Result 4: Trade-off between tree and crop yield

Increasing space between tree rows makes longer intercropping possible, but also reduces the expected yield from the trees. An efficient way of considering the trade-off is to plot crop versus tree yield.

Most of the tree crop combinations are substantially above the straight trade-off curve, suggesting that there is indeed a benefit to be obtained by the combination when compared to separate monocultures. However, the points for *A. mangium* suggest virtually no intercropping advantage. For the slower growing trees (mahogany and rubber), maximum tree yield can be obtained at about 20% of the potential long year crop yield. After accounting for this intercept, a slight positive curvature remains when tree spacing is widened. *P. falcataria* has a low intercept (low crop yield opportunity when maximum wood volume is the target), but clear intercropping advantage at lower tree population density. This may therefore well be the most promising 'agroforestry' tree at intermediate densities.

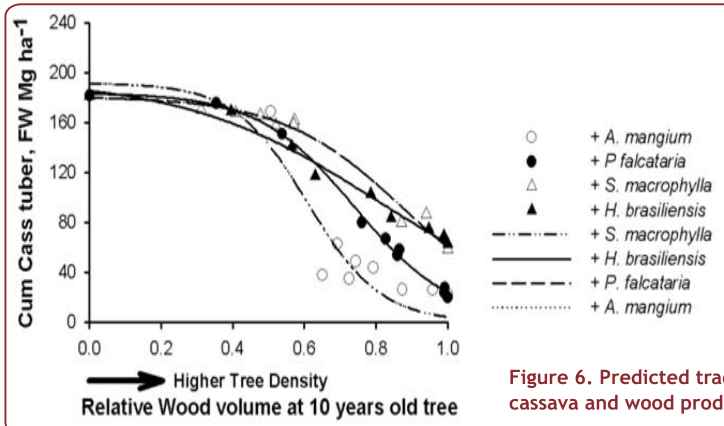


Figure 6. Predicted trade between cassava and wood production

How to get the model?

WaNuLCAS was developed in the Stella modelling platform. A free downloadable version of Stella (demo version) is available at http://www.iseesystems.com/. WaNuLCAS model is available on the Internet and it can be downloaded freely from http://www.worldagroforestry.org/sea/Products/AFModels/WaNuLCAS.

References

(http://www.worldagroforestrycentre.org/sea/Publications/index.asp)

van Noordwijk M, Lusiana B and Khasanah N. 2004. WaNuLCAS 3.01: background on a model of Water, Nutrient and Light Capture in Agroforestry Systems. Bogor, Indonesia. World Agroforestry Centre - ICRAF, SEA Regional Office. 246 p

van Noordwijk M and Lusiana B. 1998/1999. WaNuLCAS, a model of water, nutrient and light capture in agroforestry systems. Agroforestry Systems. 43(1-3):P. 217-242

Walker A, Mutuo P, van Noordwijk M, Albrecht A and Cadisch G. 2007. Modelling of planted legume fallows in Western Kenya using WaNuLCAS. (I) Model calibration and validation. Agroforestry Systems. 70(2007):P. 197-209

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

Contacts:
TUL-SEA Project
WORLD AGROFORESTRY CENTRE
Southeast Asia Regional Office
Jl CIFOR, Situ Gede, Sindang Barang, Bogor 16115
PO Box 161 Bogor 16001, Indonesia
Tel: +62 251 8625415/ Fax: +62 251 8625416
E-mail: icraf-indonesia@cgiar.org
http://www.worldagroforestrycentre.org/sea

Credits:
Authors: Ni'matul Khasanah and Meine van Noordwijk
Photos: Kurniatun Hairiah, Tom Tomich, and Ni'matul Khasanah
Design & Layout: Vidya Fitrian and Diah Wulandari

Water Nutrient and Light Capture in Agroforestry Systems (WaNuLCAS)

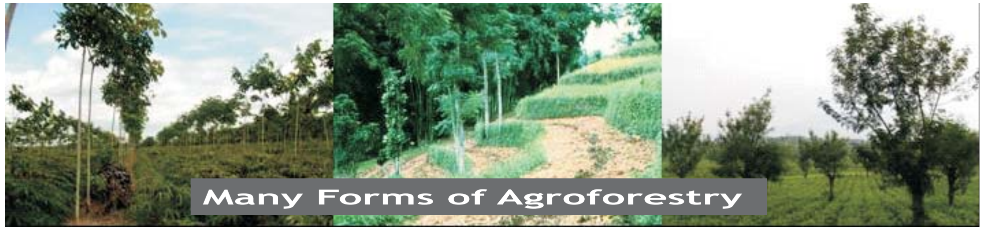
A Plot Level Model

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

Why a Tree-Soil-Crop Interaction Model?

Sustainable land use systems can be provided through agroforestry practices. Agroforestry is an agricultural approach of using the benefits from combining trees and crops and/or livestock. Therefore, knowledge on selection of species combination and good management of trees and crops are needed to maximize the production and positive effects of trees and to minimize negative competitive effects on crops.

However, empirical assessment of tree crop combinations is laborious, cost expensive and time consuming. One method for overcoming this lack of information is through development of a model which integrates soil-tree-crop interaction between the components of agroforestry.



WaNuLCAS Model

The WaNuLCAS model was developed to represent tree-soil-crop interactions in a wide range of agroforestry systems where trees and crops overlap in space and/or in time simultaneous and sequential agroforestry. The model is based on above and below ground architecture of tree and crop, elementary tree and crop physiology and soil science (daily water, N, P and SOM balance for 4 soil layers and 4 horizontal zones).

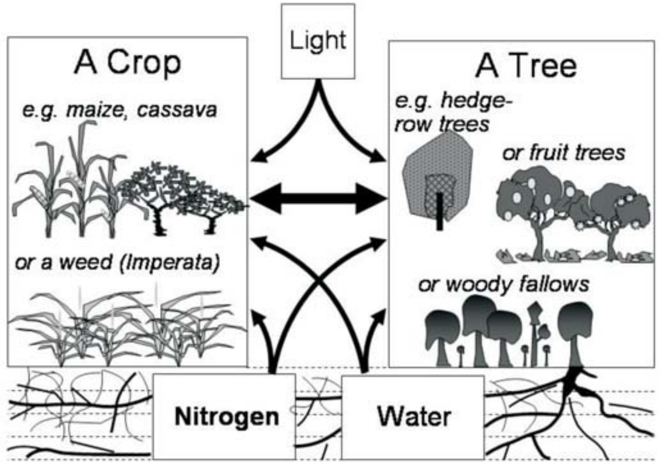


Figure 1. Components represented

The model was developed in the 'Stella' modeling platform and can be used to assess the performance in terms of profitability as well as sustainability of various agroforestry systems.

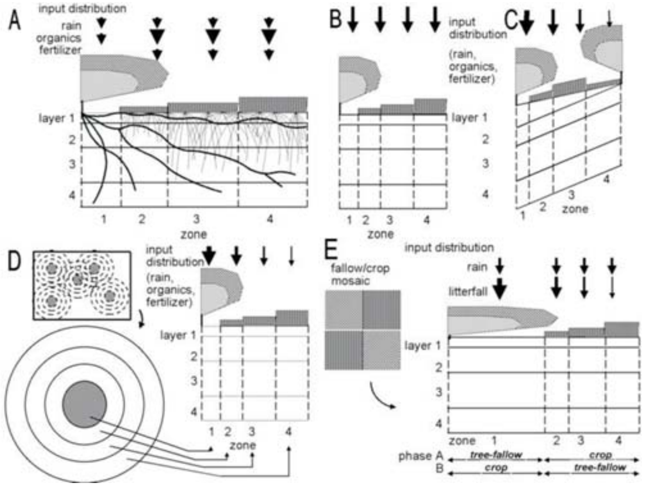


Figure 2. Two-Dimensional representation of AF sistem

Example of Model Application

Transformations from degraded soils and landscapes to agroforestry mosaics can benefit from the potential complementarity between the early stages of tree-based production systems and crop growth. Decisions by farmers managing such transition involve strategic (multi-year) decisions on the choice of tree species, the number of trees per ha and the spacing, while tactical (shorter term) decisions relate to the choice of intercrops, tree canopy pruning and/or tree root pruning. Based on the current experience in Lampung (Indonesia), we use WaNuLCAS model to explore these choices.

Cassava (*Manihot esculenta*) was simulated as an intercrop with rubber (*Hevea brasiliensis*) at eight levels of tree spacing and three timber trees (*Paraserianthes falcataria*, *Acacia mangium*, and *Swietenia macrophylla*) at nine levels of tree spacing.

The nine levels of timber tree spacing and eight levels of rubber spacing were grouped into two comparisons: the first is the effect of widening tree row spacing on crop growth, and the second is the effect of widening spacing between and within tree row on crop growth and tree growth.

The crop was simulated for twelve cropping season, once per year as long as the previous crop yield exceeded a threshold value and the trees were simulated for ten years, being planted after harvesting the crop for two years. Besides the intercrop systems, trees and crops were also simulated as monoculture systems.

Table 1. Tree spacing scenarios tested in the model

Tree Spacing groups	Timber trees	Tree density (ha⁻¹)	Rubber	Tree density (ha⁻¹)
The first group : effect of widening tree row spacing on crop yield	4 x 2	1250	6 x 3	667
	8 x 2	625	9 x 3	370
	10 x 2	500	12 x 3	278
	12 x 2	417	15 x 3	222
	16 x 2	313		
The second group : alternative spacing designs on tree - crop yield	4 x 2	1250	6 x 3	556
	3 x 3	1111	5 x 3	667
	4 x 4	625	4 x 4	625
	8 x 4	313	6 x 6	278
	8 x 8	156	12 x 6	139

Crop monoculture was simulated for twelve cropping season, once per year. Tree monocultures are planted after harvesting crop for two cropping seasons and simulated for ten years. They were supposedly kept free from weeds (other simulations involved imperata as weed).

Fertilizer of N and P were applied to each crop, at 100 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} respectively, as it is common practice for cassava. N was applied twice, half at planting time and half at a month after planting. P was applied once at planting time. Mean annual rainfall was 2641 mm.

Result 1: Crop yield as an effect of widening tree row spacing

The four tree species tested have different growth rates and canopy development rates, resulting in different opportunities for intercropping at the default spacing, but also to differential response to widening the alleys in between tree rows. For example, cassava tuber yield intercropped in *A. mangium* drops to a very low value in year 3, 4 or 5 for a tree spacing of 4 x 2, 8 x 2, 10 x 2 or 12 x 2, respectively, and continuous intercropping is only feasible for 16 x 2. With mahogany or rubber as tree species, however, prolonged intercropping is possible.

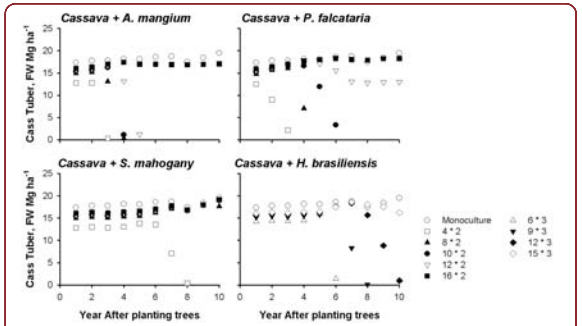
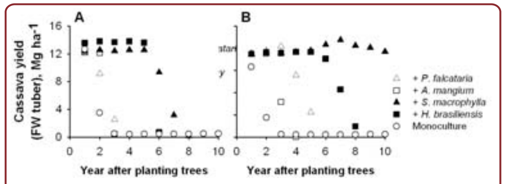


Figure 3. Cassava yields overtime

Result 2: Crop yield as alternative of spacing design

The yield of cassava was significantly influenced by tree species grown in the systems on the wider tree spacing, the longer time available for planting crop especially intercrop with fast growing trees. The highest yield was found in systems intercropped with *H. brasiliensis* and the lowest yield found in the systems intercropped with *A. mangium*. Even though crop yield of intercropped system with *S. macrophylla* was not as high as intercropped system with *H. brasiliensis*, they still offered intercropping opportunities until the trees were five or six years old.

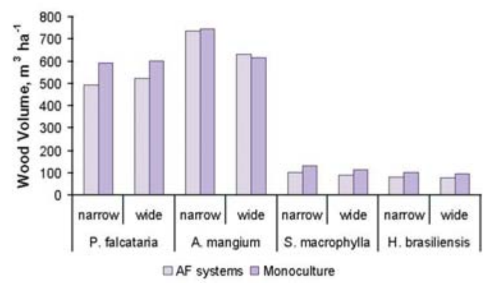


Note: A. narrow spacing (timber trees: 4x2, 3x3, 4x4; non timber trees: 6x3, 5x3, 4x4); B. wide spacing (timber trees: 8x4 and 8x8; non timber trees: 6x6 and 12x6).

Figure 4. Predicted cassava yields

Result 3: Tree performance in alternative spacing

In all tree systems studied, the crop species selected did not have a significant effect on tree growth. After 10 years, there was a small difference in wood volume between intercropped systems and (weed-free) monoculture trees, with monoculture trees slightly larger than trees in intercropped systems at the same density, except in *A. mangium*.



Note: A. narrow spacing (timber trees: 4x2, 3x3, 4x4; non timber trees: 6x3, 5x3, 4x4); B. wide spacing (timber trees: 8x4 and 8x8; non timber trees: 6x6 and 12x6).

Figure 5. Predicted wood production

TUL-SEA: A negotiation support toolbox for Integrated Natural Resource Management