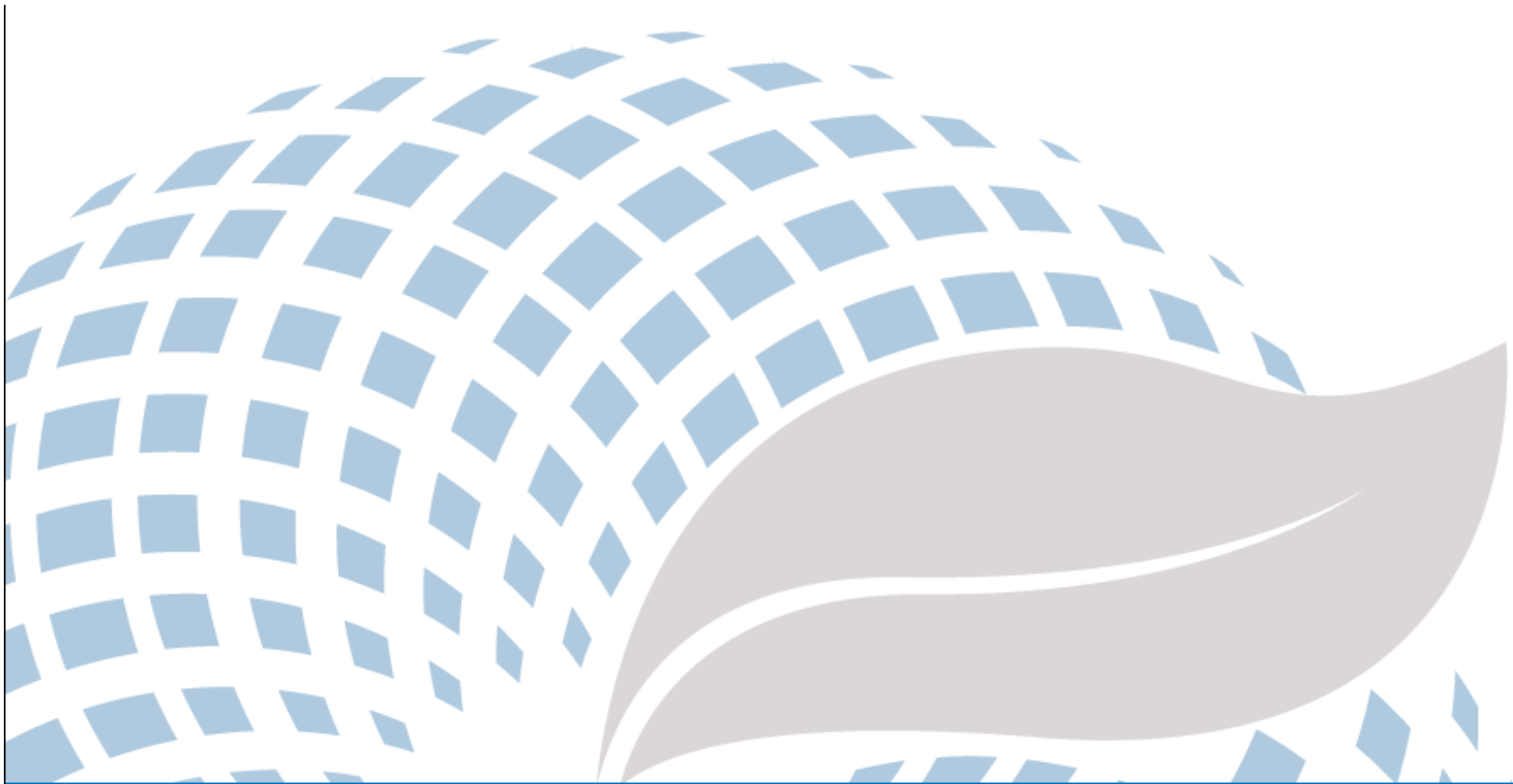
BEFS

BIOENERGY AND FOOD SECURITY RAPID APPRAISAL (BEFS RA)

User Manual

FOREST HARVESTING AND WOOD PROCESSING RESIDUES



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BEFS Rapid Appraisal

Natural Resources Module

Woodfuel and Wood Residues Component

Section 1: Forest Harvesting and Wood Processing Residues

User Manual

Acknowledgements

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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 Labor and Employment, Philippine Coconut Authority, Sugar Regulatory Administration.

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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.

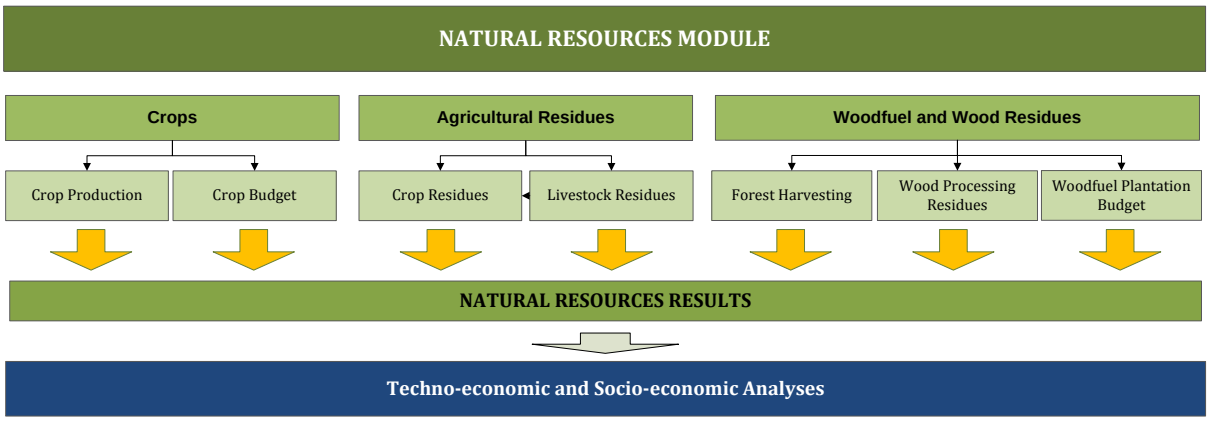


Figure 1: The Structure of the *Natural Resources* Module

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[4] that are suitable for the production of liquid biofuels and were generated using the Global Agro-Ecological Zoning[5] 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.

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*

[4] The 10 crops are: cassava, maize, sorghum, sugarbeet, sugarcane, jatropha, oil palm, rapeseed, soybean and sunflower.

[5] *Agro-ecological suitability and productivity – Total production capacity* maps

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 *Woodfuel and Wood Residues Component*

The terms and definitions described here can be found in *Forest Harvesting and Wood Processing Residues Tools*.

2.1 The *Forest Harvesting and Wood Processing Residues Tools*

- **Roundwood**: All roundwood felled or otherwise harvested and removed. It comprises all wood obtained from removals, i.e. the quantities removed from forests and from trees outside the forest, including wood recovered from natural, felling and logging losses during the period, calendar year or forest year. It includes all wood removed with or without bark, including wood removed in its round form, or split, roughly squared or in other forms (e.g. branches, roots, stumps and burls (where these are harvested)) and wood that is roughly shaped or pointed. It is an aggregate comprising woodfuel (including wood for charcoal) and industrial roundwood (wood in the rough). For FAOSTAT, it is reported in cubic metres solid volume under bark (i.e. excluding bark) (FAO, 2010).
- **Woodfuel**: The wood removed for energy production purposes, regardless whether for industrial, commercial or domestic use (FAO, 2010).
- **Industrial roundwood:** The wood removed for the production of goods and services other than energy production (woodfuel) (FAO, 2010). In FAOSTAT it is reported as under bark.
- **Removal:** Average annual of those fellings that are removed from the forest, other wooded land or other felling sites during the given reference period (FAO, 2010).
- **Theoretical potential**: The theoretical potential is the overall maximum amount of wood which can be considered theoretically available for bioenergy production within fundamental bio-physical limits.

3 Scope and Objective of the *Woodfuel and Wood Residues Component*

Forests are the main source of woodfuel, which is used for energy generation as fuelwood (firewood) or for other types of woody biofuels (briquettes, pellets, chips). Forests can have different functions, depending on how the land is primarily used. The primary function of a forest can be: production, protection of soil and water, conservation of biodiversity, socio-economic benefits (recreation, amenity, cultural) or a mix of these. Production forests are designated for the production of wood products, fibre, bioenergy and/or other non-wood forest products. According to the characteristics, production forests can be primary or planted forests. Planted forests can be semi-natural, modified natural or plantation forests.

The aim of the *Woodfuel and Wood Residues Component* is twofold:

1) to provide an indication of the possibility for additional forest harvesting and support the assessment of available wood residues for bioenergy with the *Forest Harvesting* and *Wood Processing Residues Tools*,
2) to support techno-economic analysis of the establishment of dedicated bioenergy plantations with the *Woodfuel Plantation Budget Tool*[6].

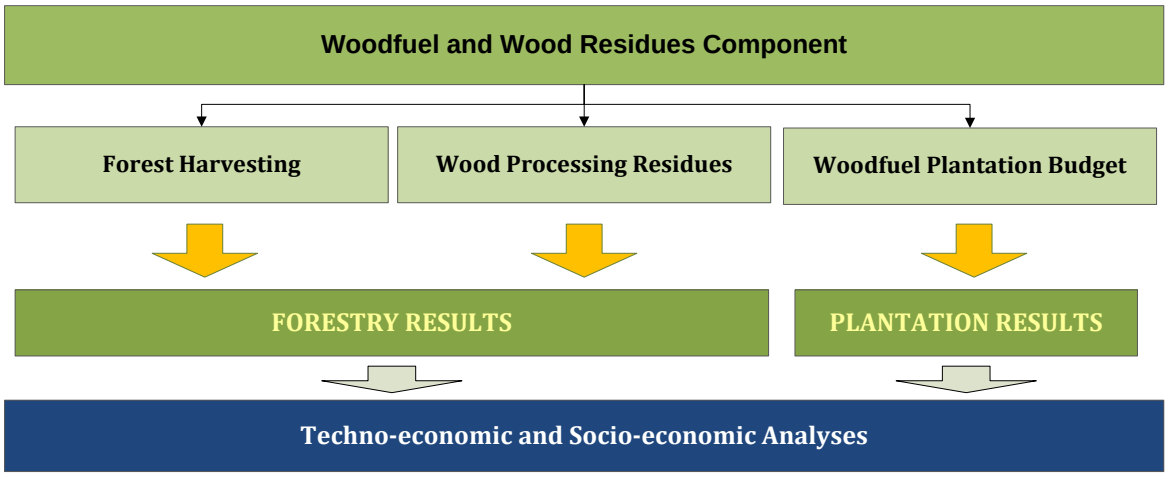


Figure 2: Structure of the *Woodfuel and Wood Residues Component*

3.1 The *Forest Harvesting Tool*

The aim of the *Forest Harvesting Tool* is to provide an indication of the possibility for additional forest harvesting and to assess how much forest harvesting residues are available for bioenergy production.

One of the main principles of sustainable forest management is to maintain the stability of the ecosystem services they provide. Along with this principle, in order to sustain the productivity and sustainable supply of products, the rate of wood harvesting should not be higher than its production rate over time. These are the underlying principles of the methodology integrated into the *Forest Harvesting Tool.*

The assessment of the possibility for additional forest harvesting is based on trends in the extent of forest area over the last 10 years, with a reference to roundwood removals in that period. The initial conclusions about the possibility of additional harvesting are based on data from the Global Forest Resource

[6] The objective and aim of the *Woodfuel Plantation Budget Tool* are described in the respective manual, which can be downloaded from the BEFS Rapid Appraisal web site.

Assessment 2010 (FRA2010) and the annual data on roundwood removals provided by FAOSTAT. Due to the fact that the tool includes only country-level numerical data, the analysis and therefore its conclusions are qualitative.

Forest harvesting residues are parts of felled trees which are not removed from the forest. The rate of removal varies among forests and usually depends on the end product that will be made and the cost-effectiveness of removing the tree. In the case of industrial roundwood, upper logs, branches and different cut-offs are often left in the forest, while stems are removed. Sometimes, stems are debarked in the forest. The rate of felling removal for woodfuel is usually higher than that of industrial roundwood, as the smaller branches, cut-offs and bark can be used as fuelwood or for production of briquettes, pellets or chips.

The use of forest harvesting residues for energy can increase energy access and/or substitute the unsustainably harvested fuelwood or other more costly fuels. In the *Forest Harvesting Tool,* the assessment of the available harvesting residues is based on the annual roundwood production, rate of felling removal and percentage of residues that are already used. Thereby, it is assumed that tree foliage, small branches and stumps are left in the forest for soil fertilization and protection and biodiversity conservation.

The calculation of the total amount of forest harvesting residues arising after fellings can be conducted using the default values integrated in the tool or with user defined values. If country/area specific data are available, they should be used, as this would lead to more accurate results. Finally, to assess the amount of residues that are still available, the user needs to provide information about the percentage of residues already used.

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

3.2 The *Wood Processing Residues Tool*

Sawdust, slabs and chips generated as residues of wood processing are a valuable resource, which can be used as feedstock for other products or for energy generation. The amount of residues generated in a sawmill depends on the type of technology used and its efficiency. Moreover, the type of final product defines the technology used. In spite of the fact that wood processing residues are often readily available and considered a cheap resource, the level of their utilization varies considerably. This variation occurs not only among countries, but also among sawmills within the same country. Often, residues are not fully utilised due to the lack of demand in the immediate vicinity of the processing plant. Furthermore, transporting residues to an area with high demand is deemed uneconomical. However, an option is to convert wood residues into modern biofuels, such as briquettes and pellets. This process increases their energy density and makes transportation over long distances easier and more cost-effective. Another option is to use residues for electricity generation, which can either be used within the sawmill or fed into the grid.

The *Wood Processing Residues Tool* is used to assess the amount of sawdust, slabs and chips generated during sawnwood production, which could be mobilized for bioenergy production. The assessment is based on the annual sawnwood production, efficiency of sawmills and current use of residues. Based on the average efficiency of sawmills (recovery rate), the amount of sawdust, slabs and chips is calculated. Either the default values integrated in the tool or the user defined sawmill efficiency factors can be used in the analysis. The user is advised to use country specific data, if available, to make results more accurate. Finally, to assess the amount of residues that are still available, the user needs to provide information about the percentage of residues already used.

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

4 Running the *Forest Harvesting and Wood Processing Residues Tools*

The *Forest Harvesting, Wood Processing Residues* and *Woodfuel Plantation Budget Tools* are embedded in the Excel file named *Woodfuel*. It contains eleven Excel sheets, of which the first two give information about the *Natural Resources* module and the *Woodfuel and Wood Residues Component.* The next four sheets are the *Forest Harvesting and Wood Processing Residues Tools* and their results. The last five sheets pertain to the *Woodfuel Plantation Budget Tool* and its results.

Depending on the aim of analysis, the user can decide whether he/she will use all of the tools or only those of his/her specific interest. The flow of analysis is pre-defined and the user is navigated step by step through the tools and asked to enter necessary data in order to obtain final results. When the required data are limited or unavailable, then the default values provided by the tool can be utilised. 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 the previous section with the "<<BACK" button.

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

4.1 Starting the analysis

The first step after opening the *Woodfuel* file is to enable the use of ***Macros & ActiveX*** in the file, in order to use the tools (Figure 3).

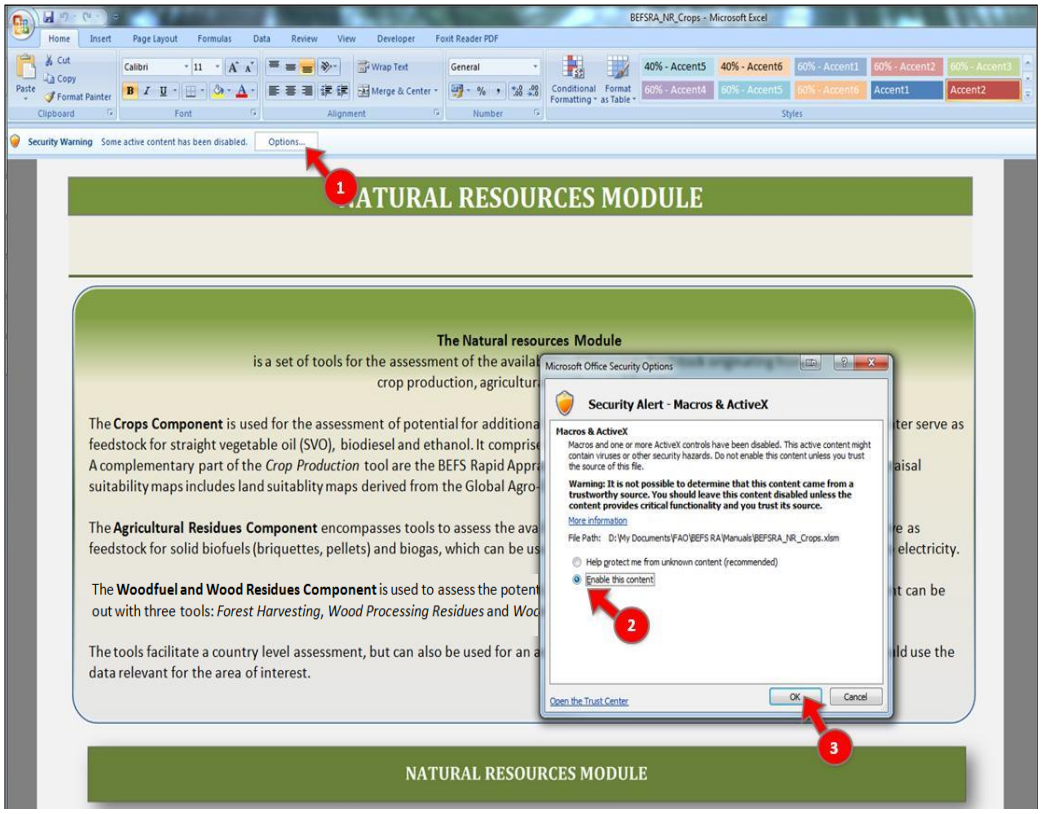


Figure 3: Opening the *Woodfuel and Wood Residues Component* File

Next, the user must select the language of preference in order to view the tool in that language (Figure 4, 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 *Woodfuel and Wood Residues Component*.

In the *Woodfuel and Wood Residues 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. Select the *Forest Harvesting* or *Wood Processing Residues Tool* button to start the analysis.

Figure 5 shows the layout of the *Woodfuel and Wood Residues Component* sheet with arrows signalling the steps previously described.

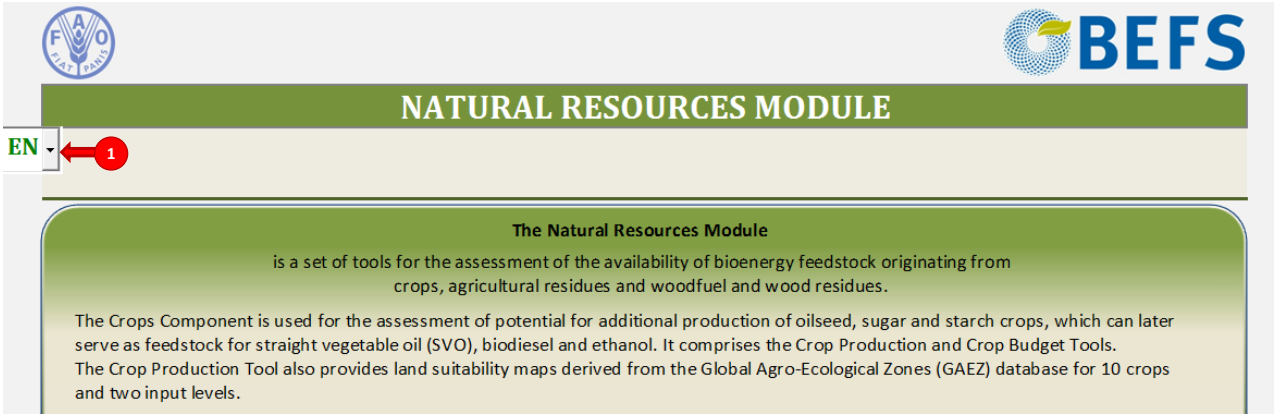


Figure 4: Language Selection

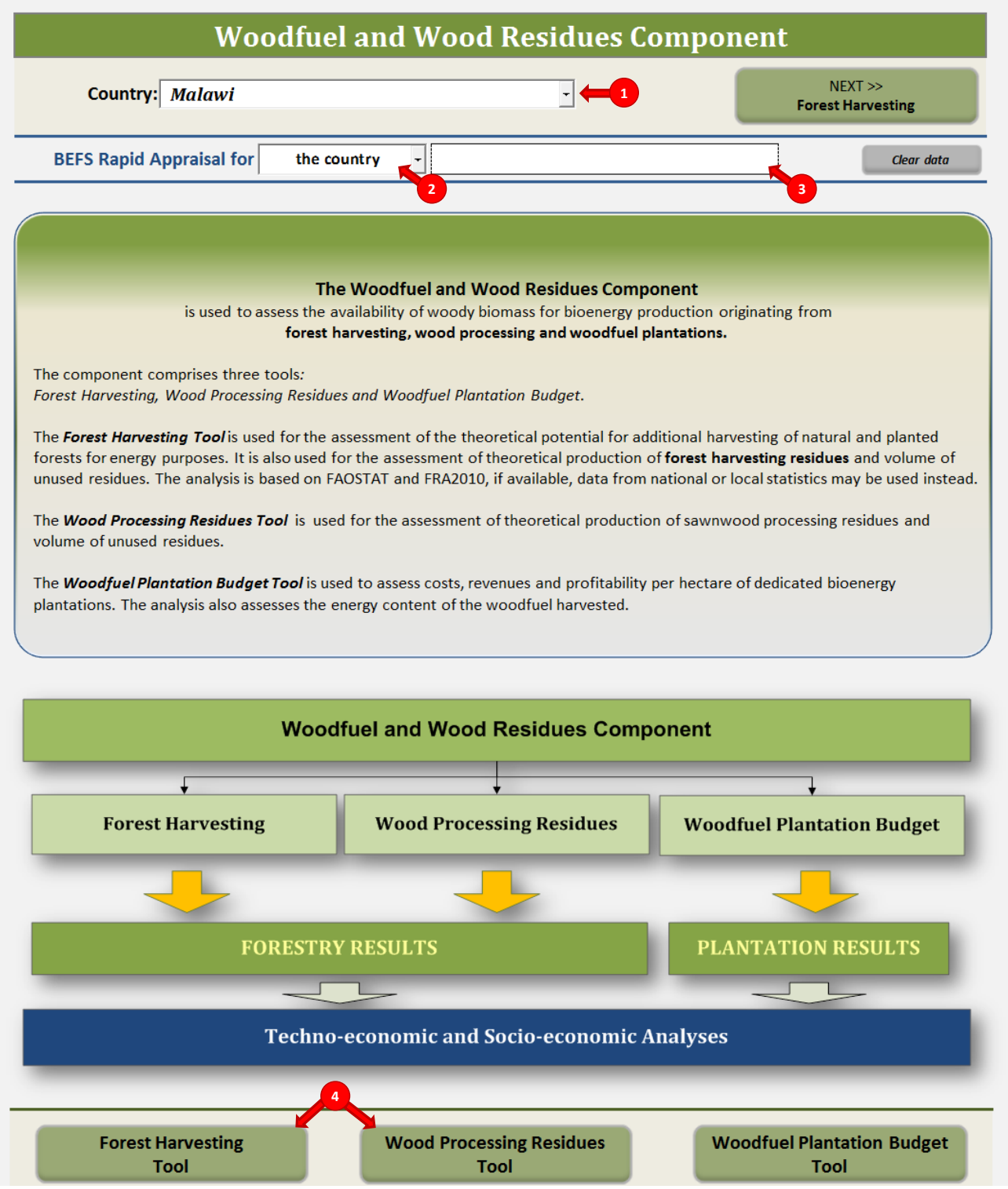


Figure 5: Layout of the *Woodfuel and Wood Residues Component* Introductory Sheet

4.2 *Forest Harvesting Tool*

4.2.1 Step 1: Additional forest harvesting

After selecting the *Forest Harvesting Tool*, the default data on trends in extent of forest area in the period 1990-2010 (FRA 2010) and annual roundwood removals for 1990, 2000 and the period 2003-2012 (FAOSTAT) are shown in the tables and graphs (Figure 6, labels 1 and 2). Suggestions about the possibility for additional forest harvesting for bioenergy and recommendations for further analysis are generated automatically and are based on the trends in the change of forest cover (Figure 6, label 3).

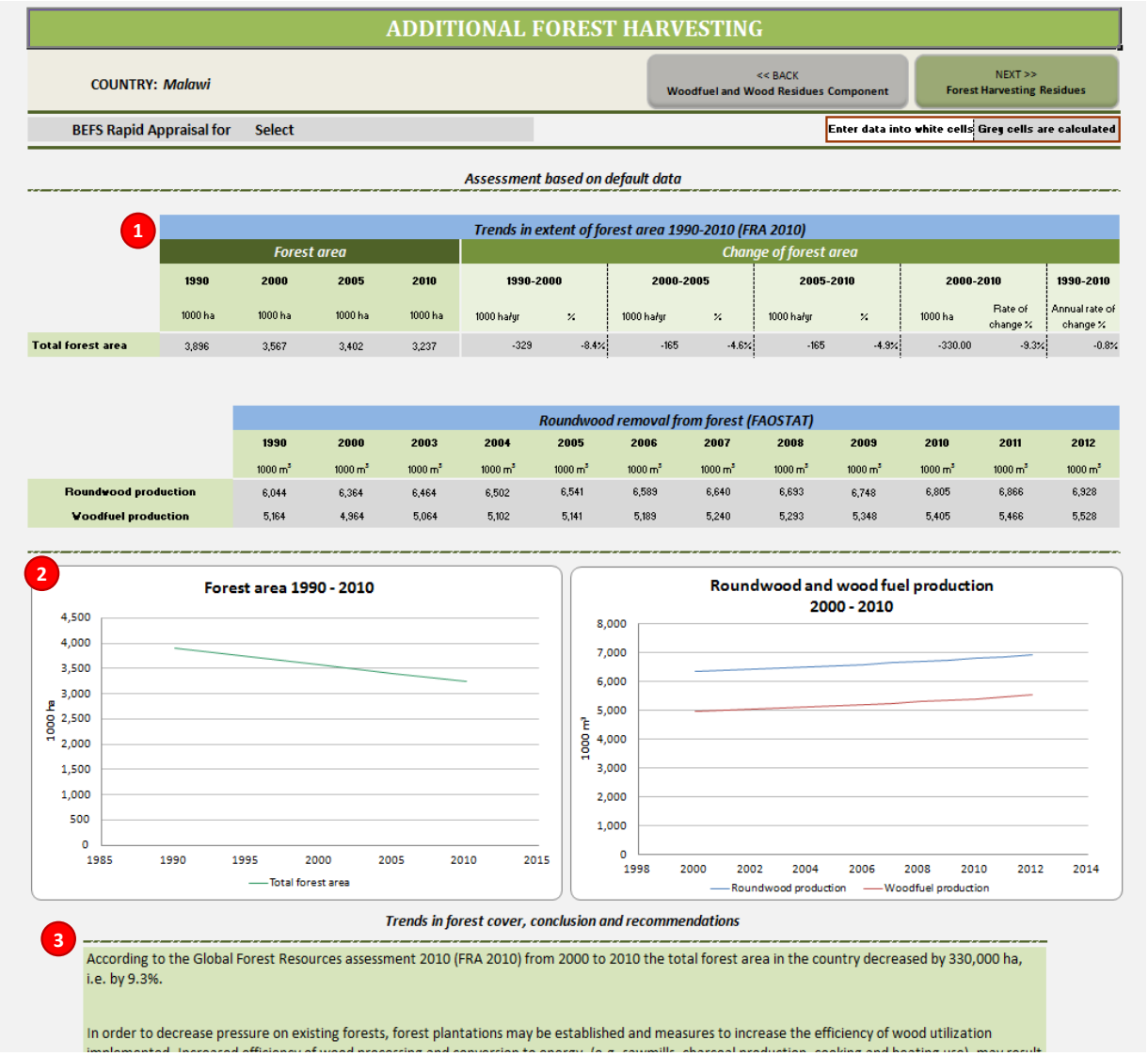


Figure 6: Layout of the *Forest Harvesting Tool* - Additional Forest Harvesting

4.2.2 Step 2: Forest harvesting residues

To assess the amount of forest harvesting residues available for bioenergy production, the user is asked to enter on the following data:

1. Annual production of industrial roundwood and woodfuel (Figure 7, label 1)
   - Year or period for the given data (e.g. 2012 or 2003-2012)
   - Annual production of coniferous and non-coniferous industrial roundwood (m^3/year)
   - Annual production of coniferous and non-coniferous woodfuel (m^3/year)

2. Rate of felling removal (Figure 7, label 2)
   - For coniferous and non-coniferous industrial roundwood (%)
   - For coniferous and non-coniferous woodfuel (%)
3. Predominant forest type in the country (area of analysis) and respective tree composition after felling (Figure 7, label 3). The tree composition should be defined according to:
   - Ratio of stem and crown, by entering data into the rows "Crown (%)" and "Stem+bark (%)" for coniferous and non-coniferous trees
   - Foliage and crown, by defining foliage to crown ratio (row "Foliage, % of crown") for coniferous and non-coniferous trees
   - Bark and stem, by defining ratio of bark to stem (row "Bark, % of stem") for coniferous and non-coniferous trees

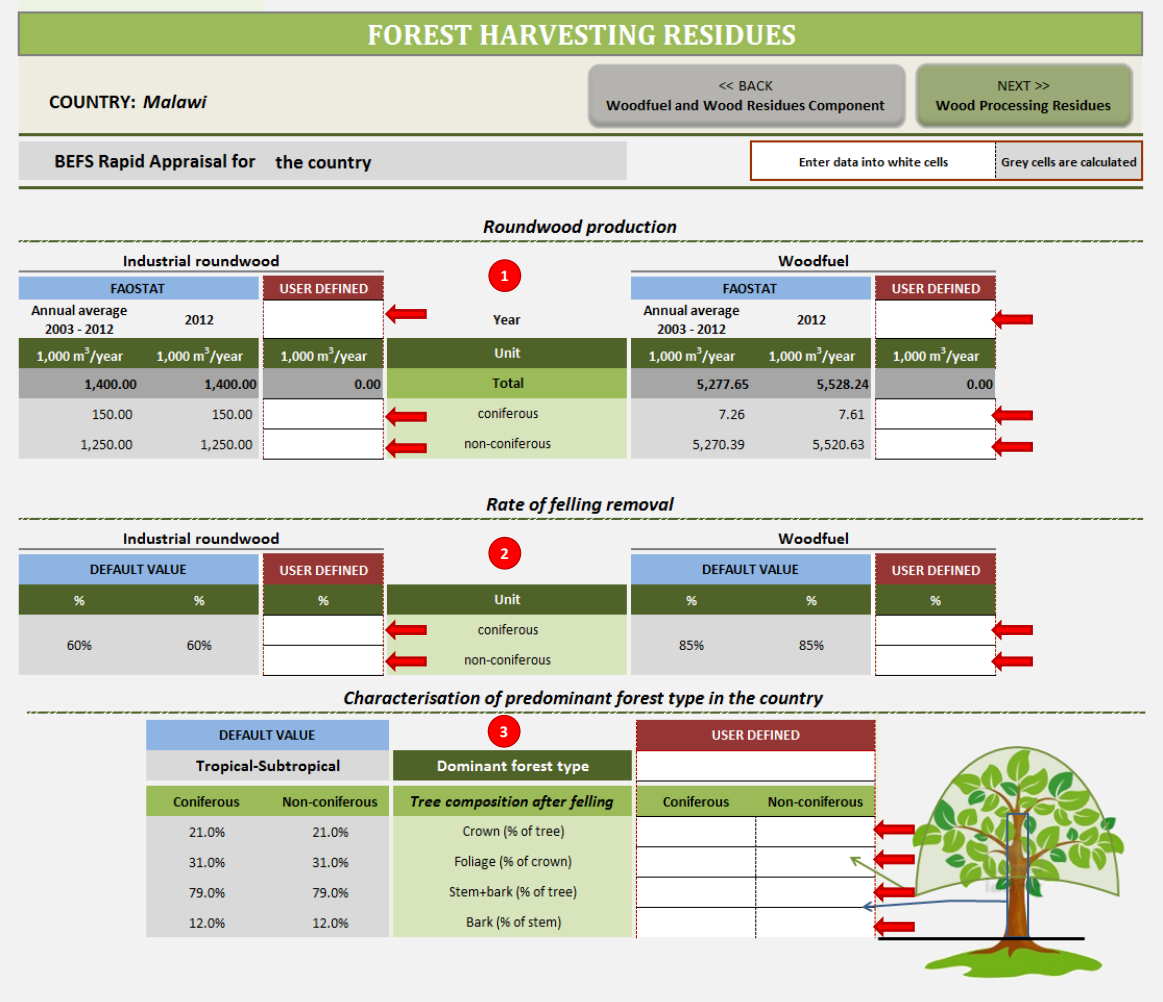


Figure 7: Layout of the Forest Harvesting Residues Sheet – Part 1

Based on the data provided, the amount of residues that arise from forest harvesting is calculated (Figure 8, label i). The calculation is based on the default values if the *user defined* values are not entered into the respective cells.

The residues are divided into three groups: branches and various cut-offs, foliage and bark. Bark is considered only in the case of industrial wood, because it is assumed that woodfuel is not debarked. Next the user has to input data on the:

1. Percentage of the harvesting residues that can be collected at a reasonable cost (Figure 8, label 4)

- The value provided should reflect the accessibility (taking into consideration infrastructure, morphology of terrain, etc.), practicality of collection (size of branches and cut-offs, etc.) and labour availability. If country specific data are not available and the respective cells are left empty, then the default values will be used in the calculations.

2. Percentage of forest harvesting residues that are collected and currently used. This value must be entered by the user (Figure 8, label 5).

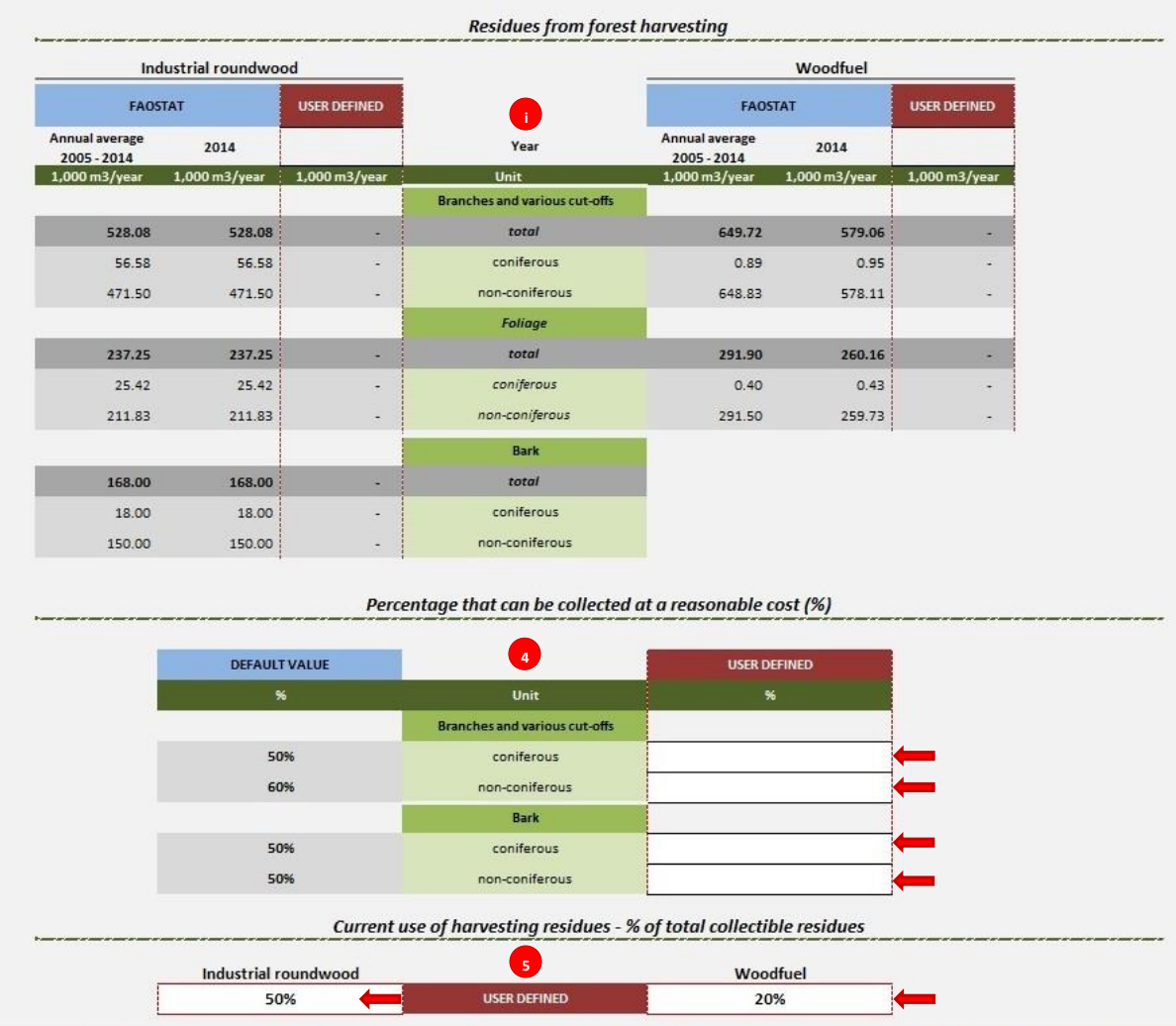


Figure 8: Layout of the Forest Harvesting Residues Sheet – Part 2

Based on the data provided, the amount of branches, various cut-offs and bark potentially available for bioenergy production is calculated by the tool (Figure 9, label ii). The calculation is based on the default values if the *user defined* values are not entered into the respective cells.

3. The user has to select the data source on roundwood production which will be used for calculating the final results (Figure 9, label 6)
   - Annual average 2003-2012 from FAOSTAT,
   - 2012 from FAOSTAT, or
   - User defined time period and respective roundwood production.
4. Finally, the user has to enter the average wood density for coniferous and non-coniferous species (t/m^3) (Figure 9, label 7). If the country specific values are not available, then default values are used.

   The harvesting residues potentially available for bioenergy production are expressed in volume (m^3) and amount (t) (Figure 9, label R).

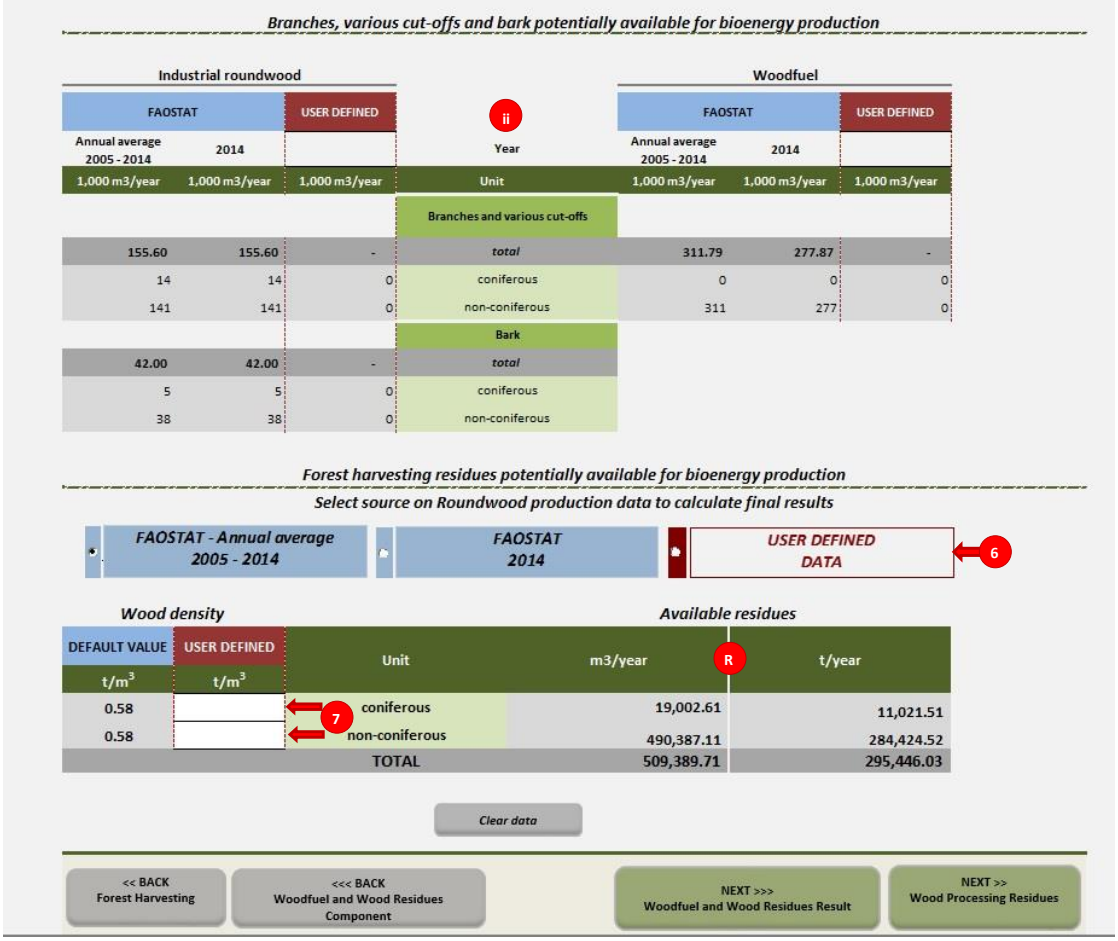


Figure 9: Layout of the Forest Harvesting Residues Sheet – Part 3

4.3 *Wood Processing Tool*

The analysis of the available wood processing residues is based on the sawnwood production in the country or the assessment area and the efficiency of production. Thus, the user should enter the data on:

1. Sawnwood production (Figure 10, label 1)
   - Year or period for the given data (e.g. 2012 or 2003-2012)
   - Annual volume of sawnwood production (m^3/year)
2. Average efficiency of sawmills in the country/area of analysis (recovery rate) (Figure 10, label 2)
   - Volume ratio of sawnwood produced and roundwood input (%)
   - Volume ratio of sawdust and roundwood input (%)
   - Volume ratio of slabs and chips and roundwood input (%)
   - Volume reduction due to shrinkage and other losses (%)

The annual volume (1000 m^3/year) of sawdust and slabs and chips from sawnwood production is calculated based on the provided information (Figure 10, label i). If the *user defined* cells are left empty, the default values are used automatically.

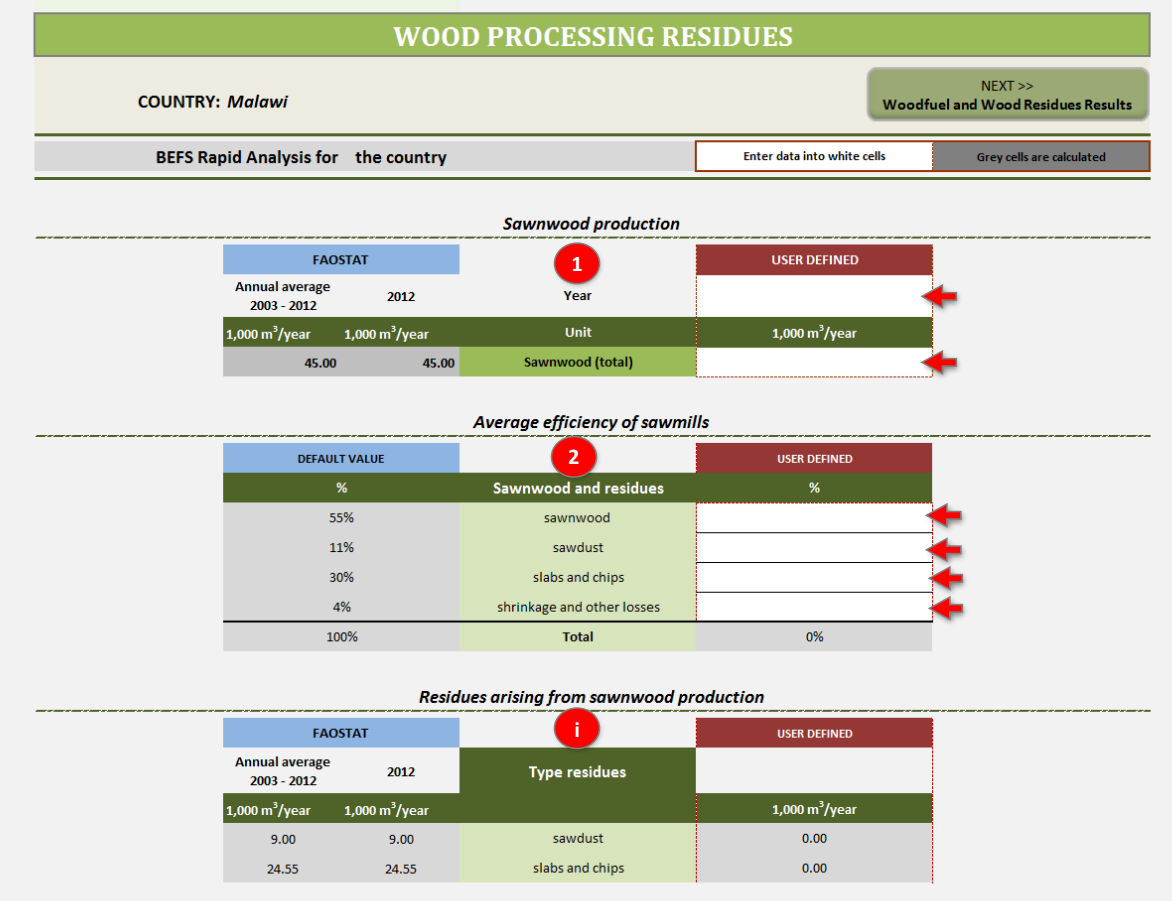


Figure 10: Layout of the *Wood Processing Residues Tool* – Part 1

3. Current use of residues (Figure 11, label 3)
   - The user is asked to enter the percentage of harvesting residues currently utilised for the production of other wood products, construction, energy and so on. This information is often not recorded in national statistics, but the user can estimate it based on sawmill surveys and reports.
4. Wood density for coniferous and non-coniferous species (t/m^3) (Figure 11, label 4)
   - If the country specific value is not entered, then a default value is used.
5. Finally, the user has to select the data source on sawnwood production for the final results (Figure 11, label 5):
   - Annual average 2003-2012 from FAOSTAT,
   - 2012 from FAOSTAT, or
   - User defined time period and respective sawnwood production.

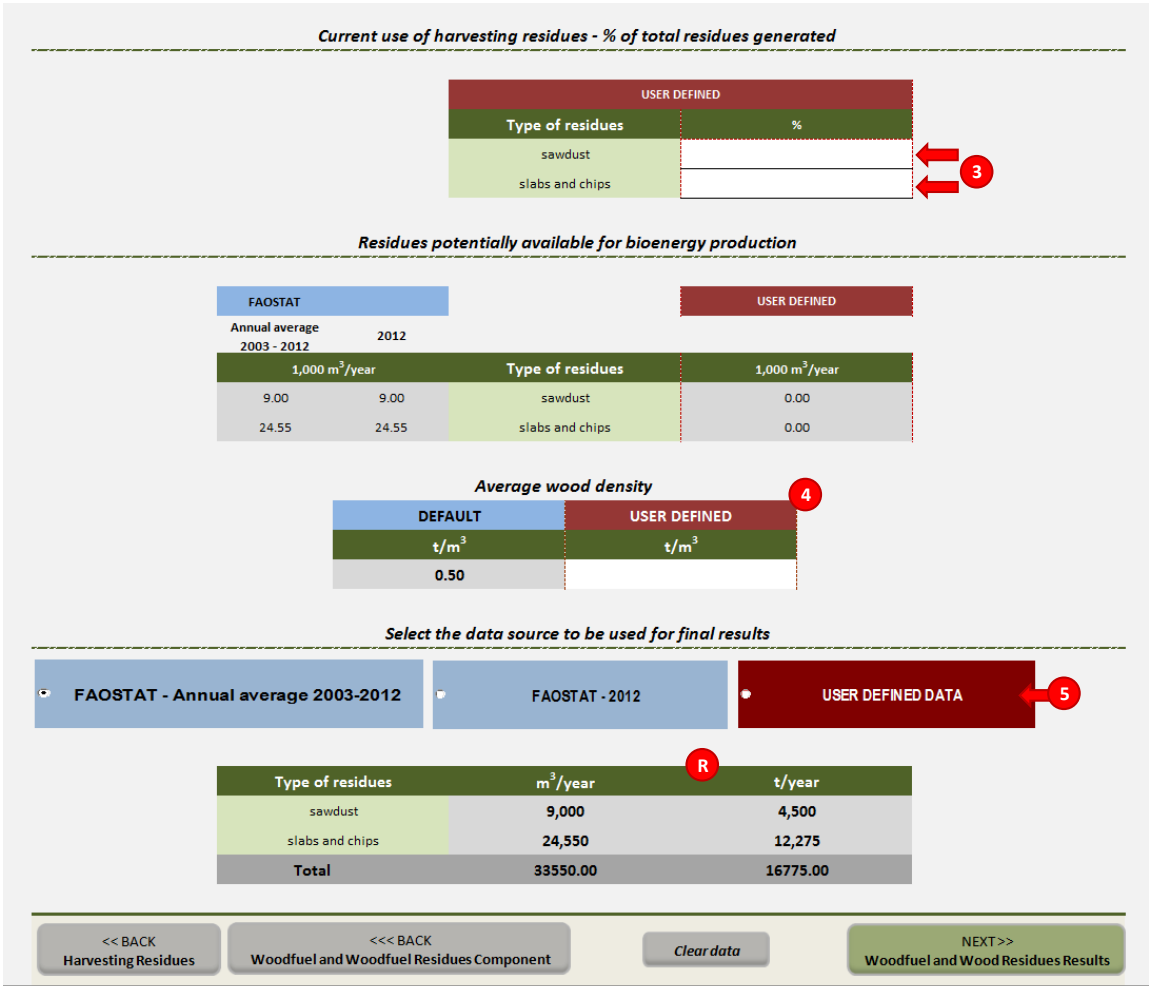


Figure 11: Layout of the *Wood Processing Residues Tool* - Part 2

5 Results from the *Forest Harvesting and Wood Processing Residues Tools*

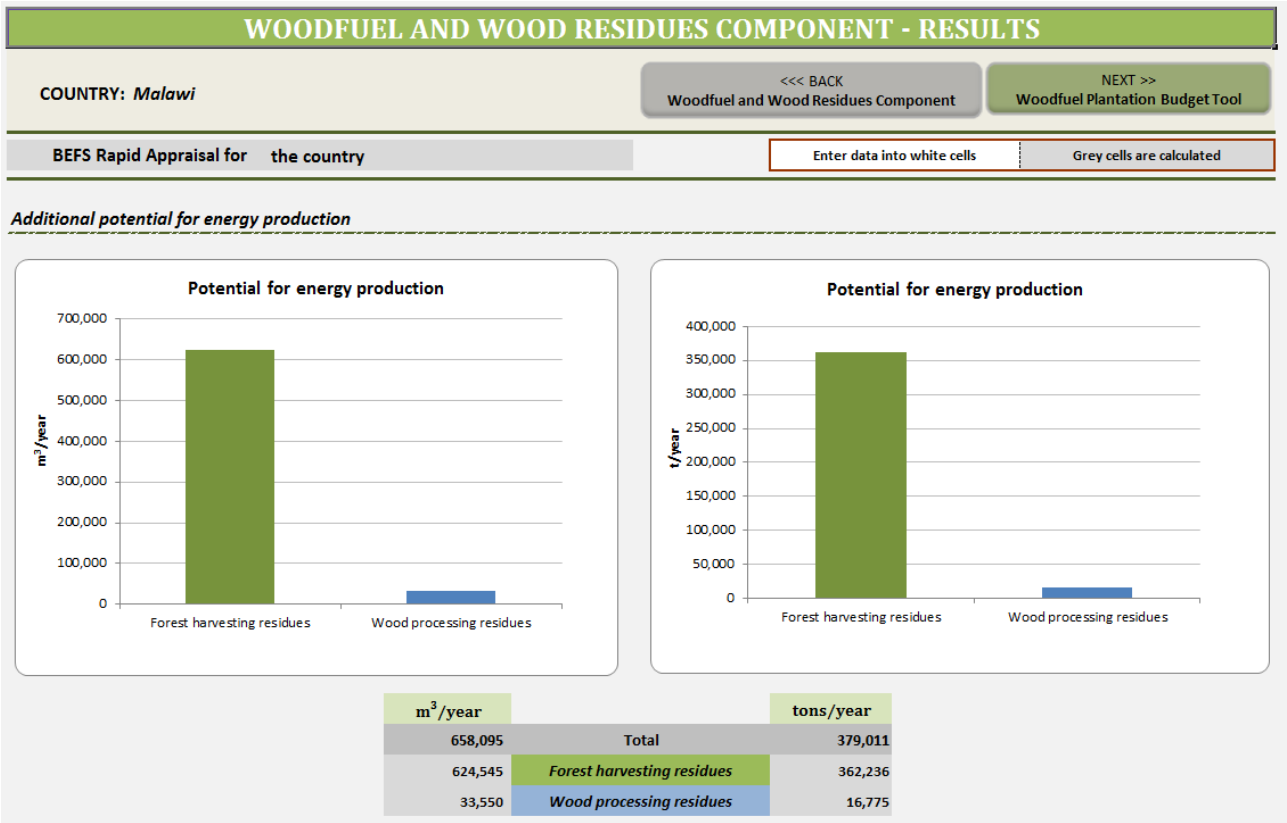
Upon finalizing the analysis, the results are summarized in the Woodfuel and Wood Residues Component Results sheet. The available forest harvesting residues and wood processing residues are expressed in tons and m^3 (Figure 12).

In this sheet, the user can allocate the amount of potentially available wood which could be used for heating and cooking and rural electrification.

The user is asked to enter (Figure 13):

1. Heating and Cooking
    a. the percentage of forest harvesting and wood processing residues that will be used for the production of briquettes
    b. the percentage of forest harvesting and wood processing residues that will be used for the production of pellets
    c. the percentage of forest harvesting and wood processing residues that will be used for the production of charcoal
2. Electricity and/or Heat
    a. the percentage of forest harvesting and wood processing residues that will be converted to electricity through combustion
    b. the percentage of forest harvesting and wood processing residues that will be converted to electricity through gasification
    c. the percentage of forest harvesting and wood processing residues that will be converted to electricity and heat through combined heat and power generation technology
3. Transport
    a. the percentage of forest harvesting and wood processing residues that will be used for the production of ethanol (second generation) for transport

The amount (t) allocated to each end use is then calculated and the results are presented numerically and graphically.



m³/year		tons/year
658,095	Total	379,011
624,545	*Forest harvesting residues*	362,236
33,550	*Wood processing residues*	16,775

Figure 12: Layout of the Woodfuel and Wood Residues Component Results Sheet – Part 1

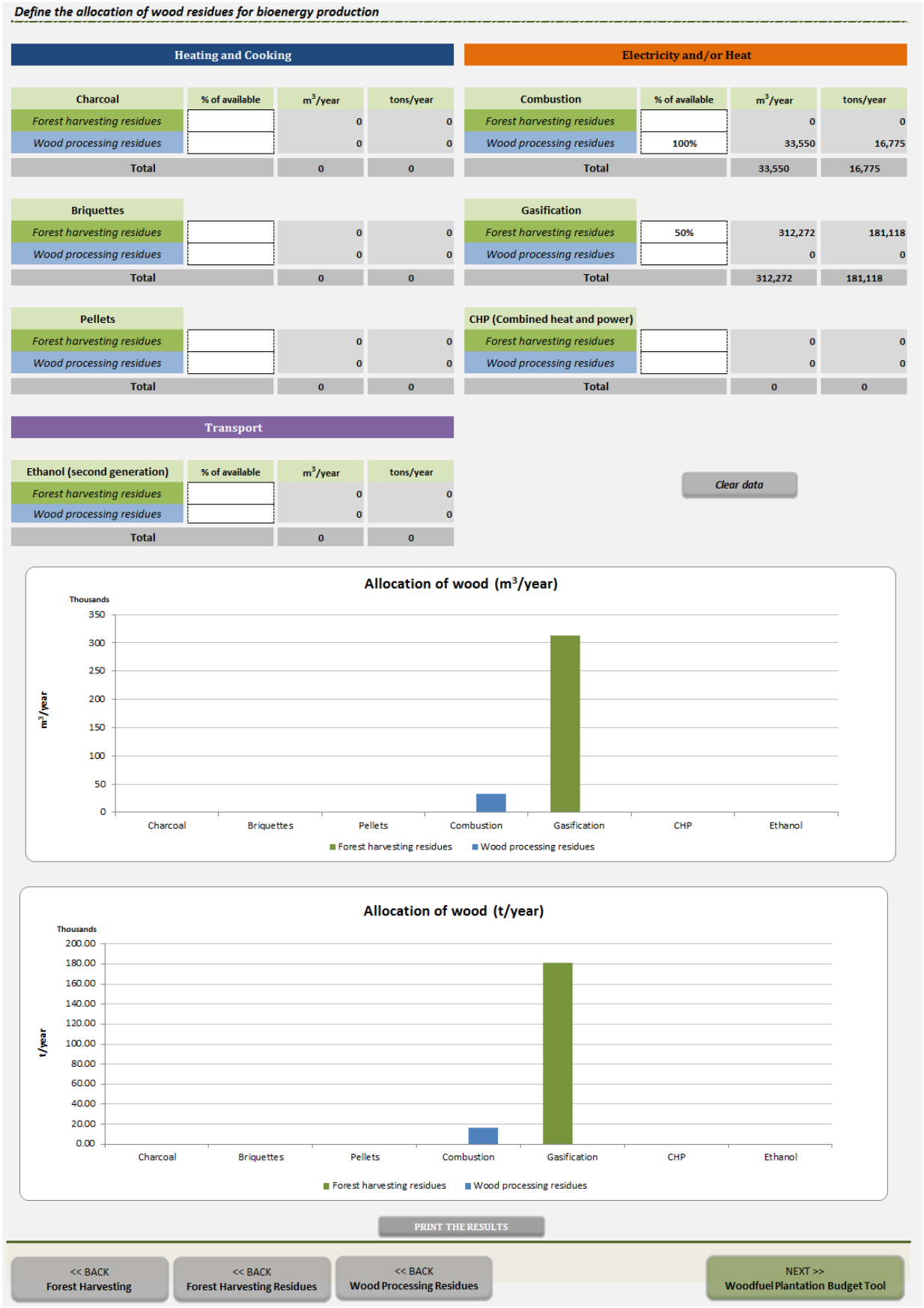


Figure 13: Layout of the Woodfuel and Wood Residues Component Results Sheet – Part 2

6 Assumptions and Limitations of the *Forest Harvesting and Wood Processing Residues Tools*

Before starting an analysis, the user should become familiar with the assumptions and limitations of the tools and take them into consideration during the analysis and most especially when interpreting the results. Apart from the limitations and assumptions, it is of utmost importance to be aware of the aim of the tool.

The aim of the BEFS Rapid Appraisal is to provide easily applicable and user-friendly tools that can support an analysis even when the user has limited access/availability to the data needed. Furthermore, the aim of the *Natural Resources* module of is to provide an indication of the potential for the production of bioenergy feedstock in a food-secure and sustainable way.

The limitations of the *Forest Harvesting and Wood Processing Residues Tools* are related with the aim and approach of analysis and the default values included in the tools:

1. The approach of the analysis – assessment of potentially available amounts for bioenergy production
   - The analysis focuses on the potentially available woody biomass, primarily the forest harvesting residues and wood processing residues. The analysis does not address the financial and logistical implications of resource mobilization in detail. For example, in the case of additional forest harvesting, there might be a theoretical potential for additional harvesting, but respective forests are not easily accessible (e.g. located in high mountains) and/or require specialized harvesting and logging equipment. Therefore, a more detailed and, if possible, spatially explicit analysis is required to assess technical and economic potential.
2. The FRA 2010 default values
   - The Global Forest Resources Assessment 2010 (FRA 2010) is the most comprehensive assessment of forests and forestry to date. It examines the current status and recent trends for about 90 variables covering the extent, condition, uses and values of forests and other wooded land, with the aim of assessing all benefits from forest resources. Information has been collated from 233 countries and territories for four points in time: 1990, 2000, 2005 and 2010.
   - The values on forest cover included in the BEFS RA tools are aggregated on the country level, thus not revealing the differences among forests, tree species and age composition, function, geomorphology and prevailing eco-climatological conditions of their location.
3. FAOSTAT data on roundwood and sawnwood production
   - FAOSTAT is a global database on the world agricultural statistics, managed by UN FAO. The statistical data stored in FAOSTAT originate from the respective countries, which send their data to the FAO Statistics Division. The FAOSTAT data integrated into the *Woodfuel and Wood Residues Component* refer to the whole country.
   - National forestry and wood production statistics often include more detailed data and should be consulted in order to obtain more accurate results.
4. The default values included in the tools
   - **Wood density:** Wood density is species-specific and changes with the moisture content of wood. In general, wood of coniferous species is less dense than that of non-coniferous species, and the density increases with the decrease of the moisture content of wood. Since the tools should be globally applicable, the default values represent global averages.
   - **Rate of felling removal:** The default values are based on a literature review, considering different forest management practices and forest types.

- **Efficiency of wood processing technologies:** The default values are based on a literature review.

An overview of the assumptions and limitations of the tool is given in the table below. They are also included as part of the methodology description.

Table 1: Overview of the Assumptions and Limitations

Assumptions	Limitations
- A decrease of the forest area over time may indicate unsustainable forest management. - Detailed and spatially defined analysis should be conducted to confirm the indicative results provided by the BEFS RA tool.	- The tool provides information about trends in forest cover and roundwood production on country level production, based on statistical data (FAO, 2012; FAOSTAT, 2013). - Only wood processing residues arising from sawnwood production are considered, i.e. the other wood processing industries are not included in the analysis. - The tool provides default values which are not country-specific, but are global averages obtained from a literature review.

7 Annex

7.1 Methodology and outputs

This section describes the methodologies used in the *Forest Harvesting* and *Wood Processing Residues Tools*. It also includes 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 tools.

7.1.1 *Forest Harvesting Tool* – Additional forest harvesting

The indication for the possibility of additional forest harvesting for energy is based on the following assumptions:

- A decrease of the forest area over time may indicate unsustainable forest management. It is necessary to conduct a detailed and spatially defined analysis to identify the reasons and drivers for deforestation and define areas where reforestation/afforestation measures are necessary.
- Increase in efficiency of wood utilization (both in wood processing industry and conversion to energy) can result in reduced demand for wood removals and consequently contribute to a more sustainable forest management.
- An increase in forest area over time may indicate a potential for additional forest harvesting for energy. In order to identify the location of forest bearing the potential and to quantify it, it is necessary to conduct a detailed and spatially explicit analysis.

7.1.2 *Forest Harvesting Tool* – Forest harvesting residues

The assessment is based on the assumptions that:

- After felling of industrial roundwood, stems and upper logs are debarked in the forest and then removed from forests. After felling of woodfuel, stems upper logs and large branches are removed from the forest (without debarking). In both cases foliage and stumps are left in the forest for soil fertility and biodiversity conservation. A certain amount of forest harvesting residues is already used. Only that part of the non-used residues which can be collected at a reasonable cost is available for bioenergy production.
- The total amount of residues is calculated based on the annual roundwood production and the rate of felling removals. The residues are classified as branches and various cut-offs, foliage and bark. Bark is calculated only in the case of industrial roundwood. The ratio of each class reflects representative tree composition (ratio of crown-stem, foliage-crown, bark-stem) in the predominant forest type in the area of analysis. Foliage is then excluded from further analysis. It is assumed that foliage will be left in the forests for soil fertility and biodiversity conservation, and therefore is not considered as a potential resource for energy production.
- The amount of branches and various cut-offs and bark available for bioenergy is calculated by subtracting the total amount by the portion already used.

The total amount of harvesting residues is calculated as:

$$TR = TR_{IRW} + TR_{WF} = \left(\frac{IRW}{R_{irw}} - IRW\right) + \left(\frac{WF}{R_{wf}} - WF\right) \quad (1)$$

Where:

TR, [m^3/year] = total amount of residues per year
IRW, [m^3/year] = industrial roundwood production per year
WF, [m^3/year] = woodfuel production per year
R_{irw} = rate of industrial roundwood felling removal
R_{wf} = rate of woodfuel felling removal

The foliage is calculated as:

a) for industrial roundwood

$$fol_{IRW} = (TR_{IRW} - b * IRW) * f \quad (2)$$

b) for woodfuel

$$fol_{WF} = TR_{WF} * f \quad (3)$$

Where:

fol, [m^3/year] = amount of foliage from harvesting of industrial roundwood and woodfuel
fol_{IRW}, [m^3/year] = foliage arising from harvesting of industrial roundwood
fol_{WF}, [m^3/year] = foliage arising from harvesting woodfuel
f, [%] = foliage: crown ratio
b, [%] = bark: stem ratio

The branches and various cut-offs are calculated as:

a) for industrial roundwood

$$BC_{IRW} = (TR_{IRW} - b * IRW) - fol_{IRW} \quad (4)$$

b) for woodfuel

$$BC_{WF} = TR_{WF} - fol_{WF} \quad (5)$$

Where:

BC_{IRW}, [m³/year] = branches and various cut-offs arising from harvesting of industrial roundwood
BC_{WF}, [m³/year] = branches and various cut-offs arising from harvesting of woodfuel
$B_{IRW} = b * IRW$, [m³/year] = bark arising from harvesting of industrial roundwood
fol_{WF}, [m³/year] = foliage arising from harvesting woodfuel
f, [%] = foliage: crown ratio
b, [%] = bark: stem ratio

The amount of forest harvesting residues available is calculated as:

a) for industrial roundwood

$$FHR_{IRW} = (BC_{IRW} + B_{IRW}) * coll_{IRW} * (100\% - FHR_{IRW_u}) \quad (4)$$

b) for woodfuel

$$FHR_{WF} = (BC_{WF} - FHR_{WFu}) * coll_{WF} * (100\% - FHR_{WF_u}) \quad (5)$$

Where:

FHR_{IRW},[m³/year] = residues available arising from industrial roundwood harvesting
FHR_{WF},[m³/year] = residues available arising from woodfuel harvesting
FHR_{IRWu},[%] = currently used residues arising from industrial roundwood harvesting
FHR_{WFu},[%] = currently used residues arising from woodfuel harvesting
$coll_{IRW}$,[%] = collectability rate for industrial roundwood harvesting residues
$coll_{WF}$,[%] = collectability rate for woodfuel harvesting residues

7.1.3 *Wood Processing Residues Tool*

The calculation of the available wood processing residues is based on the annual sawnwood production, average efficiency of sawmills in the country and the portion of residues already used.

First, the roundwood used for sawnwood production is calculated and based on the average recovery rate of sawmills (sawnwood output: roundwood input ratio). Then, by applying the output:input ratio, the volumes of sawdust and slabs and chips arising during sawnwood production are determined. By subtracting the portion currently used, the amounts of sawdust and slabs and chips potentially available for bioenergy are determined.

The roundwood used for sawnwood is calculated as:

$$IWR_{sw} = \frac{SW}{r_{sw}} \quad (1)$$

The total amount of wood processing residues is calculated as:

$$WPR_{tot} = sd + sc = (r_{sd} * IWR_{SW}) + (r_{sc} * IWR_{SW}) \quad (2)$$

Where:

$IWR_{SW,}$ [t/year] = roundwood used for sawnwood production
$r_{sw,}$ [%] = sawnwood: roundwood ratio (sawmills recovery rate)
SW, [m³/year] = annual sawnwood production

r_{sd}, [%] = sawndust: roundwood ratio
r_{sc}, [%] = slabs and chips: roundwood ratio

The amount of wood processing residues still available:

$$WPR_{be} = sd_{be} \mp sc_{be} \quad (3)$$

a) for sawdust

$$sd_{be} = sd - sd_u \quad (4)$$

b) for slabs and chips

$$sc_{be} = sc - sc_u \quad (5)$$

Where:

WPR_{be},[m^3/year] = the amount of wood processing residues available for bioenergy
sd_u, [m^3/year] = sawndust currently used
sc_u, [m^3/year] = slabs and chips currently used
sd_{be}, [m^3/year] = sawndust available for bioenergy
sc_{be}, [m^3/year] = slabs and chips available for bioenergy

7.1.4 Databases

The databases incorporated into the tool support the analyses in the *Woodfuel and Wood Residues Component*. In cases when country-specific data are not available, the data provided by the tool can be used for the analysis. The databases include:

1. **FAOSTAT production of roundwood and sawnwood**
   - **FAOSTAT_FHR -** includes the following FAOSTAT data
     - Items: Industrial roundwood (C) + (Total), Industrial roundwood (NC) + (Total), Wood Fuel(C) and Wood Fuel(NC)
     - Countries: all
     - Years: 2003 - 2012
   - **FAOSTAT_WHR -** includes the following FAOSTAT data
     - Items: Roundwood + (Total), Wood Fuel + (Total)
     - Countries: all
     - Years: 2003 – 2012
   - **FRA2010table3 -** Includes data on the extent of forest area, as reported for FRA 2010. Source: FRA 2010.
2. **Country:** includes basic information on countries.

7.2 Data requirements for running the tool

1. Forest harvesting and harvesting residues (BEFS RA tool: Forest Harvesting)

Data required | **Instructions and explanatory notes**

1.1 Roundwood production

Year/ Time period	
Unit	1,000 m^3
Total roundwood[1]	
Industrial roundwood[2]	
Woodfuel[3]	

Source: _____

Table content:

Annual/average annual total roundwood, industrial roundwood and woodfuel production in the assessment area expressed in 1,000 m^3.

Notes:

[1] *Total roundwood* includes both industrial roundwood and woodfuel, i.e. it is a sum of production of industrial roundwood and woodfuel.

[2] *Industrial roundwood* refers to the wood used for production of goods and services other than energy production.

[3] *Woodfuel production* refers to the wood removed for energy production purposes, regardless whether for industrial, commercial or household use.

1.2 Rate of felling removal

Industrial roundwood		
coniferous	%	
non-coniferous	%	

Woodfuel		
coniferous	%	
non-coniferous	%	

Source: _____

Table content:

The rate of felling removal from the forest, i.e. percentage of the wood that is removed from the forest after the felling. The data should be provided for industrial roundwood and woodfuel, for coniferous and non-coniferous species. If the rate of felling removal is the same, it should be repeated.

1.3 Wood density

average	t/m^3	
coniferous	t/m^3	
non-coniferous	t/m^3	

Source: _____

Table content:

Density of predominant coniferous and non-coniferous wood at the moisture content of 15%, expressed in t/m^3. If the information for coniferous and non-coniferous species is not available, average value can be used.

1.4 Tree composition (above stump) for the dominant forest type

Crown[1] (% of above stump tree)	
Foliage[2] (% of crown)	
Stem+bark[3] (% of above stump tree)	
Bark[4] (% of stem)	

Table content:

Tree composition in the dominant forest type harvested.

Notes:

[1] Crown (% of above stump tree) = ratio of the crown (branches, upper logs and foliage) to the felled tree. The sum of crown and stem should make 100%.

[2] Foliage (% of crown) = ratio of the foliage (leaves) and the crown.

[3] Stem+bark (% of above stump tree) = ratio of the overbark stem to the felled tree. The sum of crown and stem should make 100%.

[4] Bark (% of stem) = ratio of bark and stem.

Current use of harvesting residues		
Industrial roundwood	%	
Woodfuel	%	

Source: _____

Table content:

The percentage of the harvesting residues which is collected already used. The information for both industrial roundwood and woodfuel harvesting residues should be collected. The percentage should include officially recored removals and estimated unrecorded removals.

1.5 Share of residues that can be collected at a reasonable price

Branches and various cut-offs		
coniferous	%	
non-coniferous	%	

Bark		
coniferous	%	
non-coniferous	%	

Source: _____

Table content:

The percentage of harvesting residues that can be collected at a reasonable price.

Notes:

When determining the percentage of collectable residues, accessability, labour cost, logistics (transportation infrastracture) should be taken into account.

2. Wood processing residues (BEFS RA tool: Wood processing residues)

Data required

Instructions and explanatory notes:

2.1 Sawnwood production in the country (area of analysis)

Year / average for years:	
Unit	1,000 m^3/year
Total sawnwood produced	

Source: _____

Table content:
Annual production of sawnwood, expressed in 1,000 m^3 per year.

Indicate whether the data refer to the annual average of a certnain period, e.g. annual average 2003-2013, or to a single year, e.g. 2013.

2.2 Average efficiency of sawmills in the country (area of analysis)

Ratio of sawmill outputs and roundwood input

Product and residue types	%
sawnwood [1] (recovery rate)	
sawdust[2]	
slabs and chips[3]	
shrinkage and other losses[4]	

Source: _____

Table content:
The ratio of sawmilling outputs and roundwood inputs.
[1] Volume of sawnwood as a percentage of roundwood volume.
[2] Volume of sawdust as a percentage of roundwood volume.
[3] Volume of slabs and chips as a percentage of roundwood volume.
[4] Difference in volume of sawnwood and residues and the roundwood, expressed as a percentage of roundwood volume .

2.3 Current use of wood processing residues

Current use of wood processing residues		
sawdust	%	
slabs and chips	%	

Current use of wood processing residues		
sawdust	t/year	
slabs and chips	t/year	

Source: _____

Tables content:
Percentage of the total sawdust, slabs and chips that is currently used.
Amount of sawdust, slabs and chips currently used.
Notes:
If the data about the amount of residues used for production of different wood products and/or for heating and cooking, is avaiable in these should be noted. The respective ratio to the total residues will be calculated during the BEFS RA analysis.
In case there is no offical data on the use of residue, the estimations (% or amount) can be done through survey and/or consultation with wood processing industry in the country/area of analysis.

Information regarding use within the tool:
The tool includes defult values, but note that those represent a global average, based on the data collected from different countries and thus may only be marginally applicable for your country.

8 References

FAO (2010). FAOSTAT - Joint Forest Sector Questionnaire. FAO, Rome, Italy. Available at http://faostat.fao.org/Portals/_Faostat/documents/pdf/FAOSTAT-Forestry-def-e.pdf.

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