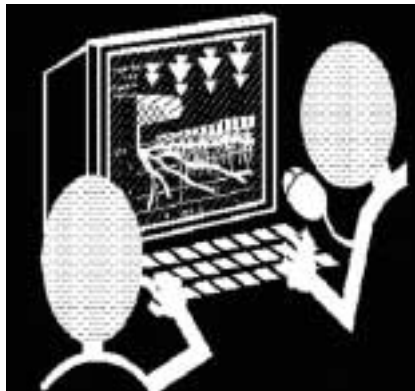


WaNuLCAS 3.01

Background on a model of
Water, Nutrient and Light Capture
in **Agroforestry Systems**



Meine van Noordwijk
Betha Lusiana
Ni'matul Khasanah



INTERNATIONAL CENTRE FOR RESEARCH IN AGROFORESTRY (ICRAF)

Correct citation:

Meine van Noordwijk, Betha Lusiana and Ni'matul Khasanah, 2004. WaNuLCAS version 3.1, Background on a model of water nutrient and light capture in agroforestry systems. International Centre for Research in Agroforestry (ICRAF), Bogor, Indonesia

PO Box 161, Bogor 16001, Indonesia

ISBN 979-95537-1-7

Copies of the software available freely from the web:

<http://www.worldagroforestrycentre/sea>

More information can be obtained by correspondence to:

M.van-Noordwijk@cgiar.org and/or B.Lusiana@cgiar.org

Related journal publication (based on version 1.0)

Van Noordwijk, M. and Lusiana, B., 1999 WaNuLCAS, a model of water, nutrient and light capture in agroforestry systems. *Agroforestry Systems* 43: 217-242

Disclaimer and copyright

This is a third release of a general model of tree-soil-crop interactions in agroforestry. Although efforts have been made to incorporate relevant process knowledge on a range of interactions, the model is not more (and not less) than a research tool. Model predictions may help in developing specific hypotheses for research, in exploring potential management options and extrapolation domains, but they should not be used as authoritative statements per se.

© Copy right, but do not copy wrong. The WaNuLCAS model was developed on the basis of publicly funded research at the International Centre for Research on Agroforestry (ICRAF) and may be used for non-commercial research purposes in the interest of the smallholder agroforesters of the world. The Stella modeling shell used is protected by international copyright.

Lay-out by:

Dwiati N Rini & Hulaesuddin, ICRAF Southeast Asia

Cover artwork:

Hulaessudin and Desi Suyamto, ICRAF Southeast Asia

Cover picture:

Nere and millet parkland systems in Sapone, Burkino Faso - Jules Bayala (INERA - Burkino Faso)

Acknowledgement

This publication is an updated manual for WaNuLCAS version 3.01. The content of this manual largely based from version 2.0 and 3.0.

WaNuLCAS model and manual of version 3.0 was exclusively released on CD to accompany the book "Belowground Interactions in Tropical Agroecosystems: Concepts and models with Multiple Plant Components" published by CAB International.

This manual is funded by the Department for International Development of the United Kingdom. However, the Department for International Development can accept no responsibility for any information provided or view expressed.

The authors wish to acknowledge valuable inputs and advice from many colleagues over the last four years. Earlier versions of the WaNuLCAS model and manual were used by a number of users and this lead to valuable feedback.

Dr. Jules Bayala, Dr. Catherine Muthuri, Dr. Simone Radersma, Dr. Didik Suprayogo, Rachmat Mulia and Dr. Christian Dupraz have contributed to specific model sectors.

Dr. Luis Fernando Guedes-Pinto, Johan Iwald, La Nguyen, Lina Nolin and Carina Ortiz have provided useful comments and feedback that build into the current version.

Previous version of the manual and the model have received valuable feedbacks from Dr. Peter de Willigen (AB-DLO Haren, the Netherlands) and Dr. Georg Cadish (Wye College, UK) in the context of the Biological Management and Soil Fertility (BMSF) Project. Dr. Richard Coe, Dr Quirine Ketterings and Dr. Edwin Rowe have also contributed to specific model sectors.

The feedback of all trainings and courses participants in UK (Agroforestry Modelling Project funded by Forestry Research Program/DFID-FRP), Bogor, Bandar Lampung, Chiang Mai, Claveria, Guadaloupe, Los Banos, Malang, Nairobi, and Turrialba, are gratefully acknowledged.

Table of contents

Chapter 1. Introduction and objectives	1
1.1 Balancing pattern and process	3
1.2 Tree-soil-crop interactions	5
1.3 Intercropping, crop-weed and agroforestry models	8
1.4 Objectives of the WaNuLCAS model	10
Chapter 2. Overview of the model	17
2.1 Model features	19
2.2 Model organization	22
Chapter 3. Description of model sectors	27
3.1 Agroforestry systems	29
3.2 Soil and climate input data	34
3.3 Water balance	40
3.4 Nutrient (nitrogen and phosphorus) balance	52
3.5 Root distribution	64
3.6 Light capture	70
3.7 Crop growth	73
3.8 Tree growth	80
3.9 Carbon Balance	90
3.10 Management options	93
3.11 Model Output	98
Chapter 4. Examples of model applications	103
4.1 Simulation based on default parameter settings	105
4.2 The use of the main switches and changes in crop or tree type	107
4.3 Crop-only controls with N and P fertilizer	111
4.4 Hedgerow intercropping: pruning regime and hedgerow spacing	114
4.5 Tree fallow – crop rotations	117
4.6 Contour hedgerows on sloping land	120
4.7 Tree-soil-crop interactions across a rainfall gradient	122
4.8 Model parameter sensitivity for P uptake	125
4.9 Hedgerow intercropping: safety-net function of tree roots	125
4.10 Water and Nutrient Use efficiency in Agroforestry Systems	127
4.11 Management options for agroforestry parkland systems in Sapone (Burkina Faso): separating the tree-soil-crop interactions using WaNuLCAS	128

4.12 Long time effect of Legume Cover Crop (LCC), sugarcane harvest residue (trash) and Bagas (sugarcane processing waste) on soil carbon and sugarcane yield	131
4.13 The effect of agroforestry systems based on differing leaf phenologies on water balance and tree and crop growth	134
4.14 Safety net efficiency - effect of root length density and distribution	134
4.15 Tree root systems dynamic - root functional and local response	137

Appendixes

Appendix 1 Introduction to STELLA	143
Appendix 2 User's guide to WAnuLCAS	149
Appendix 3 Description on Excel files accompanying WAnuLCAS model	161
Appendix 4 List of output acronyms and definition	169
Appendix 5 Deriving uptake equation (P. de Willigen)	179
Appendix 6 Trouble-shooting and tips	181
Appendix 7 Input parameters and their definition	185
Appendix 8 Other Useful parameters and their definition	235

References	241
-------------------	------------