workshop proponents. However, some new insights did emerge. Group discussions refined the workshop objective – 'To produce a working model (albeit one which needs refinement)' – and led to the observation that 'the longer-term objective is to develop the model into a useable tool over a period of perhaps 2 -3 years'.

After the initial plenary session, most of the time was spent building sub-models in small groups, with brief plenary sessions each day to report progress and discuss linkage mechanisms between sub-models as well as any emerging issues that warranted broader consultation. Again, with the benefit of hindsight, it may have been productive to have less plenary and more small-group sessions on Day 4, and more plenary sessions on subsequent days to deal more thoroughly with the thorny issue of linking sub-models effectively.

Participants worked long and hard to realize their shared vision. On occasions, frustrations became apparent, especially when negotiating workable concepts and attempting to animate them successfully. This made it clear that it was important to manage 'time out', and encourage participants to take a break, relax and unwind. Activities as diverse as cross-country running, durian[3] tasting, pool-side drinks and white-water rafting helped to re-kindle team spirit and enabled participants to look at old problems with fresh enthusiasm. The experience suggested that such activities should not be neglected, especially when workshops run for more than a few days.

PARTICIPATORY MODELLING

A key objective of the workshop was to foster participatory modelling as a way to encourage interdisciplinary collaboration and exploration of land-use options and outcomes. As many of the participants had no previous model-building experience, the choice of Simile was critical to the outcome of the workshop. Thus it is useful to explore the reasons for adopting Simile, and to review the experience of the various teams.

Modelling with Simile

Simile (Muetzelfeldt and Taylor 1997, 2001, Vanclay 2002) is a generic modelling environment that can be used for modelling a wide range of dynamic systems. It was specifically developed for ecological applications, and is particularly well suited for FLORES, because it has a graphical user interface that is intuitive and diagrammatic, making it accessible to novices and facilitating a participatory approach to model design; it embodies concepts of systems dynamics and object-oriented programming which allow efficient representation of multiple households, multiple patches of land and the interactions between them; and it is relatively easy to build and test models, compared with code-based approaches.

The design requirements of FLORES are quite demanding. The model must deal with diverse biophysical aspects such as tree and crop growth, changes in the environment, and the spatial relationships between patches of land. It must handle discrete variables (e.g. people) and continuous variables (e.g. rice stocks) within each household, the household decision-making processes, and various social aspects including co-operation, collaboration, negotiation and inheritance. Interactions between households and their resources may involve complex tenure arrangements that are central to understanding subsistence communities. Simile is unusual, if not unique, in its ability to handle these requirements (Muetzelfeldt and Taylor 2001).

[3] Durian is a local fruit, highly regarded by aficionados, but described by one critic as tasting like 'custard eaten in a sewer'.

The promoters of FLORES envisage the development of 'similar-but-different' models for a range of sites. These models will be similar, in that most will adhere to the standard structure of households-tenure-patches with sub-models for various biophysical components (e.g. crops, trees) and human components (e.g. resources, decision-making). They may differ in location-specific details such as crops, fire, fish and wildlife. Thus the FLORES approach is not to build a generic 'turn-key' system, but to provide a standard framework and basic building blocks appropriate for a range of situations. Simile has unique features to facilitate exchange of sub-models via its 'plug-and-play' feature (Muetzelfeldt and Taylor 2001). Simile's display tools can be created or customised by users and shared amongst the FLORES community. The ability of Simile to implement FLORES had been demonstrated by the construction of a prototype (pFLORES, Muetzelfeldt *et al.* 1997). Based on this experience, a template (Figure 1) was provided to assist modelling teams to visualise their place in the consolidated model. This template was intended only as a guide, not as a rigid framework.

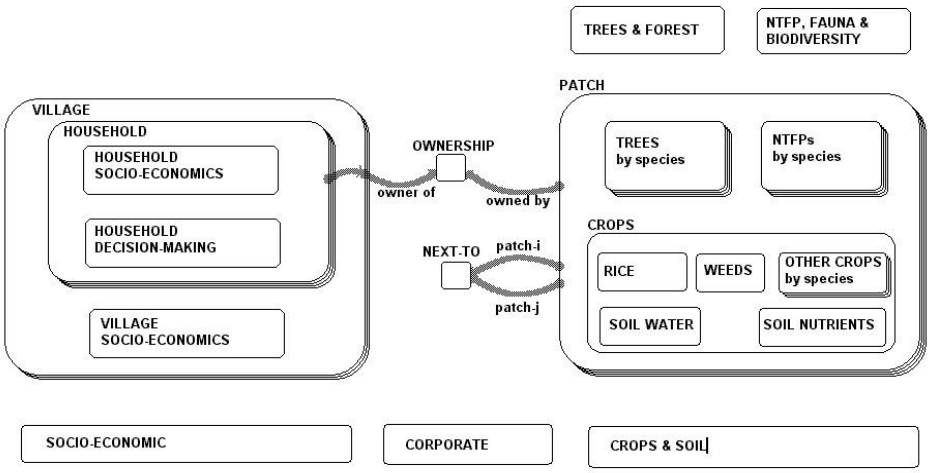

Figure 1. The skeleton model used during the workshop

Modelling Crops, Soil and Water

One team dealt with crops, soil and water. It was assumed that well-established precedents and the accumulated experience of team members would lead to an efficient approach to deal with these diverse biophysical aspects. With hindsight, it appears that their experience may have been an impediment, as it seemed to hamper their ability to generalise to a few generic indicators of nutrition, and to simplify the model to the primary determinants of crop yield. The crop sub-model was far more detailed than other components of the model. Effectively, the group implemented in Simile an existing plant model dealing with above and below-ground biomass as undifferentiated layers of vegetation. Multiple instances allowed for intercropping and weeds. Light competition was handled as a cascade between plant layers of various heights. Water balance and soil nutrients were modelled at the patch level.

Pests (and diseases) were included because of their possible impact on crop yields. Two classes of pest were recognised: one reflecting pests originating outside the plot (e.g. disturbance by feral pigs), the other reflecting internal outbreaks such as nematodes and fungal diseases. Progress of the pest outbreak is simulated and provides a basis for inferring a yield reductions. Householders may become aware of an outbreak, and may respond (e.g. by spraying crops or driving away pigs).

Modelling of Trees and Forests

The ‘forest’ team were similarly hampered by their experience and implemented an existing mathematical model in Simile. Forest development was modelled at the stand level by simulating volume increment, top height and numbers of stems. Two guilds were recognised, namely pioneer and shade tolerant species. The relative proportion of trees within each was varied to simulate ecological succession following disturbance. Because the sub-model deals with different forest types and site conditions, it provides multiple instances, each with the same structure but with different parameters.

It is possible to handle forests as a special crop, but this approach adds additional complications relating to scale (forests are usually larger than fields), interventions (intensive and frequent in fields; extensive and occasional in forests) and biodiversity. A separate ‘jungle rubber’ sub-model was constructed to deal with the specific issues of weeding, latex production and timber harvests from both naturally-regenerated and planted trees.

Modelling Non-Timber Forest Products and Biodiversity

The ‘biodiversity’ team developed two sub-models – one for non-timber forest products (NTFPs) and one dealing with selected mammals. These were not meant to be exhaustive, but rather indicative of approaches relevant to FLORES. The NTFP model was a generic description of population dynamics of a typical NTFP species, and could apply to rattan, bamboo and fruits, the main NTFPs required by the household team. The NTFP model was nested within the Forest sub-model, implying that NTFPs were dependent upon the presence of forest.

The mammal model addressed population dynamics of various mammalsand birds (pigs, deer, monkey, tiger and hornbill) selected to illustrate diverse life histories and represent game, pests, and conservation icons. Animal abundance was modelled by predicting births and deaths as a function of land cover and habitat type. Hunting was accommodated via a parameter reflecting the time allocated to hunting by households, which was in turn dependent on hunting success and the priority assigned to this activity.

Species richness was assumed to be dependent on forest cover, quality and fragmentation, which were estimated from stand basal area and successional status.

Modelling Household Decisions

Unlike the other teams which were comparatively homogeneous in their disciplinary backgrounds, the ‘household’ team encompassed diverse experience of subsistence households in many situations, but relatively limited modelling experience (and the few modellers had no prior Simile experience). Lacking established paradigms for modelling household decisions, they were much more methodical and systematic in their approach, partly because some team members were well-experienced in facilitation techniques.

They began by talking about local ethnography and about economic models of decision-making. Some decision-making 'stories' were written to give others an idea of factors affecting decisions. They divided the work into internal and external matters, and appointed a person to conceptualise the parts of the sub-model and how it might link to other sub-models. Modelling began with a whiteboard diagram with a list of topics and ideas, outlines of decision-making related to land management and economics, and a population simulator. Another prerequisite was a table showing the monthly time allocation to various household tasks. Gradually they added ethnographic detail, and began thinking about policy levers and indicators. There were intensive discussions with other teams about linking sub-models, especially how to communicate the labour information to each of the other sub-models. These discussions were long and difficult, but critical to the success of the sub-model. All of the other teams were lobbied long and hard to obtain agreement that the household decision-making model should produce output in terms of a single coherent unit (the number of days labour applied to a range of different activities, and not in terms of number of kgs of fertiliser, number of pigs hunted or number of trees cut down). It was a major achievement of the workshop that the other teams accepted that all the other sub-models should accept household labour as an input, and have each biophysical sub-model calculate the impact of that labour.[4] This systematic approach led to a household sub-model that all team members 'owned' and understood, and led to an understanding of the strengths and weaknesses of the sub-model.

The household team attempted to integrate in a single sub-model many details of the social structure (population within household), household economics (stocks and economic model) and subsistence land-use decision-making. The sub-model is characterized by the fine level of granularity (household decisions on a weekly time-step) and the integration of economic and anthropological issues. Some broad simplifying assumptions were needed to integrate these aspects (social, economic, land-use). The team carefully documented key assumptions and essential simplifications (and some consequences), including the use of:

- a weekly time-step (difficult to handle strategic decision-making);
- one hectare patches (home gardens not modelled explicitly); and
- single decision sub-model (no specialisation by individuals).

Unlike other teams, the household team provided a long list of caveats imposed by the choice of study site and the limited time and resources for modelling. Some of their concerns included:

- Few ethnic groups in the study area, thus few systems of resource use;
- Model of households only, ignores the role of villages, clans, and individuals as agents of change outside the household;
- Home gardens are smaller than the 1 ha patch size in the model, so gardens cannot be modelled explicitly and are assumed as part of the village landscape;

[4] Possibly the first time that FLORES 'found lots of really enlightening simplifications'.

- Simplified representation of NTFPs and crops has implications for indicators of landscape diversity, habitat quality and biodiversity;
- No explicit modelling of share-farming, labour sharing or patch adjacency;
- Long history of settlement in the study area means land claims likely to have been resolved, unlike frontier and transmigration areas;
- Use of a fixed number of households required a simple population model, and precludes the modelling of migration; and
- Focuses on tactical rather than strategic decision-making.

Despite this long list of simplifications (or perhaps because of it), the team developed a working sub-model, that has formed the basis for subsequent FLORES models.

Reflections on Team Composition

It is useful to examine the composition of the four teams presented above, especially in terms of their background and modelling experience, and to observe the extent to which their approach and product depended on their experience (Table 2). Note that in each group, there was at least one person experienced in simulation modelling (doctoral level or equivalent).

Table 2. Composition of selected modelling teams

Team	Experienced modellers	Modelling experience	Nature of subject	Published paradigms
Crops	Most	Systems dynamics	Biophysical	Many
Forest	Many	Mathematical	Biophysical	Many
Biodiversity	One	Mathematical	Biophysical	Few
Households	Few	Multi-agents	Social	None ?

Both the ‘Crops’ and ‘Forest’ teams seemed to have been hampered by their familiarity with particular approaches. It appears that rather than systematically addressing the needs of the case study, they set about systematically implementing in Simile a representation closely aligned with their previous work. In both teams, participants were drawn from more than one ‘school’ of modelling, and some tension was evident as these teams struggled to agree on a suitable approach. In both cases, teams seemed to make rapid progress early on, but later struggled with specific details, and found it hard to reach agreement on a coherent sub-model that could provide for the needs and expectations of other teams. The social diversions previously mentioned were especially important in managing tensions within these two teams.

In contrast, the ‘Household’ team had no template to follow[5], had a broader range of issues to deal with, and had little experience with modelling environments such as Simile. A number of the team members did, however, have experience with facilitation of collaborative processes. This was central in keeping the process smooth and constructive. They recognised that progress depended on developing a shared understanding of the issues, carefully defining the problems to be addressed, agreeing on an achievable subset, and working methodically towards a common goal. While their measured approach seemed to some to be slow and clumsy, it resulted in a sub-model that worked, was well documented, and revealed clear pathways for further enhancements. In addition, the approach retained the interest of and ‘ownership’ by all team members.

To generalise, it seems that many in the ‘Crops’ and ‘Forests’ teams assumed that their common experience in modelling industrial crops (Figure 3, left) implied a common view of how best to model the Rantau Pandan[6] situation in FLORES. Hindsight has shown that this ‘area of overlap’ related mainly to specialist technical skills, and not necessarily to participants’ view of how to approach the problem in hand. In contrast, the ‘Household’ team knew that they shared little in terms of experience (Figure 3, right), and managed the whole sub-model design process carefully to ensure a common understanding and shared interest. In the Bukittinggi workshop, the facilitator managed only the plenary sessions, and teams were left to their own devices when designing and constructing their sub-models. Hindsight reveals that this was a mistake: it is particularly important to manage the process carefully, in group-work as well as in plenary sessions, especially when participants assume that they have much in common. Never assume a common understanding and shared interests, but manage the process to achieve it.

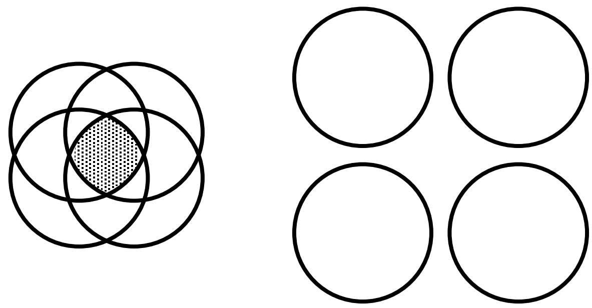

Figure 3. Venn diagram illustrating how the 'Crops' team shared substantial common modelling experience (left) while the 'Household' team represented diverse but different experience (right)

[5] There were no simulation models of household decision-making to emulate, but the team did follow two clear paradigms in their approach: participatory research (for knowledge sharing) plus knowledge engineering (where a knowledge engineer works to elicit knowledge elicitation, listening intently to experts and trying to capture their knowledge in whatever formalism is at hand). These are process-oriented paradigms, whereas paradigms for other groups tended to be product-oriented.

[6] Rantau Pandan is a district within the Bungo Regency of Jambi Province, Sumatra, and was chosen as a case study for the first FLORES model. It is one of the ‘benchmark sites’ for the international Alternatives to Slash and Burn (ASB) programme, and thus is the focus of a substantial interdisciplinary research effort (http://www.asb.cgiar.org/txt_only/indonesia.shtm).

Managing Information Exchange between Sub-models

One of the major challenges in co-ordinating teams engaged in participatory modelling is dealing with information flows. At various times, teams may assume that specific information will be available from other sub-models. It is not simply an issue of making sure that source and recipient teams use the same units, but the more complex issue of ensuring comparable concepts and constructs. This applies equally to biophysical concepts (e.g. the density of forest could be expressed as trees/ha, basal area, crown closure or leaf area index) and social concepts (e.g. poverty could be based on cash or nutrition, on the village average, or on individuals or proportion below a particular threshold). With some constructs, it is easy to transform an indicator into an alternative form; with others it is impossible. The best approach is for both teams to be well aware of each other's needs, and to negotiate a suitable standard for exchange. The workshop kept this on the agenda, and a matrix of 'I want – you need' was maintained on a large whiteboard in the meeting room, but it was a constant challenge to provide descriptions that were suitably explicit. Table 3 illustrates a subset of the exchanges envisaged on Day 5 of the workshop. It is evident that the level of detail varied greatly (e.g. the 'Crops' team requested amount, date and N:P:K composition of any fertiliser, while the 'Policy' team[7] wanted information on rate of species loss), and that some of the requests could not have been provided by or used in the sub-models as they then existed. Subsequently, each team was encouraged to prepare a lists of 'things we want from team X' with four columns dictating the construct name, description, dimensions and (anticipated) source. Nonetheless, problems remained, and resolving mismatches between what was requested and provided was a continuing concern.

WORKSHOP OUTCOMES

The Simile expert (Jasper Taylor) assembled the sub-models into a consolidated model on Day 9 of the workshop, while other participants enjoyed a well-deserved break. Deficiencies in the definitions of data passed between sub-models made this a challenging task, but a consolidated model was produced, and it ran successfully in the plenary session on Day 10. No claims were made about the quality of predictions, but participants saw the consolidated model as an important proof of concept:

- a model of a complex system can be constructed by a diverse team;
- it can be done with a graphically-based package such as Simile;
- the resulting model can remain reasonably accessible (at least in overview);
- such a model does not need a supercomputer, and can run on a notebook computer;
- useful insights can be gained in building such a model, and attempting to build such a model is a worthwhile exercise in itself; and

[7] A fifth team charged with the responsibility of identifying policy 'levers' that model users would need to explore scenarios.

- modelling in this way helps to foster interdisciplinary collaboration when researchers have a shared interest in a common problem or locality.

Table 3. Matrix summarizing some of the data exchanges between sub-models

From	To (Information used by this group)				
	Crop, Soils and Water	Trees and Forest	NTFPs and Biodiversity	Household Decisions	Corporate Decisions and Client Issues
Crops, Soils and Water		Avail. N, P, K (kg/ha) avail water (mm/y)	Cover type and age	Crop type, yield (kg/ha) Pests (none, some, lots)	Crop yield (kg/ha) Erosion (% area) Streamflow
Trees and Forest	Light interception (%)		Forest cover area and age	Rubber produced (kg/ha) Succession (stage) Timber stocks (m^3/ha)	Timber yield (m^3) Deforestation (ha/yr) Carbon flux
NTFPs and Biodiversity	Pest incidence (pigs/ha)	Browsing (kg/yr)		Harvesting success by stage of forest Game density	Agro-diversity Rate of species loss
Household decisions	Crop (date, type, % of patch) Fertilize (kg/ha, date, N:P:K) Weed (date and person-days) Harvest (date and person-days)	Harvest (m^3/ha) Plant (spp, density) Fallow (yrs)	NTFPs (species, how much, when collected)		Income and debt ($) Food security (rice days) Population growth (%) Leisure time (hrs/week)
Policy levers				Off-farm wage (yes/no) Price of rubber ($/kg) Transport to market ($) Export control (yes/no) School fees (Rp)	

Most participants were enthused by the workshop, and a strong sense of ownership of the still-incomplete model was evident. A suggestion from the floor advocated the formation of the FLORES Society, a loose collective of researchers interested in further pursuing the development and use of such models. The FLORES Society continues as an informal e-mail discussion group FLORES@CGNET.COM (subscription requests to JVanclay@scu.edu.au). Research inspired by the workshop has continued, as is indicated by other papers in this special issue (Vanclay *et al.* 2003). DFID has subsequently funded the FLAC package (FLORES Local Adaptation and Calibration, available from the FLORES Society 2001), its testing in Zimbabwe, and the development of the Mafungautsi model (Prabhu *et al.* 2003). In addition, the ASB program is funding the development of CamFlores for humid central Africa (Legg 2003).

WORKSHOP FOLLOW-UP

Towards the conclusion of the workshop, participants made the following recommendations to the FLORES Society (recorded by Stephan Weiss, 1 February 1999):

- Enhance the present household decision-making procedures by:
  - improving linkages between the household and biophysical sub-models;
  - including feedback loops, e.g. from cropping and forest use; and
  - allowing for more household activities and opportunities;
- Expand the sub-model representing an oil-palm plantation to include other types of industrial-scale activities;
- Make the present version more generic and more widely applicable;
- Identify the key parameters that drive model outputs by undertaking sensitivity testing; and
- Improve the handling of spatial and temporal issues, such as neighbourhood effects, population dynamics and land tenure.

Participants called for consideration of important landscape and regional issues:

- FLORES should maintain its role as a household/village level model for the forest margins and not be developed into a landscape or regional mega-model;
- FLORES should therefore be linked in with other modelling efforts dealing directly with forest and landscape/watershed dynamics to address the impact of household/village decision-making on forest conservation, watershed integrity and downstream effects;
- FLORES should have GIS context and village domains (i.e. specific combination of key ecological, social and economic parameters) should be defined; and
- The household sub-model should be modified to be ‘domain’ sensitive, so that FLORES can then be used on a scenario basis within pre-defined domains.

The FLORES Society recognised that the weakest area of the workshop model related to its handling of social issues. This is a fertile area for research, because there are few (if any) paradigms to follow and few modelling environments are designed for that purpose. Thus the FLORES Society lobbied for a detailed specification of the household decision-making process (Haggith 1999, Haggith *et al*. 2003a), its implementation in Simile (Taylor 2000) and incorporation into FLORES as the Rantau Pandan Model (Muetzelfeldt c 2001). This was intended to:

- improve the modelling of key aspects of the workshop model, especially relating to decision-making at the household level and above;
- produce a polished, easy-to-use, robust version of the model, calibrated for a specific community (Rantau Pandan); and
- facilitate involvement of others in ongoing work with FLORES, and in the development of versions for other communities around the world.

LESSONS LEARNED

Workshop proponents and participants learned much from the workshop. This is a brief overview of some of the important lessons learned. It is a subjective overview, and while it is intended to be constructive, others may not interpret things in quite the same way.

Workshop participants offered the following feedback (recorded by Ken MacDicken, 3 February 1999):

- The shortage of technical documentation and resource persons was a limitation;
- Too much plenary time, not enough small group time;
- Plenary sessions should be structured, on-time and responsive to group progress;
- It was a good idea to mix all groups occasionally;
- Facilitator needs to be more assertive and less democratic;
- Facilitator needs to be given a break, for example by using two facilitators or rotating the facilitation role;
- Communication between groups needs to be improved;
- Visual display of model structure and progress in the meeting room would be helpful;
- More time is needed for groups to prepare for the links between groups/sub-models;
- It is helpful to structure groups to include a modeller, model tester, facilitator and documentation specialist;
- A ‘Model Manager’ is needed to guide the overall model development process;
- The workshop tried to do too much – it would have been useful to prioritize tasks;

- Events such as the whitewater trip and hash[8] runs were important;
- Specialist groups may need to meet in advance of the workshop to prepare structures; and
- The household group should have met a few weeks before the main workshop.

While these comments reflect useful insights, they also include contradictions. Early during the workshop, participants wanted an equal say in determining objectives and specific details, but towards the end of the workshop, some wanted specialists and household modellers to have done more preparation.

The workshop composition was not ideal. Subsequent experience has shown that it can be more productive to have fewer participants but more local knowledge, fewer modelling experts but more technical (Simile) support. The right mix of factors and linkages is incorporated in a model only when modelling involves people who know the local conditions and the needs of potential users. Notwithstanding this observation, the large contingent at Bukittinggi certainly spread the idea and gave the initiative great impetus.

The facilitator has a critical role. This person needs to inspire and maintain the confidence of the group, and encourage participants to work collaboratively, setting aside old 'baggage' (less 'do it my way', and more 'how can we do it better together?'). Other important roles for the facilitator are to bring participants to focus on the problem, to listen respectfully while still working towards outcomes, and to recognize digressions quickly and evade them credibly (Haggith *et al*. 2003b). Some of our more lengthy debates were attributable to the inevitable misunderstandings that can occur when words have different usage in different disciplines; it is a challenge to recognise and clarify such confusion early in the debate. Formal feedback called for the facilitator to be more assertive, but several participants commented informally that the absence of an overt agenda by the facilitator and the convenor helped foster a strong sense of ownership of workshop outputs by participants. In subsequent related work, we have used facilitation teams (see Richards and Andersen 1995, Vennix 1996) to good effect, instead of relying on a single professional facilitator.

The AEAM approach relies on modelling the *problem*, not the *system*. Despite the discussions on Day 3, there remained some lack of clarity about model objectives and outputs desired. A clearer focus on a shared problem may have made many aspects of modelling and communication between sub-models easier. The AEAM approach should not be seen as linear: several issues discussed and resolved early on were subsequently revisited and revised in the light of new insights obtained through model-building and thinking through issues. One example of this was the decision in the plenary session that patches of land should be modelled as polygons of arbitrary size, but later discussions led to the adoption of 1-ha rasters[9] (for the duration of the workshop).

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[8] The 'hash' is a social form of 'hare and hounds' originating in Kuala Lumpur in 1938. The name originates from the Selangor Club, at the time referred to as the 'Hash House'. Hash House Harriers are less serious than other harrier groups and emphasise social camaraderie rather than competition. 'Hare and hounds' is a long-established sport, and was mentioned in 'Tom Brown's School Days' by Thomas Hughes in1857.

[9] Rasters represent the real world as a matrix of cells or pixels, all of the same size, with spatial position implicit in the ordering of the pixels.

Many participants felt that real gains would be achieved through another cycle of model criticism and improvement. One participant observed that 'I had to learn, for instance, what the computer could and could not do, and they had to learn something about life in Sumatra. I personally found the group had important, complementary skills and worked well together. I think another iteration will see real improvements.'

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