shows that maintaining the plot density to the optimum size would be better because increasing the density over the optimum size was not significantly increasing the plot root binding. Although the plot root anchoring are known to be increasing. The species selection based on the IRB and IRA value is acceptable. Other consideration may depend on farmer preferences and cost benefit comparisons of future benefit flows of various agroforestry scenarios.

How to get the model?

SExI-FS software is available on the Internet. It can be downloaded freely from http://www.worldagroforestry.org/sea/Products/AFModels/SExI. The software is targeted to be platform independent. It is developed using Java Programming Language. It will be able to run on any platform that supports Java Virtual Machine (JVM). The information about Java Programming Languages and Java Virtual Machine can be accessed through http://java.sun.com. More information on how to use the software and its documentation is available on SExI-FS user guide and software (Harja and Vincent 2008).

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This flyer is produced by
the TUL-SEA Project
funded by the Federal Ministry for Economic
Cooperation and Development, Germany

World Agroforestry Centre
Federal Ministry for Economic Cooperation and Development

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Tree - Tree Interaction Model: the Spatially Explicit Individual-based Forest Simulator (SExI-FS)

A modeling tool for agroforest management

Trees in Multi-Use Landscape in Southeast Asia (TUL-SEA)
A negotiation support toolbox for Integrated Natural Resource Management

Tree growth in mixed stands

The Spatially Explicit Individual-based Forest Simulator (SExI-FS) focuses on tree-tree interactions in a mixed multi-species agroforest. The high level of structural complexity of such traditional agroforestry systems defies classical forestry approaches when it comes to optimizing management practices. To cope with this complexity, farmers have adopted a tree-by-tree management approach, which is closer to gardening than to any usual tropical forestry or estate crop management model. Individual tree care and regular tending can consist of transplanting seedlings, selective cleaning and felling, adjusted harvesting intensity.

Farmers' approach appears to be in line with two basic tenets of biology: first, individuals are all different with behaviour and physiology that result from a unique combination of genetic and environmental influence; and second, interactions are inherently local. Based on the same premises, a computer model was developed to explore different management scenarios.

The model uses an object-oriented approach where each tree is represented by an instance of a generic class of tree. The simulated object trees, mimicking real trees, interact through modifying their neighbours' environment. These modifications are mediated through two major aboveground resources: space and light. A 3D representation of a one-hectare plot of forest serves as the basis for the simulation of this competition.

The major objective of such a model is to get a coherent dynamic representation of a complex system, where complexity refers here to the assemblage of locally interacting individuals with different properties more than to the complexity of the elementary processes involved. The model provides insight on what are the critical processes and parameters of the dynamic of the system. It should also allow exploring prospective management scenarios, and help assessing the relevance of present management techniques.

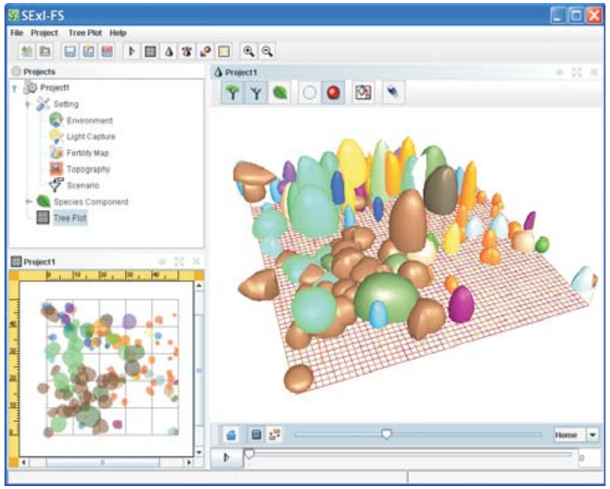

Figure 1. SExI-FS included 3D visualization interfaces to get a better view of a simulated scenario

Principle and Approach

Model sensitivity tests confirm the importance of the parameters related to tree geometry. This stems from the fact that competition is simulated by means of spatial interactions, so that anything that alters either the shape, the size, or the relative position of the trees have direct impact on the outcome of the competition and therefore on the growth dynamics. These elementary influences are usually straightforward but their effect at different times and scales are difficult to predict without simulations because of the numerous feedback loops at work and the non-linear dynamics of the system.

To illustrate this, let's examine a very simple case. By simulating growth in a mono-specific stand of regularly spaced trees planted at increasing densities, the following responses are observed. Planting at medium density translates growth into height of the trees in the center of the plot being superior to that of border trees, which is a response to the increasingly limited access to light of the trees in the center of the plot. When planting density is increased further, growth in height of the trees in the center of the plot becomes less than their neighbours, the level of competition being so high that these trees get overtopped and suppressed by border trees in more favourable position with respect to access to light.

Another simple test shows that the ability to respond to low light availability by enhanced growth in height (a response, which occurs at the expense of growth in diameter) appears to be advantageous under specific conditions and disadvantageous under others. If all species in the mixture share the same ability and the same sensitivity to light level then this potential competitive advantage turns out to be disadvantageous both for individual tree growth and for overall plot productivity. But when trees with different sensitivity to light level or different ability to alter their allocation of growth between height and diameter occurs in a mixture, then this capacity proves to be an effective competitive advantage for individual species.

By accelerating the establishment of a multi-strata structure it also increases the overall productivity of the plot through better allocation of spatial resources. Similarly, rather counter intuitively, an increased growth rate for a given crown size appears to be an advantage for a species under certain circumstances but not all. Under very crowded conditions large crowns with low efficiency in terms of light and space utilization can show competitive advantage by suffering less from crown encroachment and by shading out competitors more efficiently. These are a few examples of the insight such generic models can bring.

More direct applications of the model include comparing alternative scenarios in terms of financial return for instance involving rotational versus permanent agroforests. The main loop of SExI-FS model is shown in Figure 2.

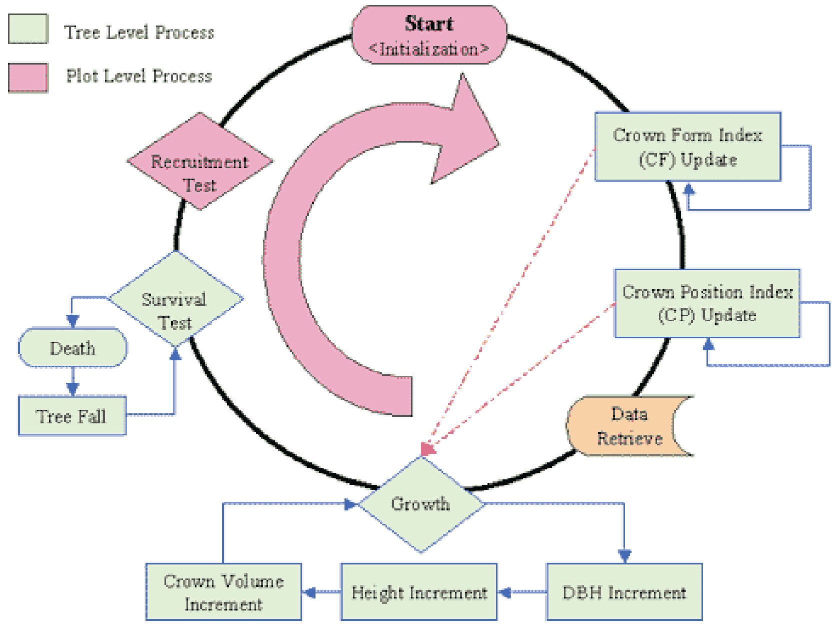

Figure 2 The loop is run on a yearly time step. It starts with an initialization step. Next the trees crown attributes (Crown Form Index (CF) and Crown Position Index (CP)) are updated. Tree growth is then computed (diameter, height and crown volume increment).At each step in time, for each tree, a survival test is made. Finally at stand level, a recruitment test is conducted.

The SExI-FS Software

The software was developed as a model tool for predicting the dynamic growth of mixed-tree stands and gives the information of its potential productivity and other aspects regarding the tree growth competition (Figure 1).

Graphical user interfaces are provided for the user to explore various scenarios and plot design of agroforestry implementation (as shown on Figure 3) and predict the performance and productivity of each species component.

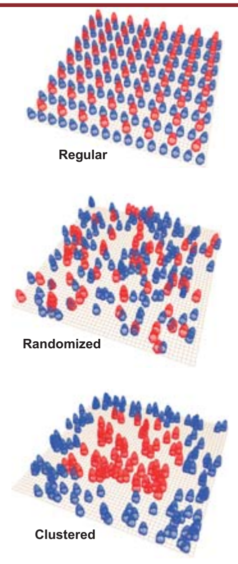

Figure 3 Plot design scenarios of Rubber (blue) and Durian (red) (Harja et. al. 2006).

Case Study[1] - compare the Rapid Landslide Mitigation Appraisal (RaLMA)

The study on the performance of various agroforest scenarios design using this software has been explored (Harja et al. 2005, Harja et al. 2006). The recent study using this software model was for exploring the potential role of trees on reducing landslide risk.

The conversion of the agroforests and reduction in tree cover in Kabupaten Bogor (District of Bogor) for urban development has been followed by large landslides causing damage to infrastructures, economic lost, and even lost of lives. In February 2007 about 300 households are considered to be at risk and were suggested to evacuate. A “bioengineering” strategy for reducing land movement and preventing accidents will require information on strategic locations for trees with confirmed capacity to anchor soil. The rate of root development will determine the options for recovery. Study of the areas at risk in Bogor can contribute to future prevention strategies, in the context of climate change adaptation, when the incidence of 'extreme' rainfall periods is expected to increase and the need for landslide prevention will be more pronounced.

Differences between tree species in root development in the topsoil and in deeper layers, contribute to differences in soil binding and soil anchoring that can reduce the downslope movement (at the level of tree root system).

Maintaining a high population density and tree diversity in uneven-aged agroforestry systems can reduce the downslope movement in the context of productive land use (at the plot level)

Good land cover with trees in strategic locations and renewal of anchoring by young trees before old tree root systems have decayed can reduce the risk of down-slope movement at the hill slope/ landscape level.

The landslide areas around Bogor provide an opportunity to collect data that can help to test the three hypotheses.

As the landslide risk is to be evaluated at the hill slope rather than tree level, the database on the 'index of soil anchoring' (IRA) and 'index of soil binding' (IRB) of tree species under local conditions needs to be associated with a spatially explicit and dynamic evaluation of tree diameters. The SExI-FS (Spatial Explicit Individual-based Forest Simulator) model is able to simulate the role of trees to reduce the risk of landslide through the quantification of species IRB and IRA within a tree plot. The simulation may apply to the plot management sensitive scenarios. The simulation result on plot management sensitive

[1] This case study was part of the TROFCA project on the role of tropical forests in climate change adaptation, coordinated by the International Centre for Forestry Research (CIFOR)