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A Model to Help People to Realize Sustainable Forestry Futures

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ABSTRACT

People usually know *how they want their situation to change* to secure a better future – but they do not always know *how to change their situation.* Initiatives intended to secure a better future do not always work as intended, and may have unintended side effects. Computer models can help advocates explore consequences of proposed initiatives, so they can make informed selections of alternatives, secure in the knowledge that consequences have been thoroughly investigated. By encouraging people to explore scenarios, models empower people to be more innovative and less dependent on technocrats. Models also enable planners to experiment with policy without risks to people or to the environment. Emerging software solves many technical limitations, but the real issue is not software, but rather the provision of a supportive framework within which people can express and experiment with ideas. FLORES, the Forest Land Oriented Resource Envisioning System, provides such a framework to stimulate interdisciplinary collaboration between researchers, practitioners and clients. Two recent workshops have demonstrated the feasibility of FLORES, one of which provides the subject matter for a forthcoming issue of *Small-scale Forest Economics, Management and Policy*. However, FLORES is not about software; it is about providing the means to explore the consequences of alternative scenarios. Ultimately, FLORES is not a physical package, but an association of users and the interactions they have amongst themselves, and with the people involved in policy-making. By promoting this emerging network and providing technical support we encourage more people, especially those from developing countries, to influence the development of FLORES and the issues that can be explored within it.

Key words: Decision support system; adaptive modelling; land-use alternatives; policy analysis; envisioning; forest frontier.

INTRODUCTION

Policies and incentives to promote sustainable forestry and better land-use do not always achieve the desired effect. Proponents rarely foresee all the consequences, and those best able to offer alternative views may be unable to contribute to the decision-making process. This leads to inefficient and sometimes counter-effective initiatives. How can policy makers and their advisors be better equipped to envisage fully the efficacy and consequences of initiatives? One way is to provide a simulator that helps people to visualize possible outcomes of proposed initiatives. FLORES is an attempt to build such a simulator.

This paper examines the role of models in forestry research, with particular reference to the FLORES modelling framework developed by authors and others for application in a range of forest industry development situations, particularly in developing countries. FLORES employs the Simile simulation modelling environment, the development of which is coordinated through the University of Edinburgh and supported by an international network of users and enthusiasts.

It is not the intention of this paper to provide details of the components, variables and structure of the FLORES model. This detail can be found in the various papers referred to in the references provided, particularly Vanclay (1998) and Vanclay *et al.* (2003). Rather, the paper examines why a need was perceived for this type of model, and the applications and progress of the simulation modelling framework, and makes some predictions about future modelling directions.

WHAT IS FLORES AND WHERE DID THE IDEA COME FROM?

FLORES[1], the Forest Land Oriented Resource Envisioning System, aims to improve the understanding of land-use patterns in time and space, especially in forested landscapes, and to facilitate rigorous analyses of policy options intended to manipulate these patterns. The idea for FLORES arose from several initiatives, among which were the desires to create a platform that would allow researchers to integrate their research, to make it possible for them to work together to reveal the bigger picture, and to provide the ability to test propositions rigorously within a realistic framework (Vanclay, 1998). These remain important influences in the development of FLORES. Accordingly, FLORES is spatially explicit, and operates at the landscape scale, spanning both forest and agricultural lands. Agricultural lands and villages form a critical component of the landscape, and must be modelled to understand fully the processes at work in and near the forest.

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[1] FLORES, and its documentation are available freely via the internet from www.ierm.ed.ac.uk/flores, and Simile can be obtained from www.simulistics.com

The basic concepts of this work are not new; what is new is the way concepts are integrated and applied. FLORES seems most closely related to work by Bousquet *et al.* (1993; 1994), who constructed a multi-agent simulation (MAS) model of an inland fishery in the Central Niger Delta as a basis for focusing discussion, evaluating options and formulating recommendations. There is an interesting contrast between FLORES and MAS: both are concerned with *agents* that can modify and respond to their environment, but the emphasis differs. Generally, MAS attempts to find the simplest set of rules that can reproduce a particular pattern from a defined scenario. In essence, the usual question for MAS is: What are the rules that might explain this pattern that is observed? FLORES considers the converse: given our knowledge about human behaviour, can future outcomes for a range of scenarios be predicted? Generally, it is not known what future outcomes should look like, except in a few specific cases that may be used to test the model. FLORES also recognises that people may have complex reasons for their behaviour, and attempts to represent present understanding of those reasons, rather than seeking the simplest rules that may reproduce a given pattern.

WHY DO WE NEED FLORES?

Some analogies may be cited to illustrate why FLORES is important. Anyone who has played Fish Banks (IPSSR, 2000), the Beer Game (MIT, 2000) or a similar management game should appreciate the need for up-to-date information. With Fish Banks, a game about sustainable resource utilization, players often destroy a fishery because they rely on information from a previous game cycle. It is only when players learn to predict current and future fish stocks that they can achieve a sustainable outcome. Using old information for resource management is like driving a car without forward vision, and relying on rear-view mirrors for information. Up-to-date information (c.f. looking out of the side windows to see the roadside) helps, but one can only drive safely when they can see forwards (c.f. predicting future outcomes).

A useful contrast may also be drawn with air travel. What makes air transport so safe and pilot error so rare? Good design, careful planning, diligent maintenance and competent supervision are factors, but pilot training is crucial. Before crew members take the controls of a commercial airliner, they will have studied the theory of flight, trained in light aircraft, spent hours in a flight simulator, and flown with more experienced colleagues. They know how to read the indicators, what every button and every lever does, and when and how these controls should be used. They know instinctively how to respond when something goes wrong, and what to do if the plane deviates from its planned course. They rarely need to use their training, because much of the knowledge of flight has been synthesised into an autopilot that takes care of most situations.

Now contrast this with efforts to foster environmentally sustainable development of forested landscapes:

- Do we know what to do when things go wrong?
- Can we tell when things are beginning to go wrong?
- Do we know which controls we can use to change things?
- Do we know what the controls are, where to find them, and how to activate them?
- Can we recognise and interpret the indicators?
- Why don't we have an 'autopilot' to give advice?

Why is it that so many amongst those who make important decisions about the world's forests and agricultural frontiers have never raised a tree, tended a garden, gathered food from the forest, or used a simulator to explore the implications of an impending decision? Would a landscape simulator make a difference?

The computer game SimCity (Maxis, 2000) provides an interesting analogy for the user interface that the designers of FLORES would like to create. The Maxis Corporation provides a simulator in the form of a game. The game offers the player an 'aerial view' of a city, a menu of policies and incentives (e.g. expenditure on education, transport, sanitation), and indicators of performance (e.g. unemployment, GNP, pollution). User groups offer a wide range of real and imaginary scenarios freely via the Internet (e.g. see http://simcity.ea.com/us/simexchange).

In FLORES, the cityscape is replaced by a landscape of forest and agricultural lands, and the menu by a range of options to manipulate the forest and land-use patterns. Performance indicators could include biodiversity and rural poverty. FLORES also differs from SimCity in that it must have a strong factual basis, and must be able to be customised to suit different situations. Every aspect of FLORES should be accessible to users, so that they can understand it, modify it, and experiment with it.

FLORES can potentially afford many benefits during various stages of its construction and life cycle. It will:

- synthesise existing knowledge and identify gaps and other deficiencies;
- express present knowledge concisely, completely, explicitly and unambiguously as a model;
- create a framework to promote collaborative interdisciplinary research;
- provide a basis for strong empirical tests of hypotheses relating to land-use policy;
- create a planning tool to allow planners and policy makers to explore future scenarios; and
- provide an educational game to improve general knowledge of tropical forest environments.

WHAT HAS BEEN ACHIEVED?

The FLORES concept was developed some years ago (Vanclay, 1995), but it was not until 1997 that work began in earnest and a prototype was produced (Muetzelfeldt *et al.*, 1997). Considerable progress was made during 1999, and during the past two years an assessment has been made of the reliability of the initial version (for the Rantau Pandan area of Sumatra), and its adaptability to a new situation (the Miombo region of Zimbabwe, Vanclay *et al.* 2003). Progress to date is the outcome of interdisciplinary collaboration between about 70 people who have contributed to model design workshops held in Sumatra in 1999 and in Zimbabwe during 2000.

Others (e.g. Holling, 1978) have demonstrated how modelling can help to bridge disparate disciplines, and experience with FLORES confirms their finding. The FLORES framework has proved an effective way to facilitate explicit dialogue between agronomists, ecologists, economists, sociologists and others. FLORES has not only provided a focus for diverse groups, but has allowed contributors to investigate the interactions of diverse concepts, and to discover and explore unexpected consequences of such interactions. Formalizing and testing mental models in this way assists in understanding the the systems under study.

The present version of FLORES is still rather simplistic, but provides the basis for continuing work. This platform is not, and must not be, a 'black box', opaque to participants. It is not enough that it should be transparent; it should be enlightening, and should empower participants to make better analyses and draw more revealing insights than they could working in isolation. An attempt has been made to provide this, with the hope that it will be used as a basis for testing a wide range of propositions, and will be modified as necessary to make these tests and incorporate findings into the model. Experience indicates that it is wise to commence with simple models, and to enrich these progressively. Models excel at exposing counter-intuitive consequences of simple assumptions. Even if initial prototypes of the model are of little practical relevance, they may offer valuable insights, and their main purpose may be to focus questions rather than to provide answers. The challenge is to construct a framework that is broad enough to accommodate a wide variety of propositions, and sufficiently accessible that researchers from a range of disciplines are stimulated to collaborate and test their propositions in this integrated way.

HOW DOES IT WORK AND WILL IT GIVE THE RIGHT ANSWERS?

FLORES relies on five basic assumptions, namely that:

1. Land-use patterns are *created by actors*, individuals or groups of individuals who collaborate as families, households, villages, associations and corporations.

2. These actors make *rational* decisions based on available information, obligations and expectations, social as well as economic. Note that an actor's *perception* of their environment, options and expected returns is what influences their decision-making.
3. When choosing an *activity*, actors explore all options available to them, within the constraints imposed by resources (e.g. of land, time and capital), knowledge, and their comfort zone (e.g. cultural attachments, willingness to attempt novel activities).
4. Actors tend to undertake activities that maximise perceived benefits or minimise anticipated risks to themselves and their beneficiaries (e.g. families, clans, shareholders). It may be possible to model both benefit-seeking and risk-avoiding behaviour by considering risk-adjusted benefits.
5. Decisions tend to be specific to any given patch of land, so the model can be spatially explicit, an advantage for model calibration and testing.

The constraints implied by an actor's comfort zone and previous experience mean that many actors consider a rather small number of activities, often only those undertaken in the past, plus a few new activities pursued profitably by neighbours. However, there are usually a few innovators who consider an extended list of activities and may attempt a diverse range of enterprises. Typically, innovators are more willing to attempt risky enterprises than are their more conservative fellows. Disposition is only one determinant of willingness to accept risk, and age, assets and income also feature prominently in many explanations.

Note that actors may make both strategic decisions ('What kind of crop am I going to grow?') and operational decisions ('Will I weed my crop today?'), and that the timeframe and decision-making processes may differ accordingly. Some decisions, such as negotiations over resources including land, water and labour, may be taken collectively. The availability and reliability of information contributes further complexity that may require the modelling of communication between actors represented in the model.

Decision-making by actors is just one component of FLORES, and other sub-models are needed to predict the growth of trees and crops, changes in the soil and water balance, interactions between key plant and animal species, and other ecosystem processes. Fortunately, many such models already exist (e.g. Vanclay, 1994; Anonymous, 1997), and some are amenable to calibration and integration within the FLORES framework.

FLORES has been implemented in Simile to minimize the amount of computer code, in the hope that potential participants who are not conversant with computer languages can be engaged in model development. Simile (Muetzelfeldt and Taylor, 1997, 2001), previously known as AME, has a graphical interface that makes the model accessible to researchers who are not fluent in computer programming, while providing capabilities comparable to third generation computer languages. Thus it offers a powerful and flexible platform that does not exclude less computer-literate participants in the project. There are other advantages in using Simile, some of which include the ability to:

- represent relationships as simple sketches, mathematical equations, or as sets of rules,
- substitute alternative models easily using its 'plug-and-play' facility, and
- create customised user interfaces with software 'helpers' that can be developed independently and linked to the model at run time.

IMPLICATIONS FOR RESOURCE MANAGERS AND PLANNERS

FLORES is an attempt to create a practical 'crystal ball' for resource managers, land-use planners, and policy-makers and their advisors; one that they can understand and use to make risk-free experiments in policy and land-use planning. This places great demands on the design of the user interface. Too many models remain under-utilised because they do not satisfy the needs of potential users and because system developers did not explicitly contact clients, ascertain their needs, and stimulate their interest. To encourage uptake, potential users must be involved in the development of the model. Obviously, users may not be interested in all aspects of model design and construction, but they should have the opportunity to participate in specification and design of the user interface. It is not enough to ask them what they want and how they want it. Team members have to engender enthusiasm and involvement through mutual understanding and collaboration. This means that the model has to be explained in an accessible way, and that simple prototypes and mock-ups need to be built so that ideas can be demonstrated, tested and modified.

FLORES will provide a range of outputs to suit different user requirements. One output will be the forested landscape of a SimForest implementation. One great contribution that information science could make for conservation and wise use of natural resources would be to provide a *virtual reality interface* for land-use planning (Vanclay, 1993). This could allow a minister and their advisors to put on a virtual reality headset and take a 'magic carpet' ride across the landscape. They could observe the spatial pattern of different land-uses and watch how they change over time, and under different scenarios. They could 'zoom in' to examine particular issues, and stand back to gain an overall perspective. The technology to do this exists, and it is possible to link resource inventory, growth models, geographic information systems and virtual reality devices in this way. However, it has not yet been done, but recent software and hardware developments now make it feasible. The developers of FLORES have been mindful that the eventual user interface may well be a virtual reality system, and have deliberately designed an open and flexible system that does not foreclose this possibility. However, the SimCity-style interface is adequate for many applications, and would be particularly useful for educational applications and general information dissemination.

FUTURE DIRECTIONS AND PROSPECTS FOR WIDER ADOPTION

There are several specific problems that need to be addressed before this model can be realised as much more than a simple prototype. Many of these challenges can be addressed as separate tasks, and are amenable to research by others, including students. Some of the more obvious issues are now examined.

In the proposed model formulation, the underlying functional relationships may be relatively simple, but the data requirements are rather demanding. Most utility functions appear innocent enough, but they require a large amount of data: anticipated yields and prices of all possible crops under a range of situations, detailed tenure and demographic data, and a thorough understanding of the socio-economic culture of the community. This is a major undertaking, and may be one limitation of the model. It is envisaged that initial attempts to calibrate the model will be restricted to a limited geographic area, allowing a complete census of all inhabitants for thorough model testing. However, subsequent operational implementations may sample only selected actors to reduce the burden of data acquisition. Crop yields may be inferred from models, but prices and elasticities must be gleaned from field survey work. This task may be particularly onerous for non-timber forest products such as medicinal plants.

Superficially, the model appears tractable, but it involves many challenges. Is it really possible to quantify the social profile of all actors in a community in sufficient detail to provide meaningful predictions from simple heuristics? There is no clear answer, and only an empirical test can elucidate if numerical approximations of complex social structures provide an adequate basis for planning. Several further issues for methodological research are evident at this stage: whether to model individual actors or classes of actors; how to quantify risk and willingness of actors to accept risk; and what is an appropriate balance between day-to-day decisions and strategic decisions, and between private and collective decisions. All are central to the FLORES approach, and in each case, the issue is whether the preliminary approach is a necessary and sufficient representation of reality. There are some advantages in modelling individual actors: it is conceptually elegant and facilitates empirical testing, but it imposes a substantial computational load. Simulation based on a few classes of actors (e.g. classified by age and gender) would speed up simulations, and may ease data input requirements, but it is not clear if this would lead to the same result as individual-based modelling. The issue may be best resolved through empirical trials and sensitivity tests.

Although the present versions of FLORES do not deal with risk, the developers recognise that an actor's attitude to risk may have a major influence on land-use decisions. It seems reasonable to assume that an actor's willingness to accept risk can be quantified, in part through the historic variation in benefits accruing from a particular activity, and from the actor's age, tangible assets and income. However, this assumption warrants closer scrutiny since ability to quantify risks and attitudes to risk may have a major influence on the accuracy of FLORES predictions.

There are many other important issues that may need to be addressed, for instance communication between actors, health, migration, and remittances. It is known, for example from the rapid introduction of rubber to Sumatra a century ago, that word-of-mouth communication can have a major influence on the uptake of new technologies, and thus on land-use patterns. Modelling these information flows may be critical to the reliability of FLORES. Nor can the interrelation between land-use patterns and the health of the workforce in agrarian communities be ignored. Health affects land-use patterns through labour availability, and land-use may in turn affect people's health (e.g. incidence of malaria). Similarly, migration to cities and remittances from those in paid employment may have a substantial influence on land-use patterns at the agricultural frontier.

Satisfactory ways to value the intangibles involved with land-use decisions pose a major challenge. One particular aspect that needs to be addressed is how to value prestige. Prestige may take many forms, and may explain land purchases at prices inconsistent with production (e.g. prestige of owning a bigger estate), herd sizes (e.g. prestige of large flocks leads to overstocking, even though smaller flocks may offer equivalent returns and lower risks), and possession or production of particular items. Prestige, leadership and social status may all affect access to resources.

A further challenge for later versions will be to model selected interactions within both plant and animal species, especially for apparently pivotal or keystone species. It is not sufficient to model the food web, because energy flows are only one of the aspects. It is also important to consider relationships such as mycorrhizal and other symbiotic relationships, pollination and transport of seeds, microclimate and other modifications of the environment that may facilitate the establishment of plant and animal species. It is probably impossible to model all of these relationships in a tropical forest, but it is important to recognise and include the pivotal relationships.

A FLORES-type model is easy to conceive for a small village, where every individual actor can be simulated. However, to be useful, ways need to be found to scale up the model to deal with broader landscapes. As the model is scaled up, it may become impractical to examine decision-making by all actors, hence it may be necessary to extrapolate from a sample of actors. The choice of sample may be critical to the outcome, and suitable sampling strategies must be investigated before the approach can be scaled-up to the provincial or national level. A crucial part of this investigation will be to identify the minimum essential set of prime determinants. It is likely that this will be an iterative process involving several cycles of idealisation and abstraction.

FLORES seeks to provide a framework for testing and refining ideas. This means that the basic framework of FLORES must be carefully tested, and that baseline data should be acquired for detailed empirical testing. Two components of these tests warrant special attention and preparation: sensitivity tests and benchmark tests (Vanclay and Skovsgaard, 1997). Ideally, a thorough program of sensitivity testing should examine every input, every parameter and all assumptions, to ascertain how much influence they have on predicted outputs. This is useful information that can be used to direct further development of a model, with a lower priority assigned to parameters and assumptions that have little influence on predicted outputs.

Thorough benchmark testing is another major task that requires planning and preparation. Comprehensive data about a series of sites for at least two points in time are required, preferably over a reasonable time interval. Ideally, the situation at some sites should remain more-or-less unchanged, while substantial changes should be evident at other sites. There are always difficult issues to be addressed if these sites involve only passive monitoring, and empirical tests are strengthened if experimental data are available. In agricultural situations, it is customary to use paired and replicated experiments to compare treatments against control plots. Such data are more difficult if obtained at the landscape scale and when people are involved, so greater ingenuity is required. Survey data pose special problems, since many factors may vary and making reliable inferences can be difficult. In theory, it is possible to conduct experiments to gather rigorous data to test FLORES, but there are ethical questions that would need to be considered carefully. For example, it is feasible go to a village and buy locally produced goods at prices higher than the prevailing market rate, and observe how the community responds. Fortunately, this experiment is not necessary, because in many developing countries, governments conduct such 'experiments' all the time. For instance, new bridges and roads can markedly change transport costs. Thus the data required for model testing may be obtained by strategically choosing and monitoring selected communities over an extended period.

Perhaps the best test of a model is how well the modeler can answer the questions 'What do you know now that you did not know before?' and 'How can you find out if it is true?'. FLORES has many limitations, but it provides a fertile test-bed for ideas, and offers ample scope for furthering knowledge of policies, incentives and land-use patterns in forested landscapes. Both the product and the process are invaluable. Also, there is a need to bring together scientists from diverse disciplines to work towards a common goal. Greater rigour is needed in forest policy research, and FLORES can contribute to achieving this.

BECOMING INVOLVED IN FLORES DEVELOPMENT

FLORES is a continuing research project, the product of close collaboration by many individuals, and others are invited to participate. The principal interaction is via an email discussion list, and all interested researchers and potential users are welcome to join this forum. More information on the current status of FLORES or on how to become involved, may be obtained from any of the authors.

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REFERENCES

ANONYMOUS. 1997. *Crop Yield Forecasting Methods*. Proceedings of the seminar, Villefranche-sur-Mer, 24-27 Oct 1994. Eurostat, JRC-ISPRA, DG VI and FAO. ECSC-EC-EAEC, Luxembourg.

BOUSQUET, F., CAMBIER, C., MULLON, C., MORAND, P., QUENSIERE, J. and A. PAVE. 1993. Simulating the interaction between a society and a renewable resource. *Journal of Biological Systems*. **1**: 199-214.

BOUSQUET, F., CAMBIER, C. and P. MORAND. 1994. Distributed artificial intelligence and object-oriented modelling of a fishery. *Mathematical and Computer Modelling*. **20**: 97-107.

HOLLING, C.S., ed. 1978. *Adaptive Environmental Assessment and Management*. Wiley, London. 377p.

IPSSR (INSTITUTE FOR POLICY AND SOCIAL SCIENCE RESEARCH). 2000. *Fish Banks Ltd*. http://www.unh.edu/ipssr/Lab/FishBank.html. 3 March 2000.

MIT (MASSACHUSETTS INSTITUTE OF TECHNOLOGY). 2000. *The Beer Game*. http://learning.mit.edu/pra/tool/beer.html. 14 March 2000.

MAXIS COORPORATION 2000. *Simcity 2000*. http://www.maxis.com. 3 March 2000.

MUETZELFELDT, R.I. and J. TAYLOR. 1997. The suitability of AME for agroforestry modeling. *Agroforestry Forum*. **8**(2): 7-9. Also see http://www.simile.co.uk

MUETZELFELDT, R.I. and J. TAYLOR. 2001. Developing forest models in the Simile visual modelling environment. Paper to IUFRO conference on *Forest Biometry, Modelling, and Information Science*, Greenwich, June 2001, http://www.ierm.ed.ac.uk/simile/documents/iufro3.pdf, 30 January 2003.

MUETZELFELDT, R.I., TAYLOR, J. and M. HAGGITH. 1997. *Development of pFLORES, a Prototype FLORES Model: Progress Report*. December 1997. Institute of Ecology and Resource Management, University of Edinburgh. http://www.ed.ac.uk/~ebfr28/flores/ rep9712/rep9712.htm

VANCLAY, J.K. 1993. Inventory and yield prediction for natural forest management. In: *Australasian Forestry and the Global Environment* (R.N.

Thwaites and B.J. Schaumberg, eds.). Institute of Foresters of Australia, Brisbane. pp. 163-169.

VANCLAY, J.K. 1994. *Modelling Forest Growth and Yield: Applications to Mixed Tropical Forests*. CAB International, Wallingford, U.K. xvii+312p.

VANCLAY, J.K. 1995. Modelling to explore land-use patterns at the forest edge: objectives and model design. In: *Proceedings, International Congress on Modelling and Simulation (MODSIM'95), 27-30 November* (P. Binning, H. Bridgman and B. Williams, eds.). University of Newcastle, NSW. pp. 113-116.

VANCLAY, J.K. 1998. FLORES: for exploring land-use options in forested landscapes. *Agroforestry Forum*. **9**(1): 47-52.

VANCLAY, J.K. and J.P. SKOVSGAARD. 1997. Evaluating forest growth models. *Ecological Modeling*. **98**: 1-12.

VANCLAY, J.K., F. SINCLAIR and R. PRABHU. 2003. Modelling Interactions amongst People and Forest Resources at the Landscape Scale. *Small-scale Forest Management, Economics and Polic y*. **2**(2): 117-120.