The Land Evaluation Tool

*within the „**Tanzania Food and Land Productivity Information System**“*

Background

The Land Evaluation Tool (LET) was developed within the framework of the Trans-SEC project (Innovating pro-poor strategies to safeguard Food Security using technology and knowledge transfer. A project that was financed by the German Federal Ministry of Education and Research.
The idea of the Trans-SEC project is to provide on a collaborative and transdisciplinary research basis, approaches that allow to upgrade food value chains.
The idea of the Tanzania Food and Land Productivity Information System is to provide on a public domain basis all kind of relevant spatial information that might support agriculture and food chain research, that is otherwise dispersed and hardly available.
Finally, the idea of the Land Evaluation Tool is to provide a Web-GIS based environment that is accessible to everybody and who is interested to test on an ex-ante basis innovations for agriculture. However, the tool should be expandable to other applications and regions.

Introduction

In development-oriented projects like Trans-SEC, very often the question appears where to apply which innovation. Empirical testing - in this regard - is a quite expensive, time-demanding and often disappointing approach. Therefore, a tool is required to identify areas in which certain innovations might have a real potential. This is a typical question posed to land evaluation. Land evaluation typically compares in the broadest sense the requirements of a defined land use and the corresponding land properties.
In the past, the UN Food and Agricultural Organisation (FAO) has developed together with numerous research institutions a number of concepts and documents that deal with this topic and provide a kind of standardisation (e.g. A framework for land evaluation).
These concepts were the basis for the development of the LET. The LET was from the beginning designed in a manner that the basic principles are simple and do not represent black boxes but are explicit and can be transferred to other questions, disciplines and regions. Though the LET is extremely simple and self-explaining in its use, it appears necessary to explain the single concepts use and the dos and don’ts, as well as to discuss the limits in its application. This is what this short brevet is doing in the following.

Basic functionality of the LET

The LET is embedded as one tool in the „Tanzania Food and Land Productivity Information System“ Other tools are the Food Security Monitor and the Map Viewer.

You arrive at the LET by clicking onto the „Land Evaluation Tool“ in the header section and then by clicking on „Open the Land Evaluation Tool“ in the grey upper right hand box.

By intention you arrive at a page that looks quite similar as the Map Viewer. In fact, you can use the information provided by the Map Viewer displayed at the right hand side as background layers during your land evaluation procedures. For the basic functionality of the Map Viewer, please refer to the respective document. To orient in space, it might for instance be useful to include the district or ward boundaries into the map. This is done by double clicking onto the „Boundaries folder“ and then by clicking into the respective check boxes. If your background map is created it might appear useful to close these options by clicking onto the white triangle in the header Map Display. You can return the information any time, clicking onto the same symbol again.

Now you can drag the Calculation Guide panel to the right hand side in order to have a better view onto the GIS functionality at the left hand side.

In order to understand the following descriptions, please open the LET window now and follow the described steps on the screen.

The land evaluation Calculation Guide - Step by step

Intro

The major applications of land evaluation in the agricultural context relates to crop production. Either the question is whether a certain crop can be used in an area or whether a management measure might be potentially successful. Therefore, the LET was designed to primarily respond to this demand.

In Tanzania, the major staple crop is maize. Consequently, we used maize as a model crop in the calculation procedure. However, you can change this, as will be explained later.

The best way to use the LET is to precisely define how your innovation looks like, and in particular which demands it poses to the land. This is a very crucial step. Please define as concrete as possible the demands of your technology with respect to single measurable properties like rainfall, soil pH, slope inclination etc.. You should be aware that e.g. mechanisation is limited by slope inclination or total biomass production by rainfall if no irrigation is available. So before you use the LET please do a literature review and try to contact experts that do have precise knowledge about your technology. If you want to introduce a new crop, e.g. it would be good to have a precise description of the variety, and you should know under which intensity of cropping you want this variety to perform. Again, before you use the LET please build as much as knowledge background as possible. Otherwise you might be disappointed by the output of the tool.

Step 1: Area selection

The LET was designed to be applicable to the whole territory of Tanzania. However, it is not expected that any innovation might serve the whole country. This is simply due to the fact that ecologies and infrastructure are much too diverse that there could be one solution serving all. To take an example, in Tanzania we have regions with unimodal and bimodal rainfall distribution. It is hardly imaginable that the same maize variety could serve all these. Consequently, in the first step you should choose your intervention zone. For ease of use, the administratively defined regions in Tanzania can be chosen by default. You choose the region by opening the pull down menu and clicking once on the name of the region. As result, a rectangle beige in tone pops up. If you click on this rectangle, it changes its color to blue and two dragging points appear in the centre and the lower right corner. If you click on the point in the center, you can move the whole rectangle. The dragging point in the lower right corner serves to change the size of the rectangle. All the calculations you intend to do, will only apply to the area indicated by the rectangle.

Step 2: Upload your own data layers

Though the LET is primarily designed for application to cropping, other applications can be imagined. Therefore, you are enabled to upload a maximum of four own data layers. The number was restricted in order not to reduce the performance of the web-GIS environment.

Let's imagine an application outside cropping. If you are an economist, you might be interested to check for marketing potential of a certain commodity Marketing is very much depending on infrastructure, in particular road access. So you can use the road map provided in the map viewer and delineate in your own desktop GIS distance classes from the roads that represent increasing costs for transport. You can upload this information to the Web-GIS and continue your analysis.

The upload function serves also to introduce updated information as soon as it becomes available, e.g. new maps with climate data in higher resolution.

If you click on the „Upload Raster Data“ button, a new windows appears. Here you first enter the name of the information layer as it should appear in the LET. There are a number of conditions related to data upload. Only raster data can be uploaded, the file should not exceed 10 MB storage capacity, the layers need to have the same spatial extend and map projection. The data layer with the highest resolution provided by the LET is 250m, therefore uploaded data will be automatically resampled to the same resolution. All

these conditions have been posed for practical reasons and to keep the LET functional as a web-GIS that has per se restricted performance with respect to data transfer, in particular in the development context of Tanzania.
In order to upload data files, a browse function is included. Please choose a file on your local host and then on the „Upload Raster Data“ button. If the upload cannot be realized within 5 minutes, a timeout is programmed. The uploaded data layers will automatically be included in the following steps.

Step 3: Select calculation layers and adjust classification
This is the most crucial step in the procedure. So you should do it in the most informed way possible.
First you are asked to select the input layers. In order to be able to do so, you need detailed knowledge about the innovation you want to test. You need to ask yourself the following question: Which are the most important factors (expressed by single data layers) that impact on the success of my innovation? In consequence, you need insider knowledge on your innovation as well on the territory in which you want to implement it. Just to give an example: In a levelled terrain the solum depth might be most important variable for plant performance, in a mountanious terrain the topographic position or the slope angle.
Due to the calculation algorithm that is implemented and that will be introduced later in this text, it is recommended not to use more than 6 data layers for the evaluation procedure. Please avoid to use redundant information. For instance, it does not make sense to use the average temperature and the minimum temperature during the cropping season at the same time. Please choose the variable that has the greater impact on the variability of plant performance.
Since the system is primarily dedicated to cropping, four important variables have been pre-selected as default layers. These are:

i. The average precipitation of the growing season, since in a seasonal climate the average precipitation is a proxy for the potential biomass production.
ii. The available water capacity provides the information, how much of the precipitation can potentially be used by the crop and is a factor that represents spatial variability. The lower the available water capacity, the lower the expected yield, since a lot of the rainfall is either lost by surface flow or deep drainage.
iii. The soil organic carbon content is a proxy for nutrient stocks, in particular nitrogen as one of the most limiting nutrients in terrestrial ecosystems.
iv. And finally, the soil pH, that is a proxy for nutrient availability and potential toxicities (Al, Mn) that might occur.

However, these are not necessarily those data layers that you should choose or that are necessary for your personal evaluation. Therefore it is possible to exempt these from the calculation by clicking on the check boxes or the layer names. Then the check boxes appear empty. Instead you can add other input layers from the list that you find if you click on the „Add Input Layers“ button. The window that pops up, offers two types of additional data layers. The first type are data layers for which a suitability rating is available. For the second type you have to develop your own suitability rating.
You can add four additional data layers, so that in total a maximum of eight data layers can be used for the following calculations. You include your selection by clicking on the „Add Selected“ button.

Before we continue on the topic of suitability rating, a few words on the provided data layers.
Two kinds of data are available: climate and soil data. The climate data have been calculated by the Potsdam Institute of Climate Research (PIK in person of Christoph Gornott). They have a resolution of 0.5° and are based on the observation period 1979-2012. The resolution is relatively coarse, but the averages are based on a long observation period.
The soil data originate from ISRIC (Tom Hengl, African Soil Grids 250m). A weighted average has been calculated for 0-0,3m depth in order to represent the major rooting zone for annual crops. You can calculate your own data layers for differing depths, if it occurs necessary. We have used these data, simply because they are the only available for the spatial extent of the LET. However, you need to check whether they are reliable for your zone of intervention. Given the nested underlying data set and interpolation algorithms, the estimates do not have everywhere the same quality. We do not take responsibility for the quality of these input data.

Finally, under step 3, you need to adapt the classification of data layer values according to your knowledge and needs. In order to do so, click on the „Adapt Classification“ button.
Four categories are foreseen, and the number of these cannot be changed. The categories are very suitable (e.g. >85 % of the attainable crop yield), suitable (61-85 %), marginally suitable (41-60%) and not suitable (≤40 %). The preset values are based on the publication of Sys et al. from 1993: Land evaluation. Part III. Crop requirements.
You must be aware that the crop requirements defined therein are very crude and that you should adapt them e.g. to your cultivar in the case you have better information available. As mentioned earlier, the crop in the LET is preset as maize. The parameterization used is for a maize crop with a cycle length of 90-130 days and medium intensity cropping.

If you take a look at the layer classification table, you see that you can distinguish two types of variables. On the one hand, you have the linear variables like available water capacity. For this variable the classification rule is the higher, the better. On the other hand, you find variables with an optimum response curve, like the pH. The optimum pH range to grow a maize crop according to Sys et al. is 5.8-7.8, though cropping is possible in a pH range between 5.2 and 8.5. Therefore, you find for pH two parameterization lines. One line for the case you undershoot the optimum range and the other for the case you exceed the optimum range. For individually uploaded layers only linear responses are foreseen.
Please take time to develop this classification scheme, since it is very crucial for the final evaluation result!

Step 4: Run calculation
The evaluation algorithm used is a mixed one. It has two components and as default a 50/50 mixture of those is used.
The first algorithm is the so-called Storie Index. The formula is in principle very simple and uses multiplication of the variables standardized to 100:

SI = A*B*C*etc/100

On the one hand the mathematical construction of the algorithm allows to include as many variables as possible. On the other hand, the algorithm is sensitive to single low values. Therefore, the numbers of variables included should be restricted (maximum 4-6), and redundant information avoided.
In contrast, the average reacts quite conservative to single low values, so that variables that might strongly impact on crop performance do not significantly affect the evaluation result.
In order to enable a sufficient number of data layers but sufficient response to single data layers, it was decided to use the realized mixed algorithm. In order to allow for better adaptation e.g. to field testing results, the option was included to change the ratio to which the different formulas are applied. If you want a faster response to single low variables, choose the 70/30 Si/Avg. option. If you want a more conservative reaction, use the inverse ratio.
You should be aware that for the calculation the value for the upper class boundary is used in order to avoid underestimations. This means that if a variable is classified as very suitable the value used in the calculation is 100. In contrast, if a value is classified as not suitable, the value used is 40.
You can start the calculation by clicking on the „Calculate“ button.
The already classified calculation result will be depicted in the map window on the left hand side. The legend appears under the „Base Layers“ folder on the right hand side.

Usually five classes appear reaching from grey (not included in the calculation due to lack of data) over red (not suitable) to dark green (very suitable). You can now run calculations with different variables and parameters. For each calculation an own legend is created. For comparison, you simple have to switch between the different legends by clicking on the respective check box. Or you print out the different results using the printer button in the upper center of the map window.

Step 5: Retrieve / download result
The final and optional step is then to download the calculated results. Three options exist to do so:
Option 1: provides a geotiff with the classified results as depicted in the map window.
Option 2: provides again as a geotiff the non classified results in a value range between 0-100.
Option 3: provides a tif of the classified results that can only be used as an image for presentation purposes.

The exported data from options 1 and 2 can be imported in a desktop GIS and further processed according to your needs.
Please be careful with respect to the interpretation and application of the calculated results. The results can only be as good as the incorporated data and the applied algorithms. And these decisions are yours. Please check the outcomes and resulting recommendations by field testing before you ventilate them.

Good luck with the application of the LET tool.

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