ASSESSMENT TOOL / MODEL **LandscapeLAB**

Carl Timler[1] & Roos de Adelhart Toorop[2]
[1]Lecturer & Researcher / Wageningen University & Research
[2]Post-doctoral Researcher, Farming Systems Ecology Group, Wageningen University & Research

LandscapeLAB explores trade-offs and synergies between objectives at the farm or landscape level. Configurations can be selected and visualized in a new window by clicking on the configuration. The model aggregates farm level data and enables an overview of systems performance at landscape level.

NOTE An example of this tool in use is included as a case study at the end of this learning material.

Overview

LandscapeLAB explains and explores objectives at landscape and/or farm scale, like the extent of erosion, operating profit, landscape connectivity, dietary diversity produced or consumed etc. LandscapeLAB explores and makes the trade-offs and synergies visible between objectives at landscape level, for example between the extent of erosion and dietary diversity produced. This model identifies new landscape configurations that offer improvements in these objectives. Which provide quantifiable options to support discussions between various stakeholders in the landscape.

Relevance of the level of analysis

Problems associated with food security and depletion of natural resources and the need for economically viable and socially acceptable systems are important reasons for redesign of agricultural production systems and agro-landscapes. This design-oriented model aims to analyze farming systems in their landscape context and identify alternative development options to meet objectives of management and society.

Model/tool description

LandscapeLAB explores trade-offs and synergies between objectives at the farm or landscape level. A shapefile with polygons representing different farm fields (uniform land use areas) is parameterized using FarmDESIGN. Each polygon is allocated a farm model, a region and a land use (crop) within the corresponding FarmDESIGN model. Thus farm models are built within FarmDESIGN but visualized and optimized using the LandscapeLAB GUI (see Figure 1).

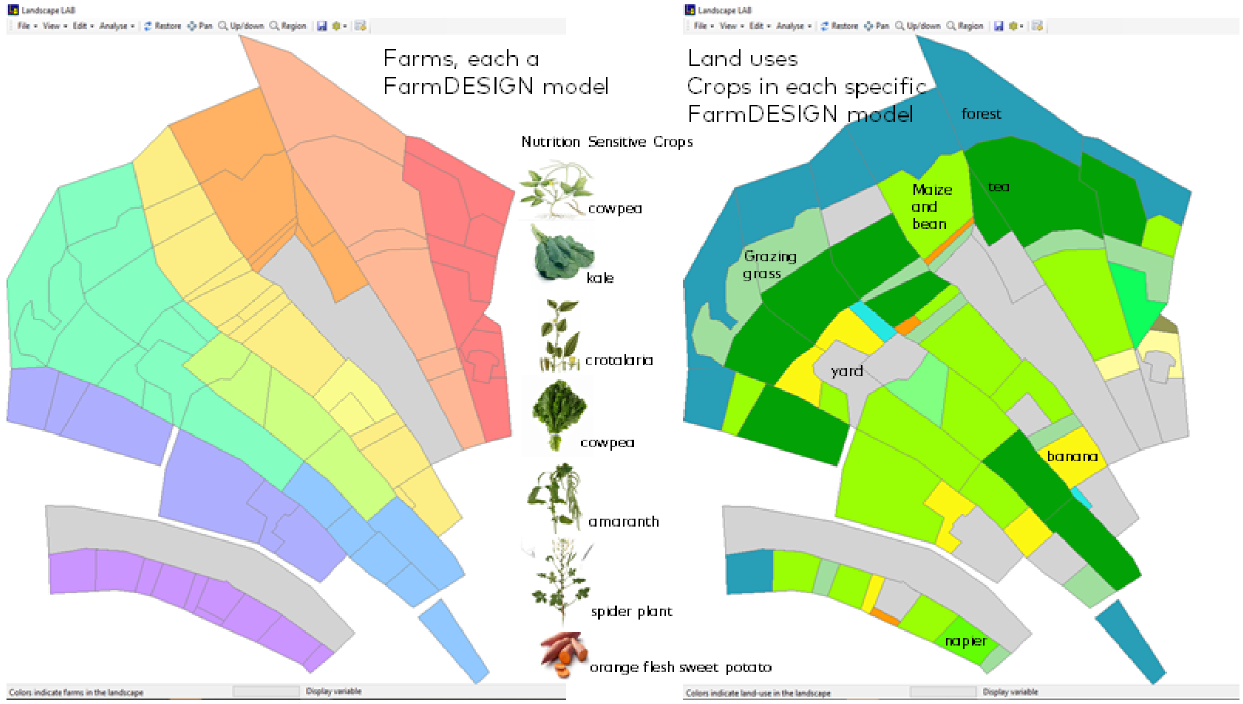
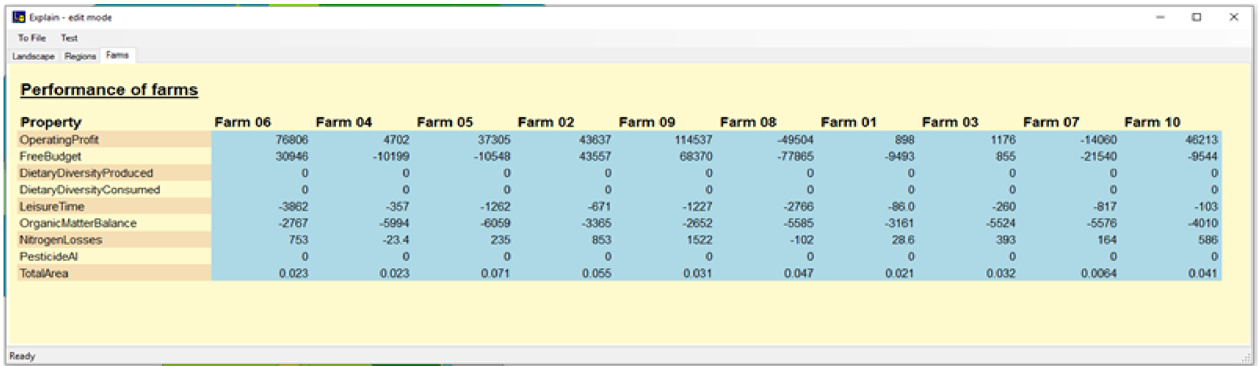


Figure 1: *Land-use in a section of Western Kenya to illustrate the functionalities of LandscapeIMAGES. The figure on the left indicates the different farms in the landscape, each color represents the fields of a farm. Each of the farms is also represented in whole-farm model FarmDESIGN. The figure on the right indicates the different crops throughout the landscape. The list of crops in the middle are 'candidate crops' that can replace existing crops when exploring options to optimize the land use.*

The current land uses can be visualized in the starting window of LandscapeLAB. Using the LandscapeIMAGES > Explain function, the current landscape can be evaluated on a number of selected indicators. These indicators can also be evaluated per individual farm or per region. In the 'Explain' window that shows these indicators, farm level or landscape level indicators can be selected as objectives and/or constraints to be used during the optimization using 'Explore' see Figure 2.



Explain - edit mode

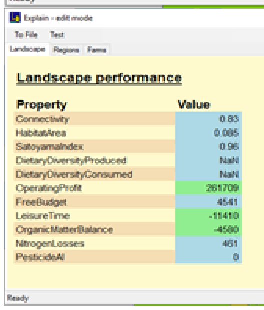
To File Test

Landscape Regions Farms

Performance of farms

Property	Farm 06	Farm 04	Farm 05	Farm 02	Farm 09	Farm 08	Farm 01	Farm 03	Farm 07	Farm 10
OperatingProfit	76806	4702	37305	43637	114537	-49504	898	1176	-14060	46213
FreeBudget	30946	-10199	-10548	43557	68370	-77865	-9493	855	-21540	-9544
DietaryDiversityProduced	0	0	0	0	0	0	0	0	0	0
DietaryDiversityConsumed	0	0	0	0	0	0	0	0	0	0
LeisureTime	-3862	-357	-1262	-671	-1227	-2766	-86.0	-260	-817	-103
OrganicMatterBalance	-2767	-5994	-6059	-3365	-2652	-5585	-3161	-5524	-5576	-4010
NitrogenLosses	753	-23.4	235	853	1522	-102	28.6	393	164	586
PesticideAI	0	0	0	0	0	0	0	0	0	0
TotalArea	0.023	0.023	0.071	0.055	0.031	0.047	0.021	0.032	0.0064	0.041

Ready



Explain - edit mode

To File Test

Landscape Regions Farms

Landscape performance

Property	Value
Connectivity	0.83
HabitatArea	0.085
SatoyamaIndex	0.96
DietaryDiversityProduced	NaN
DietaryDiversityConsumed	NaN
OperatingProfit	261709
FreeBudget	4541
LeisureTime	-11410
OrganicMatterBalance	-4580
NitrogenLosses	461
PesticideAI	0

Ready

Farm performance per FarmDESIGN model

- Individual objectives per farm can be set here.

Farm performance for the whole landscape

- Green indicates a selected objective and/or constraint

Figure 2: *Screenshot of user interface. The 'properties' are the indicators that can be assessed. The green fields were selected as objectives or constraints. An objective aims to maximize/minimize the indicator, a constraint puts upper and lower boundaries for the indicator.*

Using the LandscapeIMAGES > Explore function, a specified number of new landscape configurations can be generated using candidate land uses for each polygon (parameterized within FarmDESIGN). These are used as decision variables, with the set of selected indicators as objectives and/or constraints. The optimization uses a pareto-based evolutionary algorithm to create a solution space, and presents this solution space in a 2 dimensional graphic (see Figure 3) where trade-offs and/or synergies are visualized between the objectives.

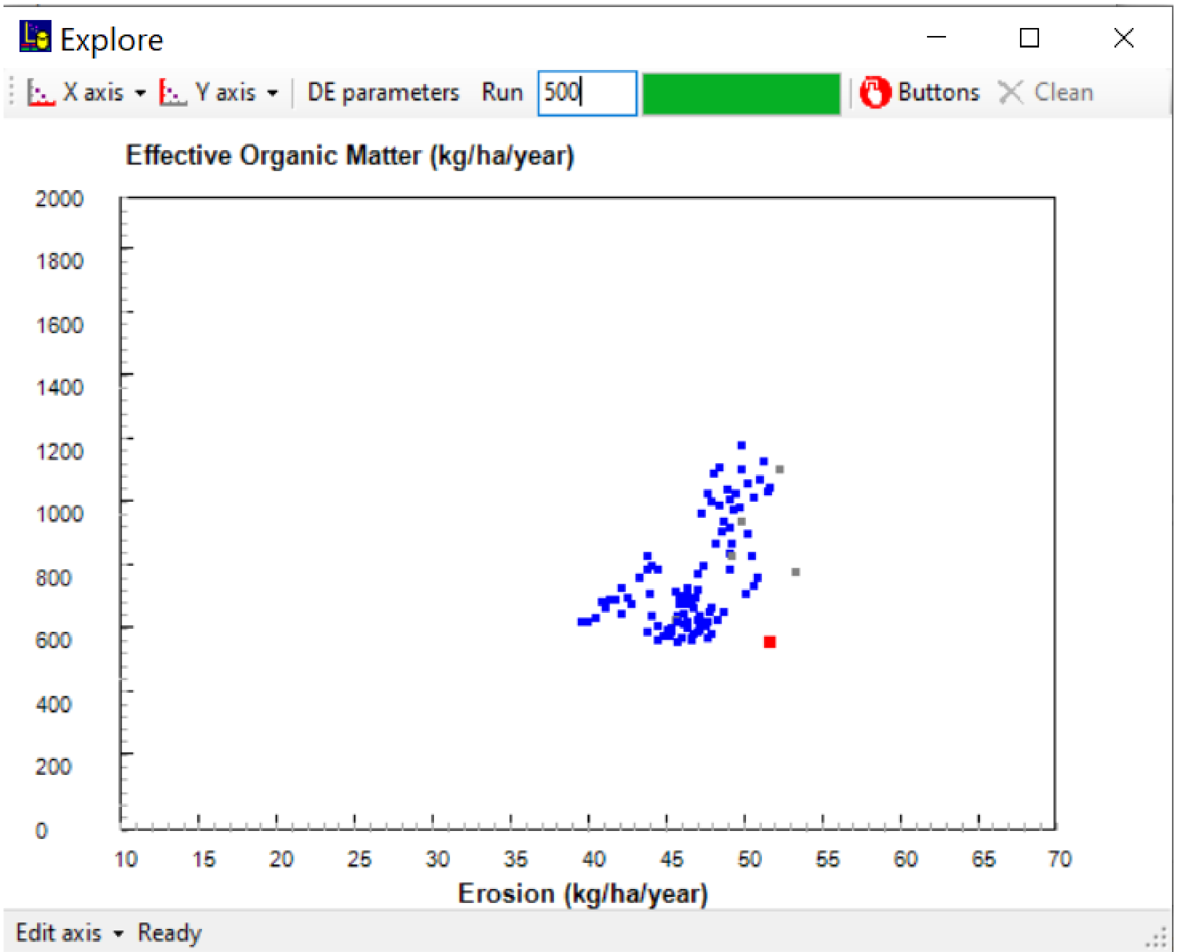


Figure 3: *The solution space generated in the 'explore' phase of the model. Blue dots indicate alternative landscape configurations, the red square indicates the current performance. In this case, both indicators could be improved.*

Configurations can be selected and visualized in a new window by clicking on the configuration. The shapefile with land uses of the new configuration can then be seen in a new window and the image saved.

Details for potential users

Proposed users - researchers
Key actors/stakeholders/beneficiaries - extension workers, policy makers, farmers
Model input - Farm specific data required for parameterizing FarmDESIGN models includes crop areas and animal numbers kept, crop yields, production rates for animal products, crop, animal and farm labor requirements, crop and animal external input -rates and -costs, crop cultivation costs, destinations of all crop and animal products, prices of crop and animal products, household composition and household food consumption patterns. Data for intervention crops includes crop yields, external input and labor requirements, cultivation costs and potential crop product prices. Secondary data relevant for all FarmDESIGN models includes chemical and nutritional composition data of all farm products, Soil data such as bulk density texture and organic matter composition, general economic data such as interest rates, and climatic data such as annual average temperature and deposition rates.
Model output - Trade-off curves, insights in characteristics of a landscape
Time period for different steps of model use and analysis - The analysis requires detailed information of the land use of the farms in the complete landscape. Collecting this takes time, but could partly be available through data bases and satellite images. Getting all data in the models and analysis requires several weeks to months.
Key references Groot, J.C.J., Yalew, S.G., Rossing, W.A.H., 2018. Exploring ecosystem services trade-offs in agricultural landscapes with a multi-objective programming approach. Landsc. Urban Plan. 172, 29–36. https://doi.org/10.1016/j.landurbplan.2017.12.008 Groot, J.C.J., Rossing, W.A.H., Jellema, A., Stobbelaar, D.J., Renting, H., Van Ittersum, M.K., 2007. Exploring multi-scale trade-offs between nature conservation, agricultural profits and landscape quality-A methodology to support discussions on land-use perspectives. Agric. Ecosyst. Environ. 120, 58–69. https://doi.org/10.1016/j.agee.2006.03.037

Case Study - Exploring Interventions for Nutrition Sensitive Landscapes with Smallholder Farmers

What can be done? The model gives insights into how two (or more) differing landscapes (communities) compare. The differences could be for instance along a market orientation, resource endowment or infrastructural gradient.

What is needed? Detailed farm data from farmers in the communities is collected via surveys and Focus Group Discussions (FGD's). Data is aggregated over a year and used to build and parameterize the farm models for each farm in FarmDESIGN.

Crop specific data is collected for the Nutrition Sensitive Interventions which are a number of agricultural interventions that can be used in the model as new candidate crops. New landscape configurations that include these new crops can be explored whereby nutritional, economic, environmental and social objectives can be improved on both the farm and landscape level.

What are possible outputs? This model output provides quantitative support for for example focus group discussions between the relevant stakeholders in the communities to discuss the newly configured landscapes with nutrition sensitive interventions. The quantitative nature of this output, allows informed discussions to take place.

Relevant stakeholders that could take part in focus group discussions or that could be interviewed: (smallholder) farmers, people working for extension services or policy makers.

Literature for further reading and details:

- Timler et al. (2020). Exploring solution spaces for nutrition-sensitive agriculture in Kenya and Vietnam. Agricultural Systems, 180, 102774. https://doi.org/10.1016/j.agsy.2019.102774

Technically this article did not look at the landscape level but at the farm level, but gives an example of how a suite of novel land uses (nutrition sensitive interventions) provides a solution space with options to improve multiple objectives.