



**BIOENERGY AND FOOD SECURITY  
RAPID APPRAISAL (BEFS RA)**

**User Manual**

**CROP BUDGET**



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BEFS Rapid Appraisal

# Natural Resources Module

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Crops Component

## **Section 2: Crop Budget**

User Manual

# Acknowledgements

The BEFS Rapid Appraisal was the result of a team effort to which the following authors, listed in alphabetical order, contributed<sup>1</sup>: Giacomo Branca (Tuscia University, Viterbo), Luca Cacchiarelli (Tuscia University, Viterbo), Carlos A. Cardona (National University of Colombia at Manizales), Erika Felix, Arturo Gianvenuti, Ana Kojakovic, Irini Maltsoglou, Jutamane Martchamadol, Luis Rincon, Andrea Rossi, Adriano Seghetti, Florian Steierer, Heiner Thofern, Andreas Thulstrup, Michela Tolli, Monica Valencia (National University of Colombia at Manizales) and Stefano Valle (Tuscia University, Viterbo).

Inputs and contributions were also received from Renato Cumani, Amir Kassam, Harinder Makkar, Walter Kollert, Seth Meyer, Francesco Tubiello and his team, Alessio d'Amato (University of Rome, Tor Vergata) and Luca Tasciotti.

We would like to thank the Bioenergy and Food Security Working Group in Malawi<sup>2</sup> as well as the National Biofuels Board<sup>3</sup> and its Technical Working Group in the Philippines for their involvement in the pilot testing of the BEFS Rapid Appraisal and the useful feedback provided. We also wish to extend our appreciation to Rex B. Demafelis and his team from University of the Philippines Los Baños for their valuable support in the pilot testing exercise.

The BEFS Rapid Appraisal benefited from feedback and comments provided at a peer review meeting held in February 2014 in FAO Headquarters by Jonathan Agwe (International Fund for Agricultural Development), Adam Brown (International Energy Agency), Michael Brüntrup (German Institute for Development Policy), Tomislav Ivancic (European Commission), Gerry Ostheimer (UN Sustainable Energy for All), Klas Sander (The World Bank), James Thurlow (International Food Policy Research Institute), Arnaldo Vieira de Carvalho (Inter-American Development Bank), Jeremy Woods (Imperial College, University of London) and Felice Zaccheo (European Commission). Useful feedback was also provided by Duška Šaša (Energy Institute Hrvoje Požar, Zagreb).

Furthermore, we would like to express our sincere gratitude to Monique Motty and Ivonne Cerón Salazar for their assistance in finalizing the tools and documents.

The work was carried out in the context of the Bioenergy and Food Security Rapid Appraisal project (GCP/GLO/357/GER) funded by the German Federal Ministry of Food and Agriculture (BMEL).

## BEFS RA User Manual Volumes

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1 Unless otherwise specified, all authors were affiliated to FAO at the time of their contribution.

2 The BEFS working Group in Malawi comprises the following members: Ministry of Energy, Ministry of Lands, Housing, and Urban Development, Ministry of Finance, Ministry of Agriculture and Food Security, Ministry of Environment and Climate Change and Department of Forestry, Ministry of Industry and Trade, Ministry of Economic Planning and Development, Ministry of Labour and Vocational Training, Ministry of Transport and Public Infrastructure, Ministry of Information and Civic Education, Ministry of Local Government and Rural Development.

3 The National Biofuels Board is chaired by the Secretary of Department of Energy and includes the following members: Department of Trade and Industry, Department of Science and Technology, Department of Agriculture, Department of Finance, Department of Labour and Employment, Philippine Coconut Authority, Sugar Regulatory Administration.

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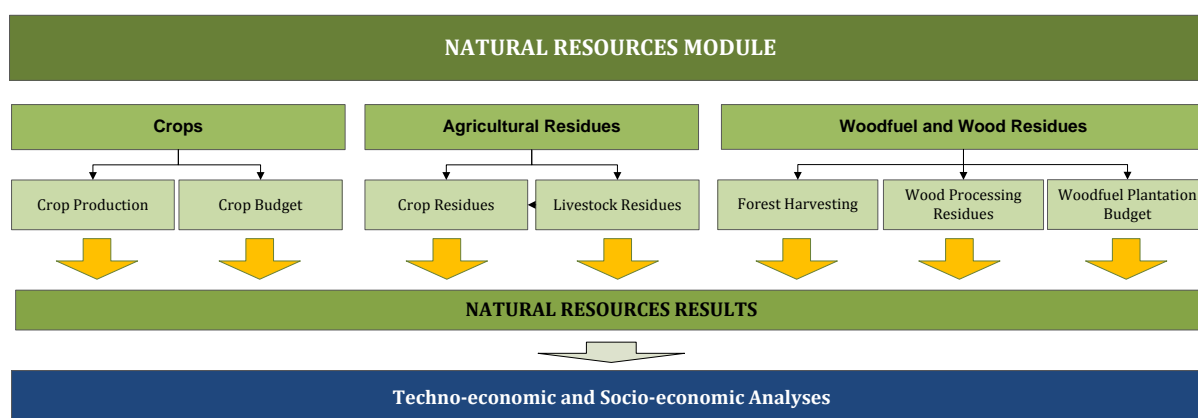
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## 1 Overview of the *Natural Resources Module*

Biofuels can be produced from different types and forms of biomass: fuelwood, crops, biodegradable residues and waste of different origins (e.g. municipal, industrial, agriculture and fisheries), etc. Biofuels come in liquid, gaseous and solid forms and can be used for heating and cooking, electricity production and as transport fuels.

The *Natural Resources* module of the BEFS Rapid Appraisal is used to assess the availability of bioenergy feedstock originating from crop production, agricultural residues and forestry. The module is divided into three components, based on the biomass type. The three components are: *Crops*, *Agricultural Residues*, *Woodfuel and Wood Residues*.

Figure 1 graphically depicts the structure of the NR Module.



**Figure 1: The Structure of the *Natural Resources Module***

Each component is an Excel file and within each file, there are one or more tools. Every Excel file starts with an introductory sheet explaining the structure and purpose of *Natural Resource* module.

The *Crops Component* includes the *Crop Production Tool* and *Crop Budget Tool*. The *Crop Production Tool* is used to assess the potential for additional production of oilseed, sugar and starch crops. The approach used to estimate the amount of these crops that could be available for bioenergy production, takes into account the countries needs for food, feed and other non-bioenergy purposes. Thus, food security measures are integrated into the analysis. These additional crops can then be used as feedstock for straight vegetable oil (SVO), biodiesel and ethanol.

The BEFS Rapid Appraisal land suitability maps are also included in the *Crops Component*. These country level maps were developed for 10 crops<sup>4</sup> that are suitable for the production of liquid biofuels and were generated using the Global Agro-Ecological Zoning<sup>5</sup> layers on land suitability and productivity (FAO, IIASA, 2012), the global land cover map GlobCover 2009 (ESA, 2012) and the World Database on Protected Areas (IUCN and UNEP, 2009). They serve to support the *Crops Production* and *Crops Budget* analyses.

<sup>4</sup> The 10 crops are: cassava, maize, sorghum, sugarbeet, sugarcane, jatropha, oil palm, rapeseed, soybean and sunflower.

<sup>5</sup> *Agro-ecological suitability and productivity – Total production capacity maps*

The *Crop Budget Tool* provides an overview of input and labour requirements, in addition to crop production costs, profitability and labour demand. The *Crop Budget Tool* mirrors the set-up of the *Crop Production Tool*, allowing for the two tools to be used collectively or individually, depending on the nature of the analysis and the requirements needed. Crop budgeting requirements are differentiated by three input levels (i.e. low, medium, high), as in the *Crop Production Tool*.

The *Agricultural Residues Component* encompasses tools to assess the availability of crop and livestock residues. Crop residues are suitable feedstock for the production of briquettes and pellets (solid biofuels), while manure is suitable for the production of biogas. These biofuels can be used for heating and cooking or for electricity generation through gasification or combustion.

The *Woodfuel and Wood Residues Component* includes three tools: *Forest Harvesting*, *Wood Processing Residues* and *Forest Plantations*. These tools facilitate the assessment of the potential for additional harvesting of fuelwood from production forests and the availability of forest harvesting residues and wood processing residues. The *Forest Plantation Tool* is used to assess the potential harvestable volume of wood from dedicated fuelwood plantations and the costs and benefits of establishing these plantations.

The foreseen flow and options of the analysis within each component are described in the respective manuals. The module can be used for the analysis of all or only selected biomass resources. Which tools will be used will depend on the aim of analysis. For example, if the user is interested to screen which biomass resources are available in the area of analysis (the country), then all of the tools will be used. Whereas, if the user is interested in a specific biofuel chain then only those relevant for the chain will be used. For example, if the user is interested in the production of briquettes from crop residues, then he/she will use the *Crop Residues Tool* of the *Agricultural Residues Component*.

All of the tools in the *Crops Component* have a results sheet that summarizes the outcomes of the analysis. Since one biomass type can be converted into final energy using different technological pathways, the user is asked to allocate the amount of available biomass among the various bioenergy supply chains.

For example, upon assessing the potential for additional production of soybean and sunflower in the results sheet, the user will need to define the percentage of the available crops for the production of straight vegetable oil (SVO) and for biodiesel. These feedstock amounts are then fed into the *SVO and Transport Tools* of the *Energy End Use Options* module. Therefore, the results from the *Natural Resources* module serve as a threshold for defining the appropriate size(s) and number of processing plants in the *SVO and Transport Tools*.

The user manual for the *Natural Resources* module is divided into four sections: *Crop Production*, *Crop Budget*, *Agricultural Residues*, *Woodfuel and Wood Residues*. Each section includes a detailed description of the tool, terms and definitions used, data required to run the analysis and the steps of analysis.

## 2 Terms and Definitions in the *Crop Budget Tool*

### General Data Entry

- **Daily wage for agricultural labour (USD/day):** Salary paid for an agricultural worker per day, i.e. 8 hours of work.
- **Machinery rental rate (average rate for agricultural operations) (USD/hour):** The price of agricultural operations carried out by mechanical equipment (tractors, machinery, etc.). The machinery rental price includes the cost of renting a machine, including the fuel needed and the operator's fee. It is expressed in USD per hour.
- **Annual farm land rental (national average) (USD/ha/year):** The cost of renting a hectare of agricultural land for one year. It is expressed in USD per hectare per year.
- **Capital interest rate (short term) (%):** The bank interest rate (the real interest rate).
- **Fertilizer<sup>6</sup> price (USD/t):** Price per tonne, for each of the following fertilizers:
  - Nitrogen
    - Under this category, the user can then select one of the following: ammonia, urea or ammonium nitrate.
  - Phosphate
    - Under this category, the user can then select one of the following: phosphate rock, MAP, DAP or TSP.
  - Potassium
    - Under this category, the user can then select one of the following: potassium chloride or potassium sulphate)
  - NPK complex
    - Under this category, the user is required to input the composition of NPK in addition to its price.
- **Water tariff for agricultural uses (if applicable) (USD/m<sup>3</sup>)**
- **Diesel price for agricultural uses (USD/l)**
- **Petrol price for agricultural uses (USD/l)**
- **Electricity price for agricultural uses (USD/kWh)**

### Crop Budget Profiles

- **Current production (user-defined crop budget):** The crop budget results are calculated using only the information provided by the user. The user-defined crop budget is used to characterize the costs of current production.
- **Low, Intermediate and High input levels (default values in crop budget):** The crop budget(s) results are calculated using the general data provided by the user, i.e. the information from the General Data Entry section, and the default values for crop-specific parameters (inputs, labour, etc.). The crop budget defined by default values is used to assess the estimated production costs, inputs and labour requirements under three projected production levels. These are based on the potential yields under low, intermediate and high input levels in agriculture in the area examined.

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<sup>6</sup> <http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/plantnutrition/fertspecs/en/>

### Crop-Specific Data Entry

- **Farm-gate price of feedstock (USD/t):** The price for feedstock if purchased directly from the producer, expressed in USD per tonne.
- **Annual crop:** A crop that completes its entire lifecycle within one year.
  - **Seed price (USD/kg):** The price of a kilo of seeds.
  - **Seedlings/cuttings (total cost per hectare) (USD/ha):** The total price of the seedlings/cuttings planted on a hectare of land.
  - **Seedlings/cuttings density (default value) (plants/ha):** The number of seedlings/cuttings planted per hectare. In the *Crop Budget Tool*, this is set as a default value.
- **Permanent crop:** Crops that are sown or planted once and do not have to be replanted after each harvest.
  - **Plant density (default value) (plants/ha):** The number of plants per hectare. In the *Crop Budget Tool*, this is set as a default value.
  - **Cost for establishing plantation (USD/ha):** The total costs of establishing a plantation in USD per hectare. The costs entered should be the sum of expenditures for: land preparation, production and planting of seedlings or price of seedlings and other material costs, expressed per hectare.
  - **Economic lifespan (years):** The period in which the plantation is profitable, expressed in number of years.
- **Water supply:** The source and delivery system of water used for agricultural production.
  - **Rainfed:** Farming practices that rely on rainfall for water.
  - **Irrigation:** Farming practices that use irrigation systems for water supply.

### Irrigation Data Entry

- **Crop water deficit (mm/year):** The difference of water naturally available (effective precipitation, soil moisture, etc.) and the amount necessary for optimal crop growth. It is specific to each crop and expressed in millimetres per year.
- **Water source:** Source of water used for irrigation.
  - **Surface:** Streams, rivers, ponds or lakes.
  - **Ground:** Groundwater.
  - **Average depth (m):** The average depth from which groundwater is pumped, expressed in metres.
- **Irrigation system:** Type of irrigation system used for the production of the analysed crop.
  - **Gravity:** Gravity alone is used for the conveyance or delivery of water to the fields or its distribution in the fields (FAO, 2014).
  - **Sprinkler:** Water is pumped through a pipe network from the source to the fields and delivered to the crop via sprinkler nozzles. These systems are also known as overhead irrigation systems (FAO, 2014).
  - **Drip:** Water is pumped through a pipe network from the source to the fields and applied as a small discharge to each plant using drip emitters (FAO, 2014).
  - **Pumping system:** Irrigation where pumps are used for water supply from the source to the field. It is a necessary part of sprinkler and drip irrigation systems (FAO, 2014).

- **Power unit source (Diesel, Petrol, Electricity, No Power):** The power source used for pumping water through the irrigation system (for sprinkler or drip irrigation systems).
- **Investment (USD):** The total investment required for an irrigation system that most closely resembles the system defined by the user.
- **Irrigated area (ha):** The total area under irrigation, i.e. the area covered by the irrigation system referred to under “Investment”.
- **Average lifespan (yrs):** The average length of life of the irrigation system, expressed in number of years.
- **Energy demand of the pump (kWh):** The energy used by pumps for water supply in drip or sprinkler irrigation systems. The value is calculated by the tool.

### **Profile, Inputs, Labour and Fixed Costs**

- **Yield (t/ha):** The yield of the analysed crop obtained in the area examined, under the existing agricultural production practice, expressed in tonnes per hectare. If the *Crop Budget Tool* is used in conjunction with the *Crop Production Tool*, then the yield should be the same as the “Current yield (t/ha)” in the intensification option of the *Crop Production Tool*.
- **Inputs:** Resources used to obtain the indicated yield, as defined above.
  - **Seed (kg/ha):** The amount of seeds sown per hectare. This parameter is only valid for annual crops, for which seeds are used as planting material.
  - **Seedlings/cuttings total cost (USD/ha):** See “Crop-Specific Data Entry” above.
  - **Fertilizer nutrients (kg/ha) – nitrogen, phosphorus, potassium:** The amount of nutrients (active components in the fertilizer) applied per hectare during one growth cycle (for annual crops this is one life-cycle, for perennial crops one year), expressed in kilos.
  - **Other agrochemicals (%):** Agrochemicals used in agricultural production other than fertilizers, such as pesticides and herbicides. It is expressed as a percentage of the total cost of fertilizer nutrients.
- **Labour:** Refers to the time spent for land preparation, planting operations, post-planting operations and/or harvesting of the analysed crop. Based on this, the related costs are:
  - **Manual (man-day/ha):** Physical work which includes both family and hired labour. It is expressed in man-days/hectare, assuming 8 hours of labour per day.
  - **Machinery (hour/ha):** Work done by machines and includes manpower for operations (i.e. driver). It is expressed in hours of work per hectare.
  - **Miscellaneous (%):** Other activities implemented during the crop cycle, expressed as a percentage of the total costs of all labour costs per hectare.
- **Fixed costs:** Costs arising during the crop production cycle regardless of the amount of product harvested per hectare, expressed in USD per hectare.
  - **Land rental (USD/ha/yr):** The costs associated with the rental of land. This may be actual land rental or the related opportunity cost if the producer is the owner of land. It is expressed as annual depreciation in USD per hectare per year.
  - **Plantation establishment (USD/ha/yr):** The costs of establishing a plantation discounted over the economic lifespan of that plantation. It is expressed as annual depreciation in USD per hectare per year.

- **Irrigation system investment (USD/ha/yr):** The costs of the irrigation system discounted over the lifespan of that irrigation system. It is expressed as annual depreciation in USD per hectare per year.

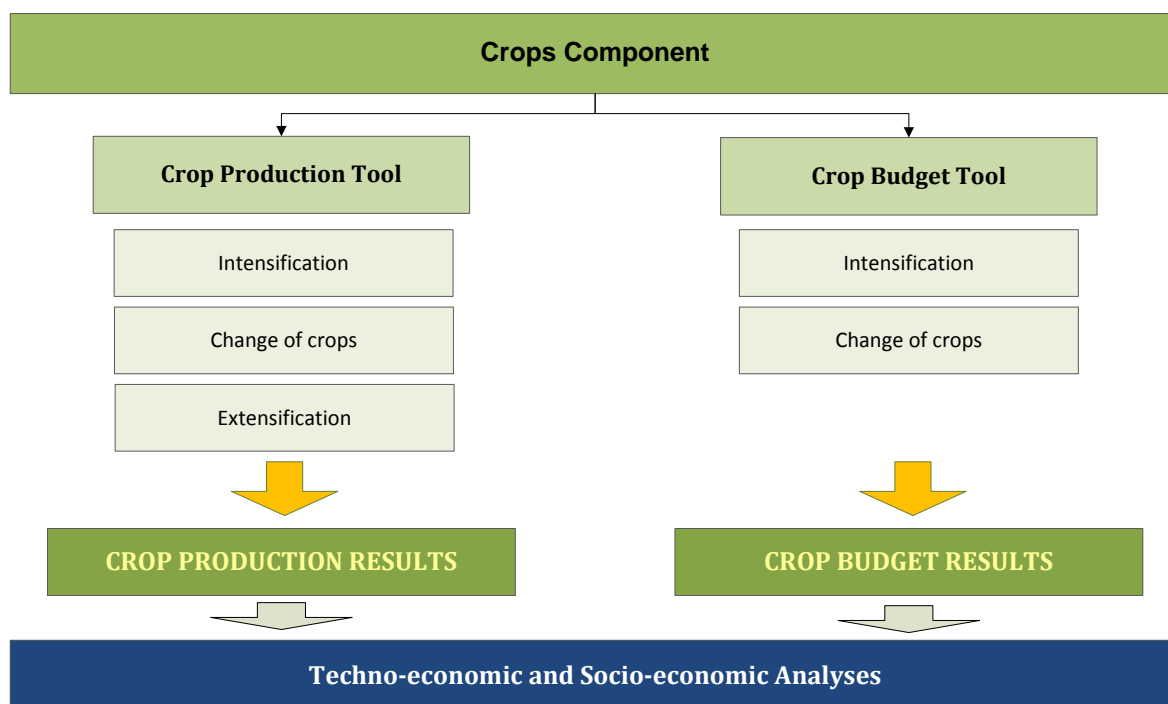
### **Main Results**

- **Revenue (USD/ha):** Income received by the farmer from selling the analysed crop that was produced on one hectare of land, expressed in USD per hectare.
- **Total variable costs:** Costs that vary according to the type and quantity of crop produced. These include input and labour costs and are expressed in USD per hectare. Note that post-harvesting costs, e.g. storage or transport to the sales point, are not included.
- **Total fixed costs:** The sum of fixed costs arising during one crop cycle in the case of annual crops, and during one year in the case of perennial crops (plantations).
- **Gross margin (USD/ha):** The difference between the revenue and the total variable costs per hectare. It is expressed in USD per hectare.
- **Interest on working capital (USD/ha):** The interest on the amount of capital that has been loaned to start operations or the opportunity cost for the amount of capital used to start operations. It is expressed in USD per hectare.
- **Net margin before tax (USD/ha):** The difference between the revenue and the total production costs per hectare. It is expressed in USD per hectare.
- **Cost of production (USD/t):** Total costs of producing one tonne of the analysed crop. It is expressed in USD per hectare.

The user can see the *Crop Production Manual* for Terms and Definitions not listed here.

## **3 Scope and Objective of the *Crop Budget Tool***

The aim of the *Crops Component* is to assess the potential for additional crop production and to evaluate the cost, revenue and labour implications of additional crop production. The *Crop Budget Tool* is one of two tools that form part of the *Crops Component* (Figure 2).



**Figure 2: Structure of the *Crops Component***

Crop budgets are used to examine the profitability of crop production. In the BEFS Rapid Appraisal, the aim of the *Crop Budget Tool* is to compare the characteristics of current production with production under different scenarios (e.g. low, intermediate, high input levels) and also allows for such a comparison among different crops. The tool estimates inputs and labour requirements on a per hectare basis, while production costs are calculated on a per hectare and per tonne basis.

The tool can be used independently, or in conjunction with the *Crop Production Tool*, in order to analyse the financial implications and socio-economic trade-offs arising from the additional production of the selected bioenergy crops. In line with the options analysed in the *Crop Production Tool*, the user can run a crop budget for intensification and a crop budget for change of crops.

The crop budget for intensification covers situations in which a crop is already in production and then examines what options are available, if any, to intensify current production in a profitable manner. Thus, in this crop budget the user can compare characteristics of current production, based on the currently achieved yields, with the projected production levels, based on the potential yields estimated by GAEZ<sup>7</sup>, for the area examined. The projected production levels considered are: Low, Intermediate and High Input Levels of agricultural production<sup>8</sup>. This allows the user to determine how production costs, labour demand and revenue will vary when moving from one production level to another. Rainfed and irrigation agricultural production options are also considered.

The change of crops section covers situations where production changes from a crop currently produced to a new crop from the list of the four crops that were analysed in the Intensification section. For example, a country currently producing tobacco may be interested in shifting part of the tobacco production toward the

<sup>7</sup> Global Agro-Ecological Zoning (see the *Crop Production Manual* for further information).

<sup>8</sup> Each of the named production levels are defined in the section Terms and Definitions of the *Crop Production Manual*.

production of cassava for ethanol use. The tool is static, but allows the user to gain an initial indication of how inputs, costs and revenue would change due to the production shift.

The tool does not cover the extensification option explicitly. For this option, since there is no current crop production, the baseline must be zero. Taking this into account, the crop budget for intensification could be used with a baseline of zero.

Overall, understanding how current production patterns, input requirements and costs compare to new situations provides an initial indication of what might be viable at the feedstock production stage of the biofuel supply chain. It is important to note the following:

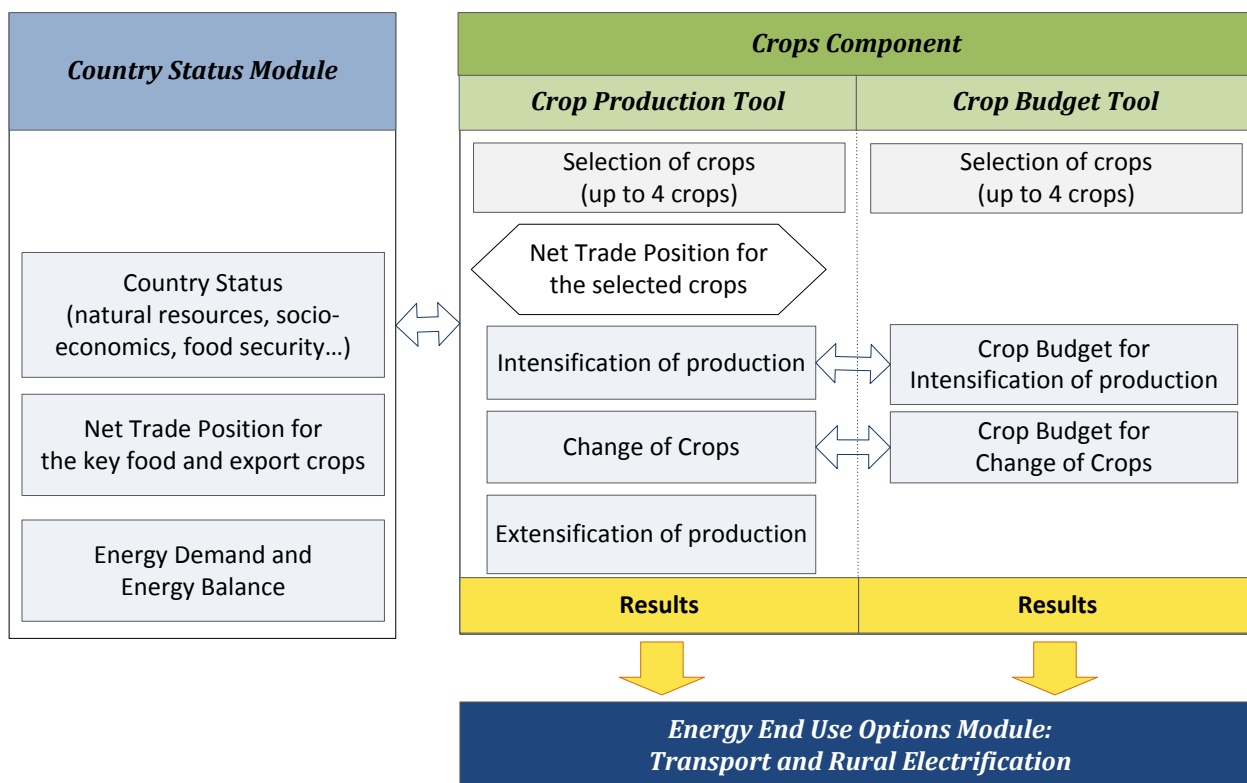
Decisions on the viability of the liquid biofuel supply chain cannot be made at this point as the actual production cost of the liquid biofuel is calculated further on in the analysis.

Rather, the results from the *Crop Budget Tool* give a first indication of the viability at the field level. For example, the analysis may show that sunflower is less lucrative for farmers when compared to palm oil. But the SVO analysis may demonstrate that SVO from sunflower is more competitive compared to SVO from palm oil. This type of result will highlight the fact that if sunflower were to be the selected feedstock for the production of SVO, some form of support at the farmer's level may be required to also make it feasible for them. Note that these results are a preliminary, rough indication of options for bioenergy production and should always be considered indicative.

The methodology applied and limitations of the tool, as well as the list of required data and suggested data sources are described in detail in the Annex.

## 4 Running the Crop Budget Tool

The *Crop Budget Tool* is embedded in the Excel file named *Crops* and contains a total of four sheets. The following figure shows the flow of analysis and the inter-linkages of the *Crops Component* with other tools and modules in the BEFS Rapid Appraisal (Figure 3).



**Figure 3: Crops Component: Flow of Analysis and Inter-linkages with BEFS RA Modules**

The *Crop Budget Tool* is structured similarly to the *Crop Production Tool*. Within the same analysis, up to four crops can be examined and their respective results compared. If used in conjunction with the *Crop Production Tool*, the same crops should be selected.

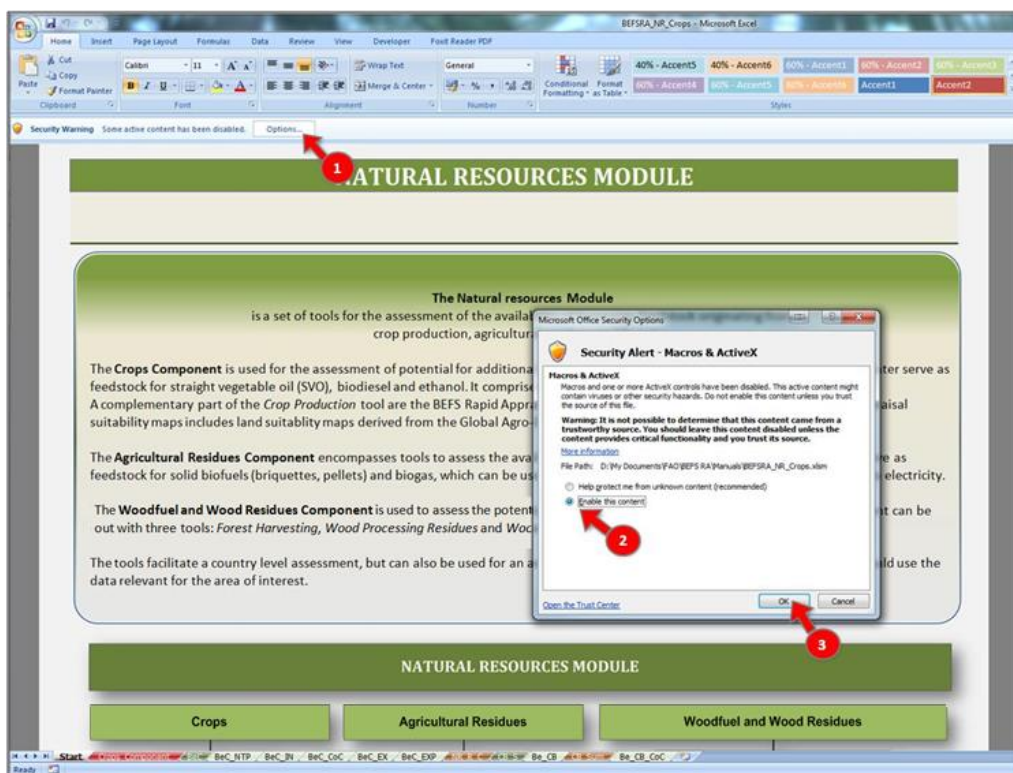
The user should enter the required data in the white cells, while calculations are shown in the grey cells. Depending on the selected crops and agricultural production options, the tool indicates which information is needed by making the respective cells white.

The navigation buttons are placed on the top and bottom of each sheet, indicating the next step with the button “NEXT>>” and allowing the user to return to a previous section with the “<<BACK” button.

The following sub-chapters describe each step of the analysis, using Malawi as the example.

### 4.1 Step 1: Starting the analysis

The first step after opening the *Crops Component* file is to enable the use of **Macros & ActiveX** in the file, in order to use to tool (Figure 4).



1 Click “Options...” on “Security Warning” bar.

2 Select “Enable the content”.

3 Click on “OK”.

**Figure 4: Opening the *Crops Component* File**

Next, the user must select the language of preference in order to view the tool in that language (Figure 5, label 1). The language choices are: English (EN), French (FR) and Spanish (ES).

At the beginning of the analysis, the user is informed about the aim and structure of the *Natural Resources* module and the *Crops Component*.

In the *Crops Component* sheet, the user should:

1. Select the country of analysis,
2. Select the area of analysis (if the analysis is conducted at a sub-national level, then enter the name of the analysed area) and
3. Press the *Crop Budget Tool* button to start the analysis.

Figure 6 shows the layout of the *Crops Component* sheet with arrows signalling the steps previously described.

When the analysis is carried out in conjunction with the *Crop Production Tool*, the user can navigate to the *Crop Budget Tool* directly from crop production results sheet by clicking on button “NEXT>>Crop Budget”.

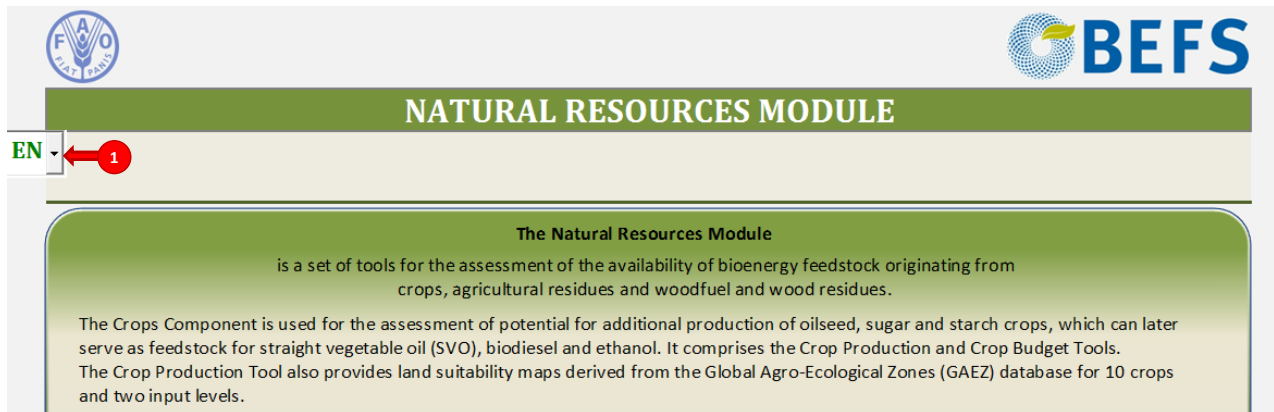


Figure 5: Language Selection

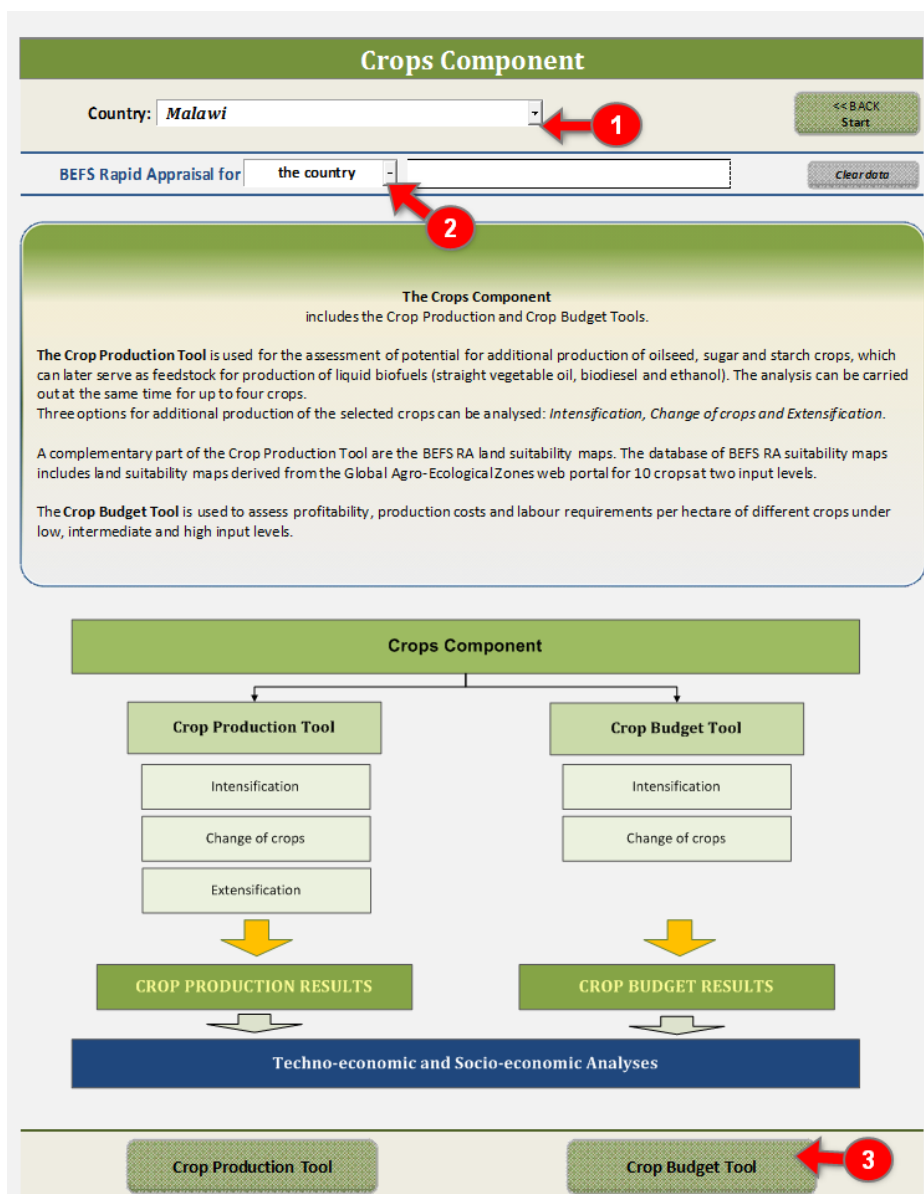


Figure 6: Layout of the *Crops Component* Introductory Sheet

### 4.2 Step 2: Crop budget – selection of crops

In the first section of the tool, the user should select the crops that will be analysed for the intensification and change of crops options. The user should choose the same crops analysed in the *Crop Production Tool*.

However, if the *Crop Budget Tool* is used independently, then the crops can be selected from the drop-down list (Figure 7). The list includes 25 key food and cash crops, among which thirteen crops are suitable for production of liquid biofuels: coconut, jatropha, rapeseed, soybean, oil palm and sunflower for production of straight vegetable oil and biodiesel, and barley, cassava, maize, sugar beet, sugarcane, sorghum and wheat for production of ethanol.

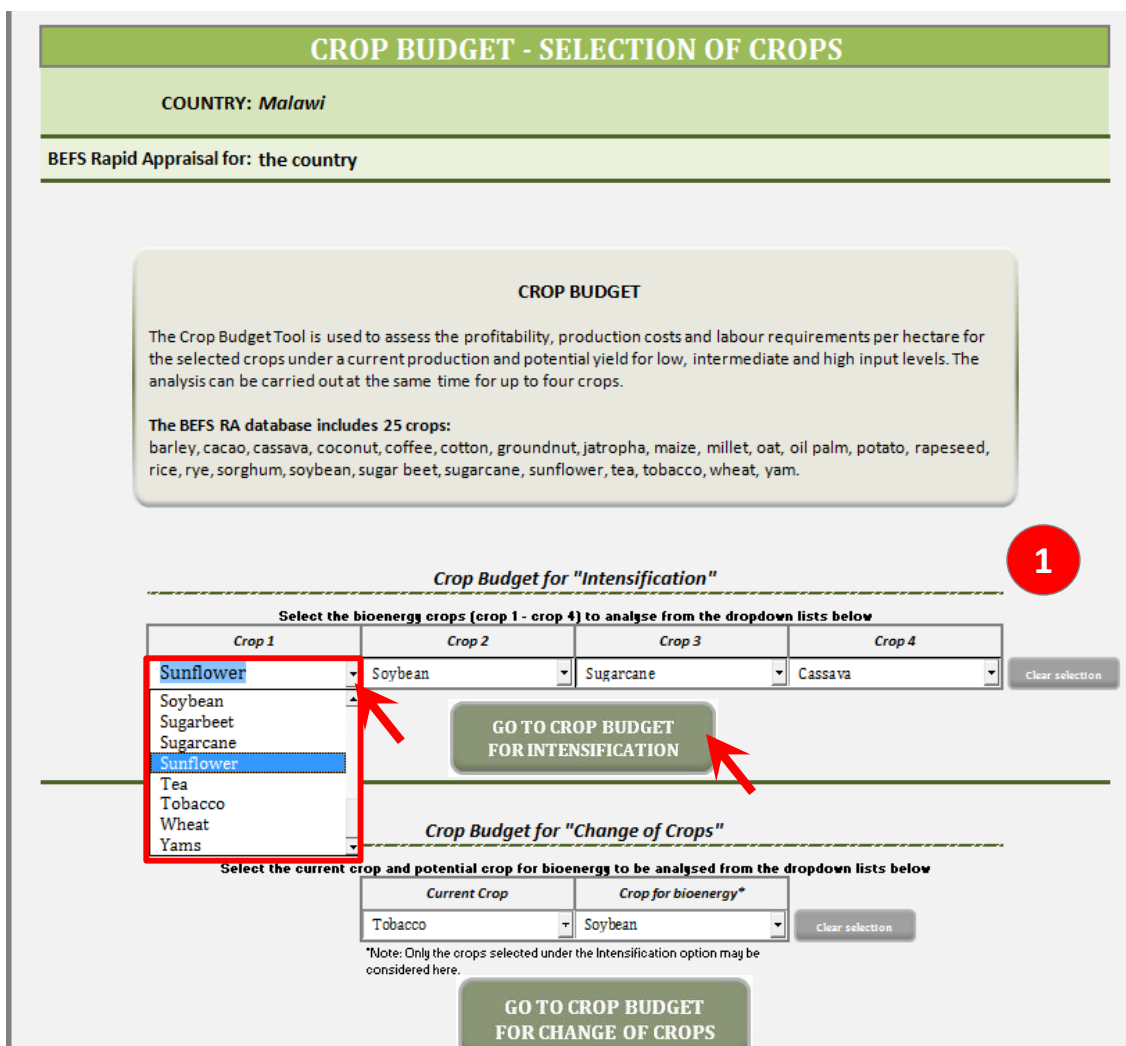


Figure 7: Layout of the Introductory Page of the *Crop Budget Tool*

In order to analyse the option for change of crops, the crop budget(s) for a bioenergy crop(s) must be defined in the crop budget for intensification. Therefore, the change of crops option follows the intensification option.

### 4.3 Step 3: Crop budget for intensification

Up to four crops can be analysed in the intensification option. The analysis starts with entering general data, which are country specific but not crop specific. This is followed by a detailed crop budget for each of the

selected crops. The user is asked to enter crop specific information about the inputs and labour used in current production, i.e. for achieving current yields. This information should be entered in the “Current Production Profile” under the “User-Defined Crop Budget” section. This is the profile in which the user inputs his/her own values to characterize the costs of current production (**Figure 8**).

Conversely, the crop budgets for low, intermediate and high input level profiles are generated by the tool using the default values for labour and inputs. The crop budgets in this section are automatically generated for the yields estimated by GAEZ for the “country average” soil suitability class. Alternatively, the user can choose to enter the expected (potential) yields for the respective input levels. In both cases, the data on the inputs and labour requirements for each input level are defined by the tool. These default values represent global averages and are stored in the tool’s database.

The results for both the “User-Defined Crop Budget” and the “Default Values Crop Budget” are shown for each crop (**Figure 8**). Thus, the results for current and projected production levels can be compared. In addition, the results for all analysed crops across different production levels can be compared in the Summary of Results sheet.

The layout of the sheet Crop Budget for Intensification is given in **Figure 8**.

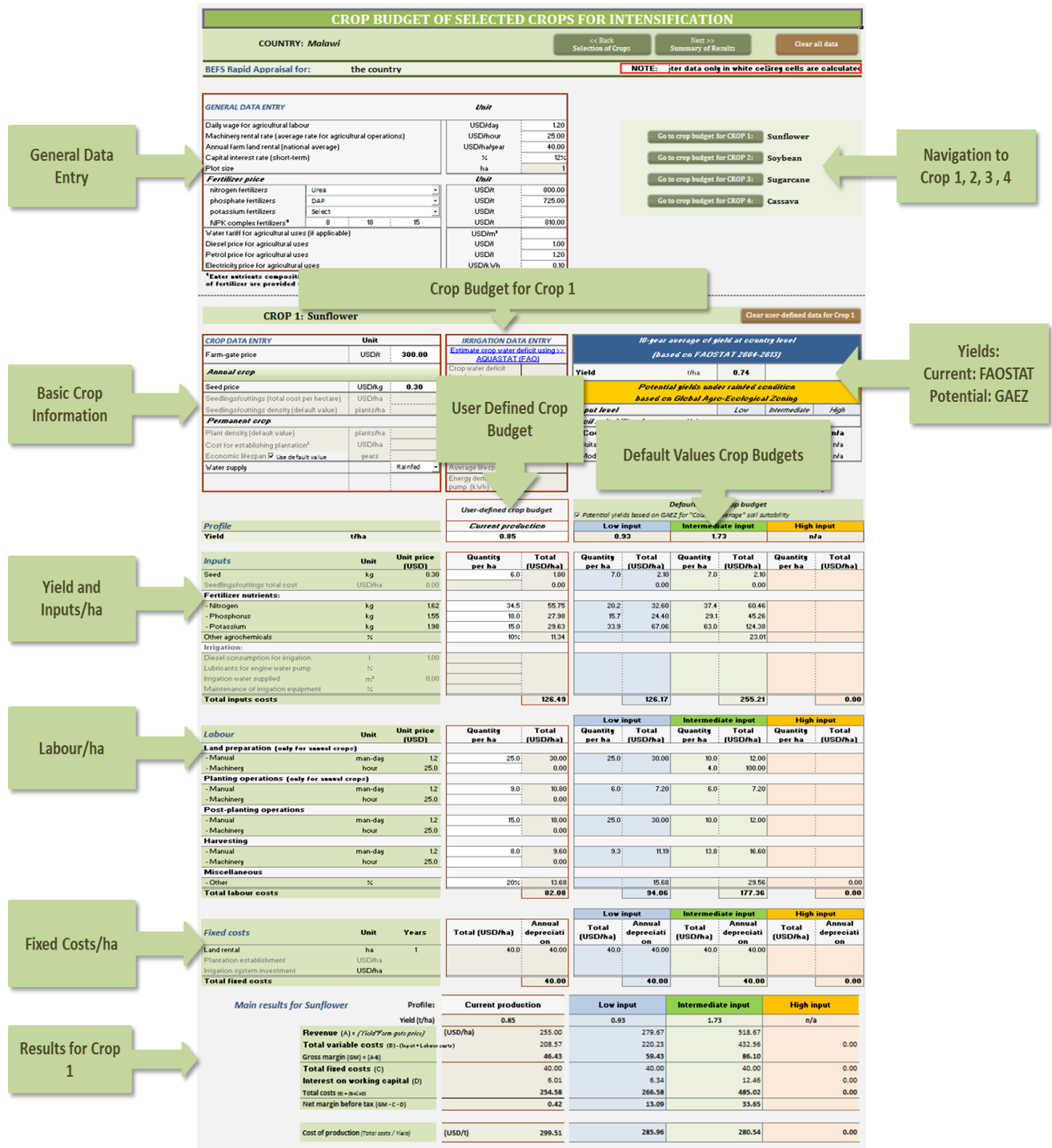


Figure 8: Layout of the Crop Budget for Intensification

### 4.3.1 Entering country general data

In the General Data Entry section, the user has to enter data on (Figure 9):

- Daily wage for agricultural labour (USD/day)
  - o Note that the tool assumes that all operations are conducted by a paid labourer. Therefore, family labour is valued at the same wage rate.
- Machinery rental rate (USD/hour)

- Annual farm land rental (USD/ha/year)
  - o Note that the tool assumes that the farmers rent the land. If the user is assessing an area in which all the farmers own the land, then he/she can decide to leave it blank.
- Capital interest rate (short term), (%)
  - o The user should input the bank interest rate.
- Fertilizer price (USD/t)

Select the most common nitrogen, phosphate and potassium fertilizers used in the country and enter their and enter their respective prices in USD per tonne. In order to obtain actual production costs, it is advised that the it is advised that the prices of fertilizers should be entered without subsidies. The fertilizers that can be selected that can be selected from the dropdown list in the tool are provided in

- o Table 1.
- o Note that in the case of NPK complex, the N:P:K ratio has to be indicated.
- Water and energy used for irrigation
  - o Water tariff for agricultural uses (USD/m<sup>3</sup>)
  - o Diesel price for agricultural uses (USD/l)
  - o Petrol price for agricultural uses (USD/l)
  - o Electricity price for agricultural uses (USD/kWh)

GENERAL DATA ENTRY		Unit	
Daily wage for agricultural labour		USD/day	1.20
Machinery rental rate (average rate for agricultural operations)		USD/hour	25.00
Annual farm land rental (national average)		USD/ha/year	40.00
Capital interest rate (short term)		%	12%
Plot size		ha	1
Fertilizer price		Unit	
nitrogen fertilizers	Urea	USD/t	800.00
phosphate fertilizers	DAP	USD/t	725.00
potassium fertilizers	Potassium chloride	USD/t	
NPK complex fertilizers <sup>1</sup>	8      18      15	USD/t	810.00
Water tariff for agricultural uses (if applicable)		USD/m <sup>3</sup>	
Diesel price for agricultural uses		USD/l	1.00
Petrol price for agricultural uses		USD/l	1.20
Electricity price for agricultural uses		USD/kWh	0.10

<sup>1</sup>Enter nutrients composition of NPK complex and its price per ton (optional if prices of each type of fertilizer are provided above).

The general data outlined in the text refers to the price/cost of main (fixed and variable) inputs.

Notice that the values are the same for any crop.

Figure 9: General Data Entry

Table 1: List of Fertilizers in the *Crop Budget Tool*

Nitrogen Fertilizers	Phosphate Fertilizers	Potassium Fertilizers
Ammonia	MAP	Potassium chloride
Urea	DAP	Potassium sulphate
Ammonium nitrate	TSP	

### 4.3.2 Entering crop specific data

The user is asked to provide specific data for each of the crops selected (e.g. the farm-gate price, price of planting material and water supply). The tool determines if the selected crop is an annual or permanent crop, and will display or shade crop specific data depending on this information. Table 2 gives an overview of the default values used in the tool for: 1) planting material for each crop, 2) plant density when seedlings or cuttings are used as planting material, and 3) plant density and economic lifespan for plantations.

**Table 2: Crop Budget Database: Default Values for Planting Materials, Plant Density (per ha) and the Plantation's Economic Lifespan**

Annual Crops			Permanent Crops		
Planting Material: seed	Planting Material: seedling/cutting	Plant Density	Crop	Plant Density	Economic Lifespan of Plantation
Barley	Cassava	10000	Cacao	1333	20
Cotton	Sweet potato	50000	Coconut	143	30
Millet	Tobacco	15000	Coffee	3300	20
Groundnut	Wheat		Jatropha	1600	20
Rice	Potato	50000	Oilpalm	143	20
Maize	Yams	15000	Sugarcane	30000	4
Oat			Tea	15000	20
Rapeseed					
Rye					
Sorghum					
Soybean					
Sugarbeet					
Sunflower					

The following data must be entered, depending on the type of crop selected (Figure 10):

- Farm-gate price (USD/t)
- Seed price (USD/kg)
- Seedlings/cuttings (total cost per hectare)
- Cost for establishing plantation (USD/ha)
- Economic lifespan (years)
- Water supply (irrigation or rainfed)

<b>CROP 1: Sunflower</b>		
<b>CROP DATA ENTRY</b>	<b>Unit</b>	
Farm-gate price	USD/t	<b>300.00</b>
<b>Annual crop</b>		
Seed price	USD/kg	<b>0.30</b>
Seedlings/cuttings (total cost per hectare)	USD/ha	
Seedlings/cuttings density (default value)	plants/ha	
<b>Permanent crop</b>		
Plant density (default value)	plants/ha	
Cost for establishing plantation <sup>2</sup>	USD/ha	
Economic lifespan (default value)	years	
Water supply		Rainfed ▾
		Rainfed Irrigation

The “Farm-gate price” in this tool is defined as the net value of the product when it leaves the farm.

**Figure 10: Crop Specific Data Entry – Sunflower in Malawi**

The seedlings/cuttings density for annual crops and the plant density for permanent crops are default values and will automatically be displayed in the tool. Additionally, the tool provides a default value for the economic lifespan of any permanent crop being analysed. However, if the user postulates a value that is different from the default value on the economic lifespan for a given plantation, then that value should be used. When the user unchecks the box “Use default value”, the cell will become white and the user can then enter the value. Finally, when information on an irrigation system is entered, the water amount that is applied seasonally for a given crop is automatically calculated by the tool and expressed in cubic metres per hectare.

### 4.3.3 Irrigation data entry

In the *Crop Data Entry* table (Figure 10), the user is asked to select whether a crop is produced under rainfed or irrigated conditions. If irrigation is selected, the user has to enter the following data in the Irrigation Data Entry (Figure 11):

- Crop water deficit (mm/year)
- Water source: surface or ground/groundwater
- Average depth (m)
  - o The user must input this value if groundwater is selected as the water source.
- Irrigation system
  - o The user must select the type of irrigation system: gravity, sprinkler or drip.
- Pumping system (yes or no)
  - o Note that if either the sprinkler or drip irrigation system is selected, there has to be a pumping system.
- Power unit source: diesel, petrol, electricity or no power
  - o Refers to the power source needed to run the pump.

- Investment (USD)
  - o This is defined as the total investment required for an irrigation system that most closely resembles the system defined by the user.
- Irrigated area (ha)
  - o The total area under irrigation, i.e. the area covered by the irrigation system referred to under “Investment”.
- Average lifespan (years)
  - o The average length of life of the irrigation system.

<b>IRRIGATION DATA ENTRY</b>	
<a href="#">Estimate crop water deficit using &gt;&gt;</a> <a href="#">AQUASTAT (FAO)</a>	
Crop water deficit (mm/year)	
Water source	Select ▾
Average depth (m)	
Irrigation system	Select ▾
Pumping system	Select ▾
Power unit source	Diesel ▾
Investment (USD)	
Irrigated area (ha)	
Average lifespan (yrs)	
Energy demand of the pump (kWh)	

**Figure 11: Irrigation Data Entry**

If the user does not have information on the crop water deficit, then he/she can calculate this value for each crop by going to the AQUASTAT link provided in the tool<sup>9</sup>. For further information on how to use the AQUASTAT tool, please see the Annex, Section 6.1.1.

If the user does not have information on the irrigation system that is selected, then he/she can use an FAO reference database that contains examples of the total investment costs for a defined area under irrigation. The database can be found at <http://www.fao.org/nr/water/aquastat/investment/index.stm> and <http://www.fao.org/nr/water/aquastat/investment/IrrigationInvestmentCosts20070416.xls>.

For further information on the irrigation data entry section, please see the Annex, Section 6.1.2-6.1.4.

#### **4.3.4 Entering data in the user-defined profile (current production)**

In this section, the user needs to provide crop specific data in order to assess the current crop production budget with the associated costs. The tool will display or shade the following data, depending on the type of crop selected (Figure 12):

1. Current yield (t/ha) (Figure 12, label 1)

The user should note that for the current yield, he/she should enter the same value from the Intensification section of the *Crop Production Tool*.

<sup>9</sup> <http://www.fao.org/nr/water/aquastat/quickWMS/climcropwebx.htm>

2. Inputs (Figure 12, label 2)
  - Seed (kg)
  - Seedlings/cuttings total cost (USD/ha)
3. Fertilizer nutrients (used for the entire crop cycle) (Figure 12, label 3)
  - Nitrogen (kg)
  - Phosphorus (kg)
  - Potassium (kg)
  - Other agrochemicals (%)
    - This refers to agrochemicals used in agricultural production other than fertilizers, such as pesticides and herbicides. The value entered should represent a percentage of the total cost of fertilizer nutrients.
4. Irrigation (Figure 12, label 4)
  - Lubricants for engine water pump (%)
    - The standard estimated percentage of the cost of engine lubrication; usually about 10-15% of the fuel cost.
  - Maintenance of irrigation equipment (%)
    - The annual cost for repair and maintenance of the irrigation equipment, approximated at 5% of the total initial system cost.
5. Labour (should be entered for both manual (man-day) and machinery (hour) labour) (Figure 12, label 5)
  - Land preparation
  - Planting operations
  - Post-planting operations
  - Harvesting
  - Miscellaneous (%)
    - Other activities implemented during the crop cycle, expressed as a percentage of the total costs of labour.

			<i>User-defined crop budget</i>	
<b>Profile</b>			<b>Current production</b>	
Yield	t/ha		1	0.85
<b>Inputs</b>			<b>Quantity per ha</b>	
	Unit	Unit price (USD)		Total (USD/ha)
Seed	kg	0.30	2	6.0
Seedlings/cuttings total cost	USD/ha	0.00		0.00
<b>Fertilizer nutrients:</b>				
- Nitrogen	kg	1.62	3	34.5
- Phosphorus	kg	1.55		18.0
- Potassium	kg	1.98		15.0
Other agrochemicals	%			10%
<b>Irrigation:</b>				
Diesel consumption for irrigation	l	1.00	4	
Lubricants for engine water pump	%			
Irrigation water supplied	m <sup>3</sup>	0.00		
Maintenance of irrigation equipment	%			
<b>Total inputs costs</b>				<b>126.49</b>
<b>Labour</b>			<b>Quantity per ha</b>	
	Unit	Unit price (USD)		Total (USD/ha)
<b>Land preparation (only for annual crops)</b>				
- Manual	man-day	1.2		25.0
- Machinery	hour	25.0		0.00
<b>Planting operations (only for annual crops)</b>				
- Manual	man-day	1.2		9.0
- Machinery	hour	25.0		0.00
<b>Post-planting operations</b>				
- Manual	man-day	1.2		15.0
- Machinery	hour	25.0		0.00
<b>Harvesting</b>				
- Manual	man-day	1.2		8.0
- Machinery	hour	25.0		0.00
<b>Miscellaneous</b>				
- Other	%			20%
<b>Total labour costs</b>				<b>82.08</b>

The values for the “Unit price (USD)” shown here, are taken from the user’s general data entry (Figure 9).

The user has to insert the production parameters: the current production yield (label 1), the quantity (per hectare) of seeds required (label 2), the fertilizer utilised (label 3), and, when relevant, the irrigation system input parameters (label 4). Lastly, the user has to enter the quantity of manual labour (man-days) and machinery work (in hours) that are needed (per hectare) (label 5).

Figure 12: Layout of the Crop Specific Data on User-Defined Current Production - Sunflower in Malawi

#### 4.3.5 Crop budgets for low, intermediate and high input level profiles (default values)

The *Crop Budget Tool* provides a 10-year average yield at the country level, based on the FAOSTAT database incorporated within the tool (Figure 13, label 1). Moreover, the tool also includes the potential yields under rainfed or irrigated conditions based on the GAEZ database. Under rainfed conditions, GAEZ provides potential yields for low and intermediate input levels of agricultural production, whereas for irrigated conditions, the database provides potential yields for intermediate and high input levels. For each agricultural production input level, potential yields for three soil suitability classes are shown: country average, suitable-very suitable, moderately suitable (Figure 13, label 2). The country average represents a weighted average of potential yields for very suitable, suitable, moderately suitable and marginally suitable land. The country average is calculated based on the potential yield for each suitability class (according to the GAEZ land suitability classification) and the proportion of each suitability class in the country.

10-year average of yield at country level (based on FAOSTAT 2004-2013)				
Yield	t/ha	0.74		
Potential yields under rainfed condition based on Global Agro-Ecological Zoning				
Input level		Low	Intermediate	High
Soil suitability class:	Unit			
Country average	t/ha	0.93	1.73	n/a
Suitable - very suitable	t/ha	1.30	2.29	n/a
Moderately suitable	t/ha	0.87	1.57	n/a

Once the country has been selected and the user has chosen the value chain parameters as seen in Figure 12, the tool gives the default values from FAOSTAT. There is one table for each crop analysed.

**Figure 13: Yields for Sunflower in Malawi under Irrigated Conditions**

To determine the “default values” crop budget for different input levels, the user can choose whether to base them on the GAEZ country average potential yields (Figure 14, label 1) or to use different potential yields. If the user decides on the latter, then he/she has to enter the potential yield in the respective cell (Figure 14, label 2). For example, if the soil suitability in the area assessed is predominantly *very suitable* and *suitable*, the user may enter the corresponding yields provided by GAEZ. Furthermore, in case the user has information about the potential yields from other sources (e.g. field research, fact sheet of the variety considered), then those values may be entered. However, the user should note that there are upper limits to the values entered, as they cannot be significantly higher than the GAEZ potential yields. If the value entered is too high, a warning sign will pop up (Figure 15).

Information about the inputs and labour requirements for each input level is defined by the tool. These agro-technical coefficients are included in the tool’s database and represent average global values retrieved from literature and case studies.

Default values crop budget					
<input checked="" type="checkbox"/> Potential yields based on GAEZ for "Country average" soil suitability					
Low input		Intermediate input		High input	
0.93		1.73		n/a	
Quantity per ha	Total (USD/ha)	Quantity per ha	Total (USD/ha)	Quantity per ha	Total (USD/ha)
7.0	2.10	7.0	2.10		
	0.00		0.00		
20.2	32.60	37.4	60.46		
15.7	24.40	29.1	45.26		
33.9	67.06	63.0	124.38		
			23.01		
	126.17		255.21		0.00
Low input		Intermediate input		High input	
Quantity per ha	Total (USD/ha)	Quantity per ha	Total (USD/ha)	Quantity per ha	Total (USD/ha)
25.0	30.00	10.0	12.00		
		4.0	100.00		
6.0	7.20	6.0	7.20		
25.0	30.00	10.0	12.00		
9.3	11.19	13.8	16.60		
	15.68		29.56		0.00
	94.06		177.36		0.00
Low input		Intermediate input		High input	
Total (USD)	Annual depreciation	Total (USD)	Annual depreciation	Total (USD)	Annual depreciation
40.0	40.00	40.0	40.00		
	40.00		40.00		0.00

This is generated by the tool according to the country characteristics and to the "Potential Yields" from GAEZ for country average soil sustainability.

Figure 14: Layout of the "Default Values" Crop Budget

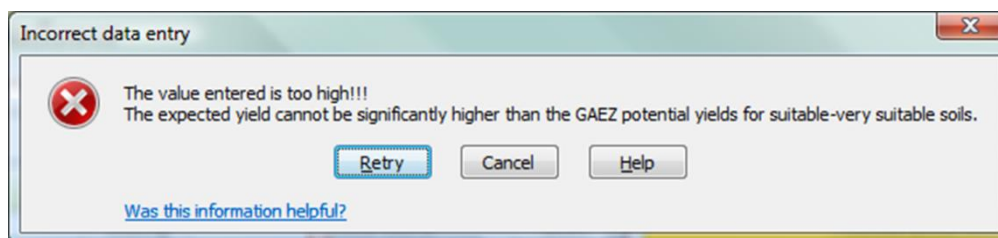


Figure 15: Potential Yield Warning

### 4.3.6 Main results for the selected crops

Based on the information provided by the user in the General Data Entry and Crop Specific Data Entry sections, the tool will generate the main results for each crop. They include profitability indicators (gross margin and net margin), total costs of production (expressed per hectare and per tonne), as well as differentiation of variable and fixed costs.

If the results do not show or seem incorrect, the user should check if all the information needed was entered in the respective cells correctly. For example, if the yield is not entered the results will show 0.00.

## 4.4 Summary of results – crop budget for intensification

Upon finalizing the analysis for the intensification option, the results are summarized in the Summary of Results sheet. The results sheet contains a set of graphical results, followed by a more detailed tabular presentation of results per crop.

Within the graphical section, four sets of results are presented. The graphs provide a comparison of the current and potential input levels across the selected crops and among the following indicators:

### 1. Total costs (USD/ha)

This graph presents the total cost of producing a crop under different input levels. In this way, the user can compare across the production options and also across the selected crops. The graph illustrates that by increasing the input level, in order to achieve higher yields, the costs can also increase. This is a first step in the analysis of the results and no conclusion should be drawn at this stage, however it may indicate the cost of intensifying production. Additionally, it shows how costs may vary by crop (Figure 16, label 1).

### 2. Production costs or cost of production

This graph illustrates the amount it costs to produce one tonne of the analysed crops at different production levels, expressed in USD/t. These results indicate how competitive the producer could be in the market at the given input level, taking into account current farm-gate prices. Furthermore, the graph provides a comparison across crops and input levels (Figure 16, label 2).

### 3. Net margin before tax

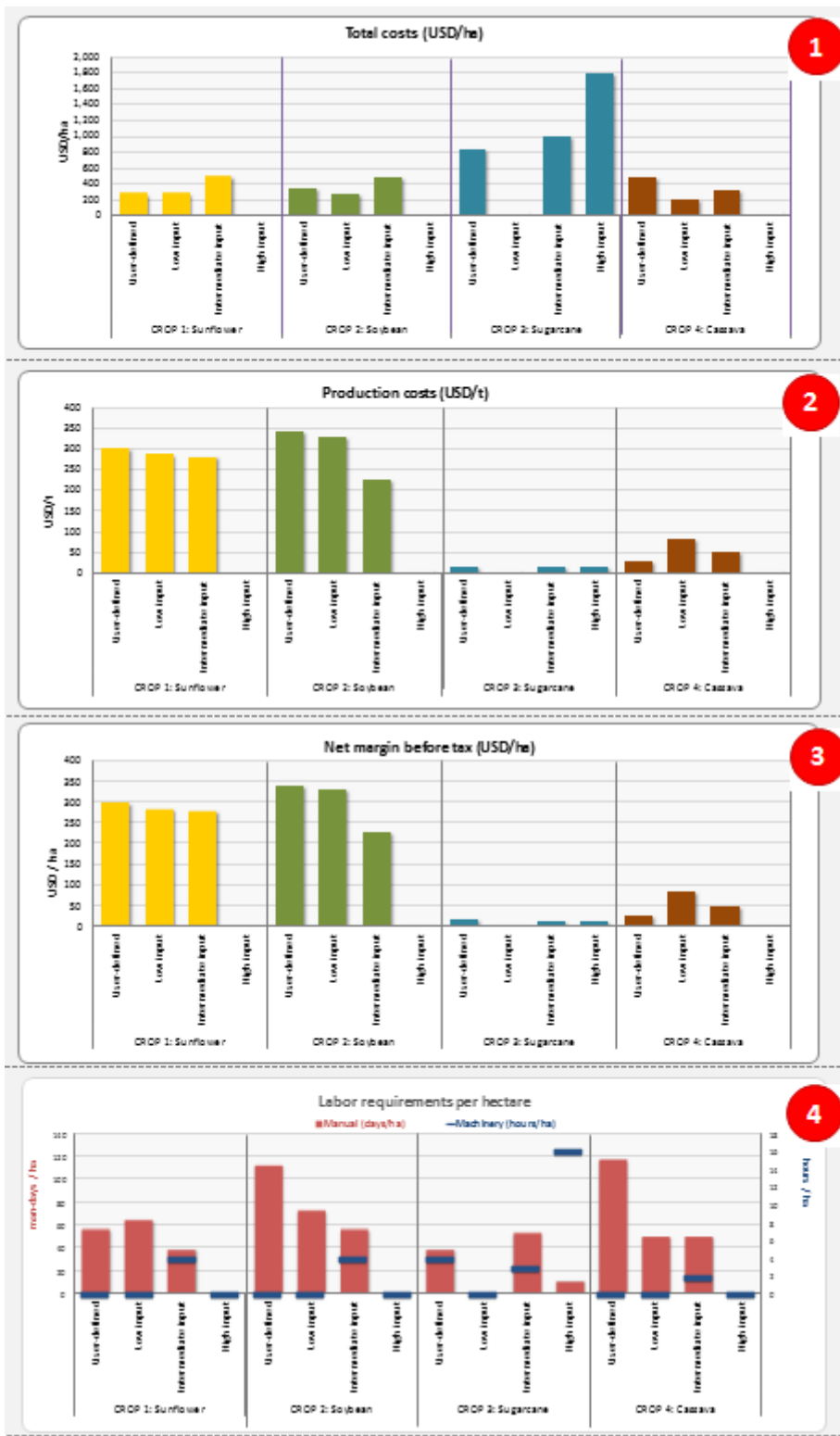
The third graph illustrates the net margin before tax, expressed in USD/ha. This indicator is calculated as the revenue minus the total costs per hectare. It provides an indication of the profitability of the selected crops at different input levels (Figure 16, label 3).

### 4. Labour requirement

This graph illustrates the amount of labour used for the production of each crop at different input levels. Labour requirements are the result of the sum of manual labour (man-days/ha) and machinery labour (hours/ha). The graph illustrates the two labour components on separate axes, due to the use of different units (Figure 16, label 4).

With these results, the user can then get an indication of the possible scenarios and consider the implication they may have on the crop producers in the analysed area.

Following the summary of graphical results, more extensive tabular results are provided. These include a record of key input information, such as the yield, farm-gate price and other essential results, i.e. revenue, total costs, gross margin, cost of production, labour, etc. Within the table the user will be able to find more details about the results (Figure 17).



Once the user has selected the country and the crop, and once the value chain parameter values (Figure 9 and Figure 12) have been inserted, the tool gives a graphical overview of the different costs to implement an intensified production.

Figure 16: Summary of Results – Crop Budget for Intensification – Part 1

The table shows simulations of different levels of intensification. This is calculated according to the values, prices and parameters previously inserted by the user. In the first column (“User-defined”), the data entered in the sheet “Crop Budget of Selected Crops for Intensification” (Figure 12) appears. Based on these values, the tool provides costs and return to capital in three possible scenarios: low, intermediate and high input.

Thus, at this point of analysis, the user is able to observe and interpret the results of the simulations regarding all relevant costs (input, labour, variable and fixed costs), the net margin before tax and the gain in USD per hectare (the revenue per hectare less fixed and variable costs).

SUMMARY OF RESULTS - CROP BUDGET FOR INTENSIFICATION									
		CROP 1: Sunflower				CROP 2: Soybean			
	Unit	User-defined	Low input	Intermediate input	High input	User-defined	Low input	Intermediate input	High input
Yield	t/ha	0.85	0.93	1.73	n/a	0.98	0.82	2.12	n/a
Farm-gate price	USD/t	300.00	300.00	300.00	300.00	380.00	380.00	380.00	380.00
<b>RESULTS OF THE BUDGET</b>									
Revenue (A) = (Yield*Farm gate price)	USD/ha	255.00	279.67	518.67		372.40	309.91	807.29	
Total input costs	USD/ha	126.49	126.17	255.21	0.00	115.54	112.64	221.21	0.00
Total labour costs	USD/ha	82.08	94.06	177.36	0.00	169.50	109.85	209.74	0.00
Total variable costs (B)=(Input+labour costs)	USD/ha	208.57	220.23	432.56	0.00	285.04	222.49	430.95	0.00
Gross margin (GM) = (A - B)	USD/ha	46.43	59.43	86.10		87.36	87.42	376.34	
Total fixed costs (C)	USD/ha	40.00	40.00	40.00	0.00	40.00	40.00	40.00	0.00
Interest on working capital (D)	USD/ha	6.01	6.34	12.46	0.00	8.21	6.41	12.41	0.00
Total costs (E) = (B + C + D)	USD/ha	254.58	266.58	485.02	0.00	333.25	268.90	483.36	0.00
Net margin before tax (GM - C - D)	USD/ha	0.42	13.09	33.65		39.15	41.01	323.93	
Cost of production (E / Yield)	USD/t	299.51	285.96	280.54		340.05	329.72	227.52	
Returns to capital (A / Input and labour costs)		1.22	1.27	1.20		1.31	1.39	1.87	
<b>LABOUR REQUIREMENTS</b>									
Total manual (F)	day/ha	57	65	40	0	113	73	56	0
Total machinery (G)	hour/ha	0.0	0.0	4.0	0.0	0.0	0.0	4.0	0.0
		CROP 3: Sugarcane				CROP 4: Cassava			
	Unit	User-defined	Low input	Intermediate input	High input	User-defined	Low input	Intermediate input	High input
Yield	t/ha	50.00	n/a	67.54	121.10	17.86	2.39	6.31	n/a
Farm-gate price	USD/t	35.00	35.00	35.00	35.00	90.00	90.00	90.00	90.00
<b>RESULTS OF THE BUDGET</b>									
Revenue (A) = (Yield*Farm gate price)	USD/ha	1,750.00		2,363.90	4,238.50	1,607.40	215.23	567.77	
Total input costs	USD/ha	398.55	0.00	563.43	1,010.24	274.57	89.31	148.92	0.00
Total labour costs	USD/ha	177.60	0.00	167.43	499.09	155.60	67.29	122.02	0.00
Total variable costs (B)=(Input+labour costs)	USD/ha	576.15	0.00	730.86	1,509.33	430.17	156.60	270.94	0.00
Gross margin (GM) = (A - B)	USD/ha	1,173.85		1,633.04	2,729.17	1,177.23	58.63	296.83	
Total fixed costs (C)	USD/ha	240.00	0.00	240.00	240.00	40.00	40.00	40.00	0.00
Interest on working capital (D)	USD/ha	16.59	0.00	21.05	43.47	12.39	4.51	7.80	0.00
Total costs (E) = (B + C + D)	USD/ha	832.74	0.00	991.91	1,792.80	482.56	201.11	318.74	0.00
Net margin before tax (GM - C - D)	USD/ha	917.26		1,371.99	2,445.70	1,124.84	14.12	249.03	
Cost of production (E / Yield)	USD/t	16.65		14.69	14.80	27.02	84.10	50.52	
Returns to capital (A / Input and labour costs)		3.04		3.23	2.81	3.74	1.37	2.10	
<b>LABOUR REQUIREMENTS</b>									
Total manual (F)	day/ha	40	0	54	12	118	51	51	0
Total machinery (G)	hour/ha	4.0	0.0	3.0	16.1	0.0	0.0	2.0	0.0

Figure 17: Summary of Results – Crop Budget for Intensification – Part 2

#### 4.5 Step 4: Analysing the change of crops option

The *Crop Budget Tool* also allows the user to examine the change of crops option to increase the production of bioenergy crops. In this case, the production area of the selected bioenergy crop expands on the land which is currently used for the production of another crop. Therefore, the production area of the current

crop decreases. Only the crops selected under the Intensification section can be considered under this option, as the crop for bioenergy (Figure 7).

For example, a country currently producing tobacco may be interested in shifting part of the tobacco production toward the production of cassava for ethanol use. Only two crops can be considered at one time, as the analysis is static, but it allows the user to gain an initial indication of how inputs, costs and revenue would change due to a shift in production.

The layout is similar to the intensification option, with the default values on the potential yields and production provided by FAOSTAT and GAEZ placed at the top of the sheet. The values in the General Data Entry section are automatically transferred by the tool from the intensification sheet (Figure 18, label 1). The users only need to enter the same data as in the intensification option for the current crop (Figure 18, labels 2 and 3; Figure 19). The steps are the same as those in the Intensification section, so users can follow Steps 4.3.2 to 4.3.5 to obtain the results. The results are provided at the bottom of the sheet and are similar to the intensification option, except that there are only two scenarios.

10-year average of yield and annual production at country level (based on FAOSTAT 2004-2013)							
Crop	CURRENT CROP			CROP FOR BIOENERGY			
	Tobacco			Soybean			
Yield	t/ha	0.93			0.87		
Annual production	t/year	140,144			73,247		
		Potential yields under rainfed condition based on Global Agro-Ecological Zoning			Potential yields under rainfed condition based on Global Agro-Ecological Zoning		
Input level		Low	Intermediate	High	Low	Intermediate	High
<b>Soil suitability:</b>							
Country average	t/ha	1.34	2.52	n/a	0.82	2.12	n/a
Suitable/very suitable	t/ha	1.84	3.19	n/a	1.15	2.77	n/a
Moderately suitable	t/ha	1.30	2.33	n/a	0.69	1.76	n/a

GENERAL DATA			Unit	1	CROP DATA ENTRY			2	Current crop	Crop for bioenergy
								Tobacco	Soybean	
Daily wage for agricultural labour		USD/day	1.20		Farm-gate price	USD/ton	380.00			
Machinery rental rate (average rate for agricultural operations)		USD/hour	25.00		<b>Annual crop under rainfed agriculture</b>					
Annual farm land rental (national average)		USD/ha/year	40.00		Seed price	USD/kg	0.50			
Capital interest rate		%	12%		Seedlings/cuttings (total cost per hectare)	USD/ha	0.00			
Plot size		ha	1		Seedlings/cuttings density (default value)	plant/ha	15,000			
<b>Fertilizer price</b>					<b>Permanent crop under rainfed agriculture</b>					
nitrogen fertilizers	Urea	USD/t	800.00		Plant density (default)	plant/ha				
phosphate fertilizers	DAP	USD/t	725.00		Cost for establishing plantation	USD/ha	-			
potassium fertilizers	Select	USD/t	0.00		Economic lifespan (default)	year				
NPK complex fertilizers	8:18:15	USD/t	810.00		Water supply		Rainfed	-	Rainfed	
Water tariff for agricultural uses (if applicable)		USD/m <sup>2</sup>	0.00		Seasonal water application	m <sup>2</sup> /ha				
Diesel price for agricultural uses		USD/l	1.00		<b>3 IRRIGATION DATA ENTRY - TOBACCO</b>					
Petrol price for agricultural uses		USD/l	1.20		Crop water deficit (mm)		Estimate crop water deficit using 2.2			
Electricity price for agricultural uses		USD/kWh	0.10		Water source	Select	Investment (USD)	AD (FAOSTAT/FAO)		
					Average depth (m)		Average lifespan (yrs)			
					Irrigation system	Select	Irrigated area (ha)			
					Pumping system	Select	Energy demand of the pump (kWh)			
					Power unit source	Petrol				

- 1 All relevant data is shown.
- 2 Under “Crop Data Entry”, the user must enter the farm-gate price (net value of the product when it leaves the farm) and the total cost per hectare of seedlings/cuttings.
- 3 If the current crop (the crop that has to be replaced) is equipped with an irrigation system, the user has to enter the system’s characteristics in this section.

Figure 18: Layout of Change of Crops Sheet – Part 1

Thus, once the user has inserted information regarding the needed quantity of fertilizer (per hectare) and the farm-gate price, the tool shows the simulation results for all costs and returns from the investment for the crop to be replaced and for the one that is considered for replacement in bioenergy production.

			User-defined		Default values					
			Current production		Low input		Intermediate input		High input	
			Quantity per ha	Total (USD/ha)	Quantity per ha	Total (USD/ha)	Quantity per ha	Total (USD/ha)	Quantity per ha	Total (USD/ha)
<b>Profile</b>					<input checked="" type="checkbox"/> Potential yields based on GAEZ for "Country average" soil suitability					
Yield	t/ha				1.34		2.52		n/a	
<b>Inputs</b>										
Seed	kg	0.00								
Seedlings/cuttings (total cost per hectare)	USD/ha	0.00			0.00		0.00			
<b>Fertilizer nutrients:</b>										
- Nitrogen	kg	1.62			52.1	84.19	98.4	159.06		
- Phosphorus	kg	1.55			20.7	32.18	39.1	60.80		
- Potassium	kg	1.98			72.1	142.53	136.3	269.27		
Other agrochemicals	%						0.00			
<b>Irrigation:</b>										
Petrol consumption for irrigation	l	1.20								
Lubricants for engine water pump	%									
Irrigation water supplied	m <sup>3</sup>	0.00								
Maintenance of irrigation equipment	%									
<b>Total inputs costs</b>			0.00		258.91		489.13		0.00	
<b>Labour</b>										
<b>Land preparation (only for annual crops)</b>										
- Manual	man-day	1.2			25.0	30.00	10.0	12.00		
- Machinery	hour	25.0					4.0	100.00		
<b>Planting operations (only for annual crops)</b>										
- Manual	man-day	1.2			15.0	18.00	15.0	18.00		
- Machinery	hour	25.0								
<b>Post-planting operations</b>										
- Manual	man-day	1.2			30.0	36.00	15.0	18.00		
- Machinery	hour	25.0								
<b>Harvesting</b>										
- Manual	man-day	1.2			21.4	25.65	32.3	38.77		
- Machinery	hour	25.0								
<b>Miscellaneous</b>										
- Other	%				0.00		0.00			
<b>Total labour costs</b>			0.00		109.65		186.77		0.00	
<b>Fixed costs</b>										
Land rental	ha	1	Total (USD)	Annual depreciation (USD/ha)	40.0	1,600.00	40.0	1,600.00		
Depreciation of plantation	USD				0.0		0.0			
Irrigation system investment	USD	0			0.0					
<b>Total fixed costs</b>			0.00		1,600.00		1,600.00		0.00	

Figure 19: Layout of Change of Crops Sheet – Part 2

## 5 Assumptions and Limitations of the Crop Budget Tool

Before starting the analysis, the user should be aware of the basic assumptions and main limitations of the tool, as summarised below.

Basic assumptions:

- Level of analysis: The tool itself does not support spatial analysis, but provides only quantitative elements which can be used in the analysis. Also, when using default values provided by the tool, the results represent a country level average, thus not revealing differences at the sub-national and local levels. For sub-national or spatially defined assessments, the user should provide specific data.

- Estimation of default values: For some estimated default values (e.g. quantity of nutrient fertilizers, labour requirements) the methodology embodies an assumption of linearity in the calculation under different input level technologies.

Main limitations:

- FAOSTAT is a global database on the world agricultural statistics, managed by the UN FAO. The statistical data stored in FAOSTAT originates from the respective countries, which send their data to the FAO Statistics Division. The FAOSTAT data integrated into the *Crop Budget Tool* refers to the whole country, i.e. the yields are averaged on the country level. This means that differences among farming systems and input levels are not revealed (e.g. subsistence-market oriented, smallholder-commercial).
- Use of data from GAEZ reported in the *Crop Budget Tool* includes information about potential yields for rainfed and irrigated agricultural production of 25 crops for a country average land suitability class under three input levels.
- This is a simplified crop budget as it does not quantify the costs of all operations (only first-level information about the production costs, labour requirements and profitability (net margin, gross margin)) for the analysed crops; a detailed analysis would require more data from the user.

## 6 Annex

### 6.1 Methodology and outputs

This section contains further details on some sections of the *Crop Budget Tool* and a description of the databases integrated in the tool. The databases are not visible to the user, but their structure and content are important for interpretation of the results and for those who will update them and/or work on the improvement of the tool.

#### 6.1.1 Crop water deficit

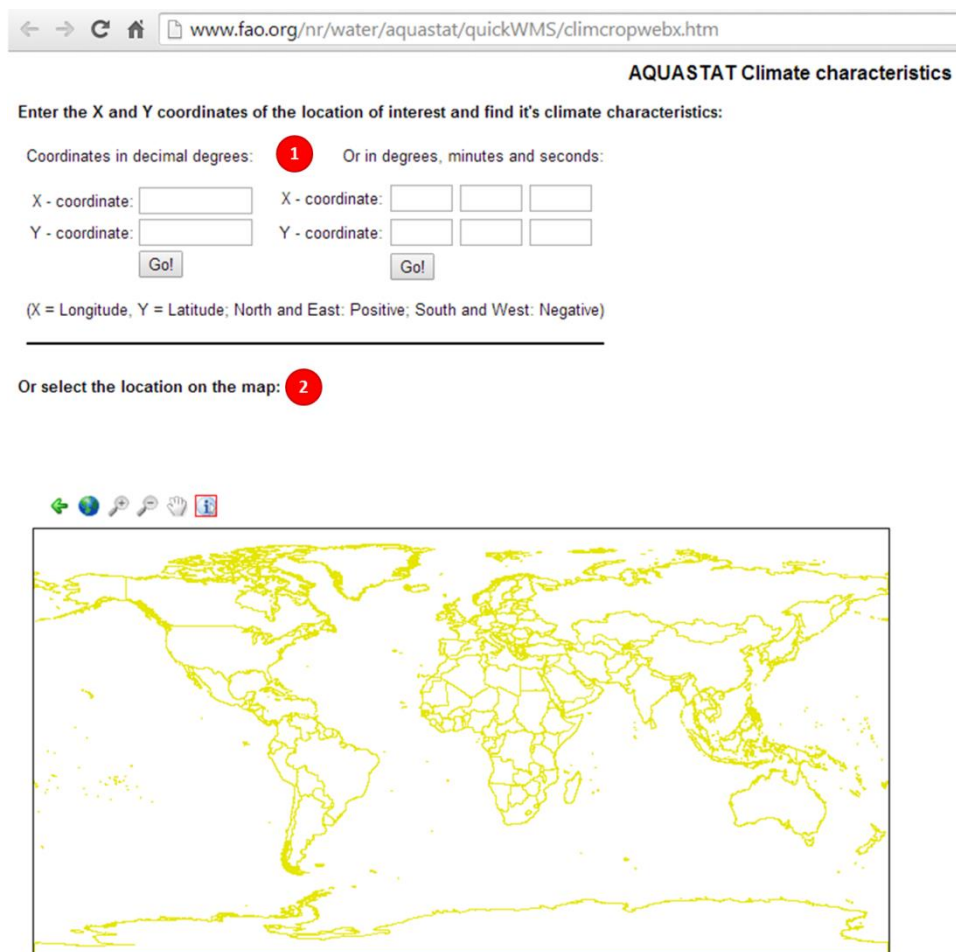
The crop water deficit (or net irrigation requirement) is used to calculate the quantity of water required to meet optimal crop growth. It is expressed in millimetres (1 mm = 10 m<sup>3</sup>/ha) and it depends on the specific crop water requirement and the water naturally available to the crops (effective precipitation, soil moisture, etc.). In order to estimate the crop water deficit, the user can access AQUASTAT (FAO) through the link<sup>10</sup> provided in the table *Irrigation Data Entry* (Figure 11).

AQUASTAT provides an interactive tool to calculate crop water requirements: calculations of crop water requirements are carried out with inputs of climate, crop and soil data. This tool calculates a soil water balance and gives an indication of the water requirements of a crop under the given agro-climatic conditions. For a more accurate assessment, the tool can be used in combination with locally collected data regarding climate, soil and crop characteristics. Further general information about the 25 crops included in this analysis is also provided in the BEFS Rapid Appraisal – Crops Catalogue, based on the Ecocrop database of FAO (<http://www.fao.org/energy/befs/86187/en/>).

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<sup>10</sup> <http://www.fao.org/nr/water/aquastat/quickWMS/climcropwebx.htm>

Once the user clicks on the AQUASTAT link provided, he/she must either select the coordinates of the location of interest or click on the location on the map provided in order to find the area’s climatic characteristics (Figure 20).



**Figure 20: Selecting Area of Interest on AQUASTAT**

In the next screen, the user will be given the climatic characteristics (precipitation, temperature, sun shine, etc.) of the area chosen and can choose whether to edit the climatic variables and re-calculate the reference evapotranspiration or use the default values provided in order to calculate the soil water balance and crop water requirements (Figure 21).

Latitude: 2.571° Longitude: -74.571° Elevation: 460m 1

Month	Prc.	Prc.	Prc. cv	Wet days	Temp. mean	Temp. max.	Temp. min.	Grnd Frost	Rel. hum.	Sun shine	Wind (2m)	ETo	ETo
	mm/m	mm/d	%	days	°C	°C	°C	days	%	%	m/s	mm/m	mm/d
Jan	48	1.5	94.2	8.2	25.6	31.2	20.0	0.0	75.0	48.8	1.7	124	4.0
Feb	93	3.3	71.9	10.0	25.7	31.3	20.2	0.0	74.5	40.7	1.8	112	4.0
Mar	169	5.4	60.1	14.2	26.0	31.2	20.8	0.0	78.3	35.0	1.6	117	3.8
Apr	286	9.5	39.8	19.1	25.6	30.4	20.8	0.0	83.2	28.4	1.6	101	3.4
May	256	8.3	35.1	20.9	25.3	30.1	20.5	0.0	84.1	35.6	1.7	105	3.4
Jun	278	9.3	34.0	21.6	24.8	29.6	20.1	0.0	84.4	28.0	1.8	92	3.1
Jul	232	7.5	33.6	20.5	24.6	29.4	19.9	0.0	82.1	32.1	1.9	101	3.2
Aug	194	6.2	37.5	19.0	25.0	30.3	19.8	0.0	80.0	35.5	1.9	111	3.6
Sep	186	6.2	44.5	17.4	25.4	30.7	20.2	0.0	79.0	37.3	1.7	112	3.7
Oct	229	7.4	36.3	18.3	25.4	30.5	20.3	0.0	81.3	38.8	1.6	113	3.7
Nov	180	6.0	40.8	17.8	25.5	30.4	20.6	0.0	81.8	41.5	1.4	106	3.5
Dec	103	3.3	58.3	12.3	25.3	30.4	20.2	0.0	79.1	46.1	1.6	114	3.7
Total	2 253											1 308	

Click [here](#) to edit climate variables and re-calculate reference evapotranspiration. 2

Click [here](#) to use these values to calculate a soil water balance and crop water requirements.

**Figure 21: Climate Characteristics of Area of Interest**

Next, the tool will show default values on climatic parameters (precipitation, wet days, and evapotranspiration) that the user can edit (Figure 22, label 1). Then, the user must select the reference crop, which should be the same one being analysed in the *Crop Budget Tool*, and the respective planting/sowing date of that crop along with the soil type in that area (Figure , labels 2 and 3).

## AQUASTAT On-line crop water requirements calculator

This section provides an interactive tool to calculate crop water requirements. Calculations of crop water requirements are carried out with inputs of climate, crop and soil data. The tool calculates a soil water balance and gives an indication of the water requirements of a crop under the given agro-climatic conditions. For more accurate assessments, the tool can be used in combination with locally collected data regarding climate, soil and crop characteristics. The methodology used is described in [FAO Irrigation and Drainage Paper 56. Crop Evapotranspiration - Guidelines for computing crop water requirements](#).

### Form to edit input data

#### Climate parameters:

Month	Prc.	Wet days	ETo
	mm/mnth	days	mm/mnth
Jan	48	8.2	124
Feb	93	10	112
Mar	169	14.2	117
Apr	286	19.1	101
May	256	20.9	105
Jun	278	21.6	92
Jul	232	20.5	101
Aug	194	19	111
Sep	186	17.4	112
Oct	229	18.3	113
Nov	180	17.8	106
Dec	103	12.3	114

#### Select crop:

#### Select planting / sowing date:

#### Select soil:



**Figure 22: Climate Parameters, Crop and Soil Selection in AQUASTAT**

The AQUASTAT crop water requirements calculator will then provide default values on the total cropping period, rooting depth, soil moisture, and other crop and soil parameters that the user can modify if needed (Figure ).

**Selected crop parameters:**

Sugar cane		
Growth stage:	Crop factor (kc):	Period (days):
Start cropping season	<input type="text" value="0.4"/>	
Initial stage		<input type="text" value="30"/>
End initial stage	<input type="text" value="0.4"/>	
Development stage		<input type="text" value="60"/>
End development stage	<input type="text" value="1.25"/>	
Middle stage		<input type="text" value="180"/>
End middle stage	<input type="text" value="1.25"/>	
Ripening stage		<input type="text" value="95"/>
Harvest	<input type="text" value="0.75"/>	
<b>Total cropping period:</b>		<b>365</b>
Depletion factor:	<input type="text" value="0.65"/>	
Rooting depth:	<input type="text" value="1.6"/>	
Default values outside growing season:		
Kc-factor:	<input type="text" value="0.5"/>	
Depletion factor:	<input type="text" value="0.5"/>	
Rooting depth:	<input type="text" value="0.5"/>	

**Selected planting / sowing date:**

**Selected soil parameters:**

Silty clay loam	
Soil moisture at field capacity (in mm/m):	<input type="text" value="440"/>
Soil moisture at wilting point (in mm/m):	<input type="text" value="230"/>
Maximum infiltration flux (in mm/day):	<input type="text" value="120"/>
Maximum drainage flux to saturated zone (in mm/day):	<input type="text" value="0.7"/>

**Figure 23: Crop and Soil Parameters in AQUASTAT Calculator**

Finally, the user will be given the soil water balance, which provides the crop deficit in in mm/year which is the value he/she must enter in the tool (Figure ).

**Soil water balance**

Month	Prc.	Wet days	ETo	ETc	ETa	Crop days	ETc-crop	Crop deficit	GW recharge	Drain	Soil water
	mm / mnt	days	mm / mnt	mm / mnt	mm / mnt	days	mm / mnt	mm / mnt	mm / mnt	mm / mnt	mm
Jan	48	8.2	124	155	155	31	155	0	3	0	112
Feb	93	10	112	140	130	28	140	11	0	0	75
Mar	169	14.2	117	146	140	31	146	5	0	0	103
Apr	286	19.1	101	126	126	30	126	0	8	0	256
May	256	20.9	105	121	121	31	121	0	19	79	293
Jun	278	21.6	92	91	91	30	91	0	20	152	308
Jul	232	20.5	101	84	84	31	84	0	21	131	304
Aug	194	19	111	44	44	31	44	0	21	120	313
Sep	186	17.4	112	71	71	30	71	0	20	114	294
Oct	229	18.3	113	120	120	31	120	0	20	107	277
Nov	180	17.8	106	133	133	30	133	0	18	30	276
Dec	103	12.3	114	143	143	31	143	0	14	0	222
<b>Total</b>	<b>2 254</b>	<b>199</b>	<b>1 308</b>	<b>1 374</b>	<b>1 358</b>	<b>365</b>	<b>1 374</b>	<b>16</b>	<b>165</b>	<b>733</b>	

**Figure 24: Soil Water Balance provided in AQUASTAT Calculator**

### 6.1.2 Pumping system and power unit source

The pump unit takes water from the source and provides the right pressure for delivery into the pipe system. The power unit source for the pumping system may be selected between diesel or petrol engines, or an electric motor.

When the water source is the surface, the user can choose whether a pump unit is used or not to pressurize the pipelines for sprinkler or drip irrigation systems, while a pumping system is essential when groundwater is selected as the water source. In this second option, the user is requested to enter an average depth in order to consider the calculations for the height needed to bring the water from the ground. The amount of water extracted and the height through which it must be lifted from the ground to the surface demands additional energy.

### 6.1.3 Energy demand of pump irrigation system

Energy demand to pump water is calculated using the following formula in which the volume of water (V) is multiplied by the head required (H), divided at the denominator by the pump plant efficiency:

$$E_d = (V \times H) / (367 \times p_e)$$

Where:

$E_d$ , [kWh] = seasonal energy demand

V, [m<sup>3</sup>] = seasonal volume of water

H, [m] = head

$p_e$ , [%] = pumping plant efficiency

The seasonal volume of water (V) is calculated according to the selected crops by multiplying the crop water deficit per hectare by the efficiency of the irrigation system.

For the purpose of this analysis, typical field application efficiencies for irrigation systems are considered:

Irrigation system	Efficiency (%)
Gravity	50
Sprinkler	75
Trickle	90

The head (H) is calculated according to the Bernoulli’s equation which provides a correlation among pressure (p), velocity (V), and geometric height (z), above a reference plane.

$$H = (p/w) + (V^2/2g) + z$$

where:

H, [m] = head

Z, [m] = elevation head

V, [m/s] = velocity

$G, [m/s^2]$  = gravity acceleration

$p, [Pa]$  = pressure

$w, [N/m^3]$  = weight density for the following fluid

#### 6.1.4 Pumping plant efficiency

Pumping plant efficiency is also taken into account in the energy demand calculation as reported below. This value is the ratio of the amount of work done (output) by a pumping plant (pump and power unit) to the amount of energy required to do the work (input). The overall efficiency of the pumping system is calculated by multiplying together the efficiencies of each component, assuming transmission efficiency 100%:

*Pumping plant efficiency (%) = power unit efficiency x pump efficiency x 100*

Follows a table with typical values for each component:

<i>Power unit efficiency (%)</i>	
Diesel engine	25
Petrol engine	15
Electric motor	80
<i>Pump efficiency (%)</i>	
60	

#### 6.1.5 Databases

The databases incorporated into the tool support the analyses in the *Crops Component*. In cases when country specific data are not available, the data provided by the tool can be used for the analysis. They include information on the country level agricultural production and the potential yields extracted from the global databases FAOSTAT and GAEZ:

##### 1. FAOSTAT production, yields and land

- **FAOSTAT\_production:** includes data on the country level annual production of 25 key food and cash crops for the years 2003-2012. Source: FAOSTAT.
- **Production:** includes data on the country level 10-years average (2003-2012) annual production of the 26 crops. Source: FAOSTAT\_production database.
- **FAOSTAT\_yield:** includes data on the country level yields of 26 key food and cash crops for the years 2003-2012. Source: FAOSTAT.
- **Yield:** includes data on the country level 10-years average (2003-2012) yields of 25 the crops. Source: FAOSTAT\_yield database.
- **FAOSTAT\_Land:** includes data on the land use/land cover in 1990, 2000, 2005, 2011 and 2012 for agricultural area, arable land, country area, forest area, land area, other land, permanent crops, permanent meadows and pastures, total area equipped for irrigation.

##### 2. GAEZ yields

- **GAEZ\_LIL\_Y:** includes potential yields for 25 key food and cash crops for rainfed, tillage based agriculture under the low level input, for three land suitability classes: country average, very suitable/suitable land and moderately suitable land. Source: GAEZ Portal, Summary tables.
- **GAEZ\_IIL\_Y:** includes potential yields for 25 key food and cash crops for rainfed, tillage based agriculture at the intermediate level input, for three land suitability classes: country average, very suitable/suitable land and moderately suitable land. Source: GAEZ Portal, Summary tables.
- **GAEZ\_IIL\_IR:** includes potential yields for 25 key food and cash crops for irrigated, tillage based agriculture at the intermediate level input, for three land suitability classes: country average, very suitable/suitable land and moderately suitable land. Source: GAEZ Portal, Summary tables.
- **GAEZ\_HIL\_IR:** includes potential yields for 25 key food and cash crops for irrigated, tillage based agriculture at the high level input, for three land suitability classes: country average, very suitable/suitable land and moderately suitable land. Source: GAEZ Portal, Summary tables.

### 3. Country

- **FAOSTAT 2013:** Rural population, Total population, Urban population
- **WDI, 2013:** GDP/capita (current US\$), GDP/capita, PPP (current int. \$), GDP/capita (const. 2005, int. \$), Agriculture added value, (% of GDP), Undernourished population (% of total), Poverty headcount ratio at national poverty line (% of population), Energy use (kg of oil eq. per capita), Electricity consumption (kWh/capita), Electricity access (% of population), GDP per unit of energy use (const. 2005 PPP \$ per koe)

4. **Fert. Quantity Calc.:** Provides macro nutrient removal/uptake per unit of product (kg/t) for 27 key crops (and it is the same across countries); it is based on the different soil needs and other production process parameters. For each key crop, the following are listed: the main product yield (in tonnes per hectare), the residue for unit of product, the yield (in tonnes per hectare) of the whole plant dry matter, and the necessary nutrient for the investigated crop - based on *W. Wichmann et al. (1992) World Fertilizer Use Manual* and other minor references- namely kilograms per hectare of nitrogen (N), phosphate (P205) and potassium (K20). Combining these parameters with the crop yield and the residue removal data, the sheet calculates the total nutrient request in kilograms of nutrients per tonnes of crop for any chemical composition of the given fertilizer.

5. **CB\_DB:** The crop budget database includes data for the 27 key crops (and it is the same across countries), based on an extensive literature review in order to provide the designed model. The principal source of modelling design is *Mémento de l'agronome*, a document oriented to provide technical assistance for the rural sector. The document was completed in 2002, as an update of the previous 1991 version, and is a joint work among the French Ministère des Affaires Étrangères, the Centre de Cooperation International en Recherché Agronomique pour le Développement (CIRAD) and the Grope de Recherché et d'Échanges Technologiques (GRET). For some crops like cotton, coffee, tea, oilpalm, and others, there are specifics references<sup>11</sup>.

Thus, the **CB\_DB** sheet includes crop specific data on: seeds, expressed in kilograms per hectare, or seedlings density (in seedling per hectare) for annual crops, plant density (in plants per hectare) and economic lifespan (in years) for permanent crops and fertilizer inputs (taken from Fert. Quantity Calc.

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<sup>11</sup> In addition to the listed references and the “on desk” work, it is useful to mention that some of the specific values of the database are a result of several interviews with technical internal officers.

database). Additionally, it includes crop-specific data on labour for the three input levels: low, intermediate and high, specifically:

- For **Barley, Cotton, Millet, Groundnut, Maize, Oat, Rapeseed, Rye, Sorghum, Soybean, Sugarbeet, Sunflower, Sweet Potato** and **Wheat**: The “land preparation” process entails machinery work only for high and intermediate input, while, manual work is null under the high input scenario. Similarly, machinery work is included only with high input for “sowing or planting cuttings”, “field operations” and “harvesting” processes; with intermediate and low input there is only manual work.
- For **Cacao, Coconut, Coffee, Jatropha, Oilpalm, Olive** and **Tea**: There are null default parameters for the “land preparation” and “sowing of planting the cuttings”. Manual work is always included for “field operations” and “harvesting”. In the case of high input, machinery work is also added to manual work for “field operations” and “harvesting”.
- For **Cassava**: There is manual work for any operation with any input level. Machinery work is also included for intermediate and high input level for the “land preparation” and only for the high input for “field operations” and “harvesting” phases.
- For **Rice**: The “land preparation” entails machinery work only for high and intermediate input, while with high input manual work is not used. On the contrary, manual work is entailed as necessary for any input level for “sowing or planting the cuttings”, “field operations” and “harvesting”. Manual work is complemented by machinery work for a high input level.
- For **Potato, Tobacco** and **Yams**: The “land preparation” entails machinery work only for high and intermediate input, while, with high input manual work is not used. Machinery work is included only with high input for the “sowing or planting cuttings”, “field operations” and “harvesting”; with intermediate and low input manual work is always used; for “field operations” manual work is null in the case of high input level.
- For **Sugarcane**: There are null default parameters for the “land preparation” and “sowing of planting the cuttings”. Manual work is always included in the “harvesting” process. In the case of high input, machinery work complements manual work. In the “field operations” process, with low input level only manual work is null, while both manual and machinery work is included for intermediate input level, and only machinery work is used under high input level.

The database also includes information on the irrigation system (sprinkler or drip) to calculate the energy demand of the pump (kWh). The price of the fertilizers is entered by the user (Figure 8, first frame). The tool, through these two sheets (Fert. Quantity Calc. and a CB\_DB), calculates the expenditure on fertilizers per hectare.

Following, the details of the default values of one of the 27 key crops investigated throughout the CB\_DB sheet:

CROP BUDGET DATABASE		cassava	cassava	cassava
INPUTS	UNIT	<i>cassavaHigh</i>	<i>cassavaIntermediate</i>	<i>cassavaLow</i>
Seed (traditional varieties)	kg/ha			
Seed	kg/ha			
Seedling	seedling/ha	10000.00	10000.00	10000.00
<b>Fertilizer Nutrients</b>				
- Nitrogen (N)	kg/t	3.12	3.12	<b>3.12</b>
- Phosphorus (P2O5)	kg/t	0.76	0.76	0.76
- Potassium (K2O)	kg/t	3.05	3.05	3.05
Organic fertilizer	t/ha			
	m3	0.00	0.00	0.00
<b>Land preparation</b>				
- Manual (1)	days/ha	10.00	10.00	20.00
- Animal traction	days/ha			
- Machinery (1)	hours/ha	2.00	2.00	
<b>Sowing or planting the cuttings</b>				
- Manual (2)	days/ha	5.00	5.00	5.00
- Machinery (2)	hours/ha			
<b>Field Operations</b>				
- Manual (3)	days/ha	4.00	20.00	20.00
- Machinery (3)	hours/ha	2.00		
<b>Harvesting</b>				
- Manual (4)	days/t	1.00	2.50	2.50
- Machinery (4)	hours/t	0.20		
Plantation	plants/ha			
Lifespan	years			
Approximate values of seasonal crop water needs:				
Crop water needs (Min Optimal)	mm	1000	1000	1000

## 6.2 Data requirements for running the tool

The tables below include data requirements for running the *Crop Budget Tool*:

**Table 3: Data Requirements for Running the *Crop Budget Tool***

Country data entry	
Daily wage for agricultural labour	USD/day
Machinery rental rate (average rate with fuel included)	USD/hour
Annual farm land rental (national average)	USD/ha
Capital interest rate (short term)	%
Selection and unit prices of fertilizers	USD/t
Water tariff for agricultural uses	USD/m <sup>3</sup>
Diesel price for agricultural uses	USD/l
Petrol price for agricultural uses	USD/l
Electricity price for agricultural uses	USD/kWh

Crop data entry	
Current farm-gate price for each selected crops	USD/t
Price of seed if applicable for selected annual crop	USD/kg
Seedlings/cuttings (total cost per hectare) if applicable for selected annual crop	USD/ha
Cost for establishing plantation for permanent crops	USD/ha
Irrigation data entry	
Crop water deficit	mm
Irrigation system, water source, pumping system	
Average depth of the groundwater	m
Irrigation system investment (capital cost)	USD
Average lifespan of the irrigation system selected	years
Hectares covered by the investment of irrigation system	ha
Inputs	
Seed	Kg/ha
Seedlings/cuttings (total cost per hectare)	USD/ha
<b>Fertilizer nutrients:</b>	
- Nitrogen	Kg/ha
- Phosphorus	Kg/ha
- Potassium	Kg/ha
Other agrochemicals	%
Labour	
<b>Land preparation</b>	
- Manual	man-days/ha
- Machinery	hours/ha
<b>Planting operation</b>	
- Manual	man-days/ha
- Machinery	hours/ha
<b>Post-planting operations</b>	
- Manual	man-days/ha
- Machinery	hours/ha
<b>Harvesting</b>	
- Manual	man-days/ha
- Machinery	hours/ha
<b>Miscellaneous</b>	
- Other	%

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