USER MANUAL: NAMIBIA BUSH BIOMASS QUANTIFICATION TOOL

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N-BiG
Namibia Biomass industry Group

Beyond Bush
De-bushing Advisory Service

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1. Background

Bush control for rangeland restoration, with or without engaging in the wood value chain for a supplementary income or the use of bush for a drought survival feed, is increasingly practiced in Namibia. This has resulted in an increase in the wood and wood product industry in Namibia.

To assist landowners and improve the sustainability of the biomass industry, the De-bushing Advisory Services (DAS) initiated the development of a user-friendly standard model for estimating bush biomass in Namibia. The initiative was funded by the Bush Control and Biomass Utlisation project implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in close cooperation with the Ministry of Environment, Forestry and Tourism (MEFT). It was conducted by rangeland experts, Mr. Jerome Boys of the Namibian Ministry of Agriculture, Water and Land Reform (MAWLR) and Professor Nico Smit of the University of Free State in South Africa. Its core aim was to develop an excel based model on three commonly harvested woody species *(Terminalia sericea, Senegalia mellifera, Vachellia reficiens)*. This base model will have the ability to be expanded over time with the addition of regression equations for other species should the need arise.

1.1. The model

The "Namibia Bush Biomass Quantification Tool" provides the user with five (5) different field data collection options associated with different accuracy levels of the predictions, as well as different parameters that can be calculated. With the required field data, the model can estimate the following:

- ETTE / ha (total and on a species basis),
- TE / ha (total and on a species basis),
- Plants / ha (total and on a species basis),
- Wood biomass (kg DM/ha, total and on a species basis),

- Wood biomass obtainable from thinning to a specified density (kg DM/ha),
- Total bush feed biomass (kg DM/ha, total and on a species basis),
- Bush feed biomass obtainable from thinning to a specified density (kg DM/ha),
- Bush feed fluctuation over months/seasons (kg DM/ha) or (kg fresh material/ha),
- Land area (ha) needed to harvest a certain quantity of wood, and
- The TE's or ETTE's to be removed when thinning the land to a predetermined density (TE / ha or ETTE / ha).

The calculated Evapotranspiration Tree Equivalents (ETTE)[1] and/or Tree Equivalents (TE)[2] as indicators of bush density can be used as selective bush thinning guidelines.

This user manual will equip the user (rangeland manager/farmer or harvester) with the basic information needed to use the model and also explain how to do the appropriate field data collection.

1 Leaf volume equivalent to a 1.5m single stemmed woody plant (volume = 500cm^3)
2 The equivalent of a 1.5m single stemmed woody plant

2. The Namibia Bush Biomass Quantification Tool

The user is introduced to three (3) interfaces namely:

1. **General information,**
   - ▷ General information entry
   - ▷ Belt transect dimension entry (compulsory)
   - ▷ Options for field data collection and the selection thereof for data entry
2. **Data input, and**
   - ▷ Species and plant dimension measurement(s) input after field data collection
3. **Results/report.**
   - ▷ Results that are generated from all the inputs.

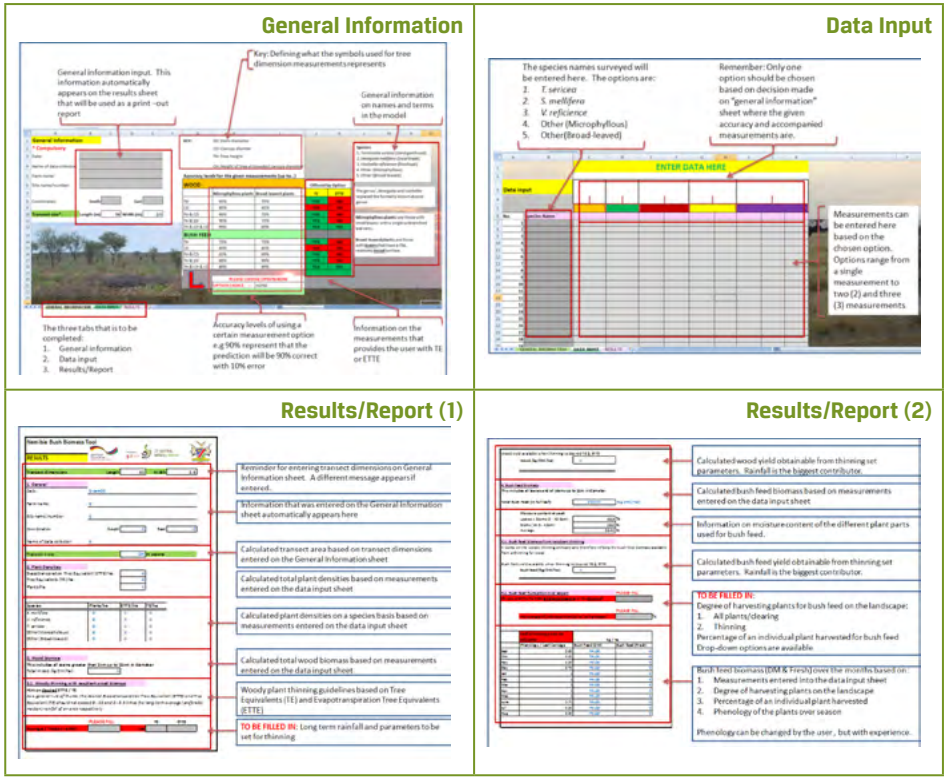


Figure 2.1: Overview of the model with its different interfaces. More detail is available in the booklet.

3. The use of the model

3.1. Before field work

3.1.1. Selecting an option

While the user familiarises him/herself with the model (section 2), the selection of a specific option can be decided upon based on the objection of the user's application: The user selected option include the following:

- The required field survey measurement(s),
- The required accuracy level (%) based on the selected measurement(s) option, and
- Whether TE and/or ETTE need to be calculated.

The wood, bush feed and plants/ha can be estimated by the model from any option. Figure 3.1 provides detail on data collection options.

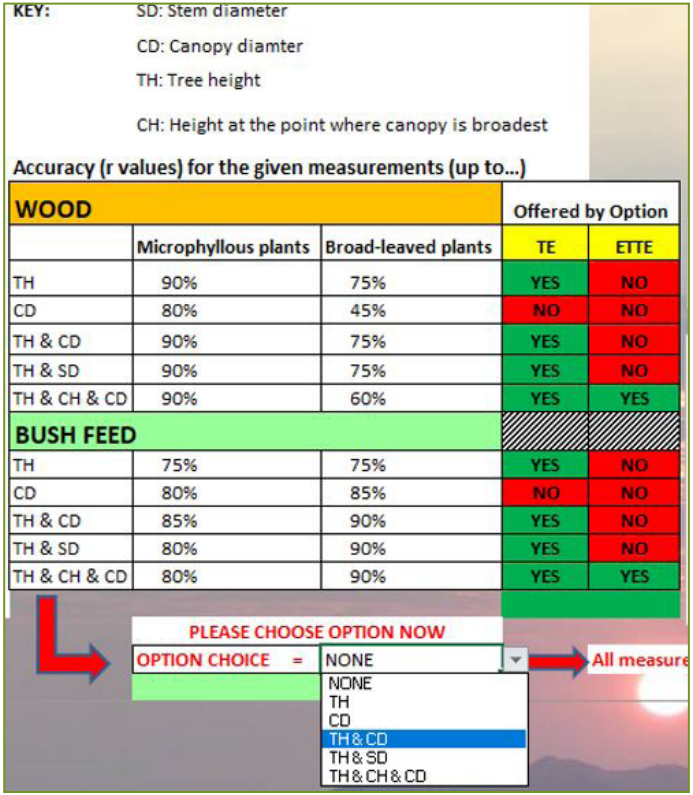


Figure 3.1: Selecting the measurement option for field data collection.

Example:

1. Veld type to be surveyed is Thornbush veld. This means that the dominant plants will be microphyllous[3] and not broad-leaved[4] plants.
2. Tree height (TH) is the most comfortable measurement of trees and the user is satisfied with the prediction accuracy and plant data available from this measurement only (TE and plants/ha on a species basis)

With these options selected:

The user will have an accuracy of 90% and 75% for predicted wood (kg/ha) for the microphylous and broad-leaved plants, respectively. The bush feed (kg/ha) will have a predicted accuracy of 75% for both microphylous and broad-leaved plants. The user will also have TE/ha calculated, which can be used in the selective thinning guidelines when harvesting.

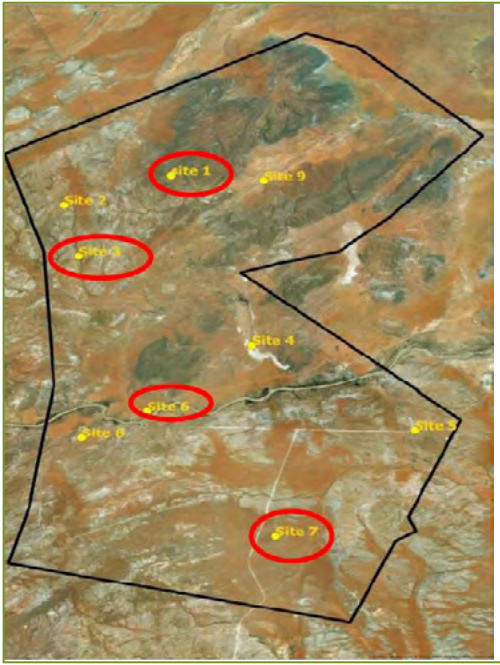
The model provides the option for estimating plants/ha only, for mature plants or saplings when only plant names are entered in the species list on the data input tab without any measurements entered.

3 Are those with small leaves with a single un-branched leaf vein.
4 are those with leaves that have a flat, relatively broad surface.

3.1.2. Selection of survey sites

Figure 3.2 (a & b) illustrates examples on the (a) number and (b) strategic placing of sites that are representative of the larger population.

Figure 3.2a: Example of the minimum number and correct placement of survey sites to ensure representativeness of the larger population for these two specific camps.



There are nine (9) representative sites on this farm covering all geological areas with the resultant differences in vegetation types.

Depending on the user, a certain number of sites can be selected from these, but still in such a way that the entire farm is represented. Depending on the geology and vegetation of the farm, minimum of four (4) sites is recommended.

If the user decides on four (4) sites, the red circles would be the sites that best represents the farm

Figure 3.2b: Example of the minimum number and correct placement of survey sites to ensure adequate representation of the larger plant population on farm level.

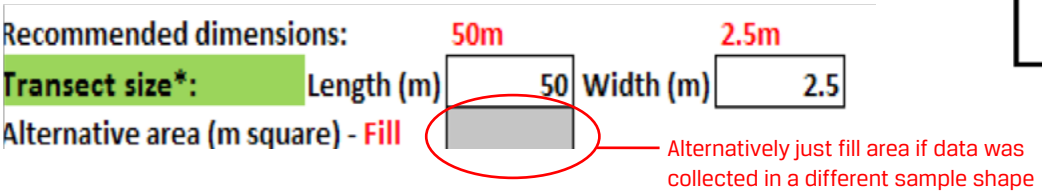
The selection of representative survey sites should preferably be done before going out to the field for data collection. Various resources such as Google earth, Google maps, GIS packages, drone images etc. can be used to identify sites that are representative of the area to be sampled. If the user does not have access to these resources, the user will have to select sites in the field that are visually representative of the larger population.

The selection and number of survey sites depends solely on the homogeneity and heterogeneity of the bigger landscape area. The more heterogeneous the area, the more survey sites need to be strategically placed for adequate representation and a more accurate estimation of the biomass of that area.

3.2. Conducting the data collection

3.2.1. Setting up a transect

Section 3.1.2 dealt with the procedure to select survey sites that are representative of the larger population. At each specific identified survey site, a standard belt transect of at least 50 x 2.5 m (125 m^2) should be laid out in such a way as to best represent the woody vegetation of that site. In cases where the woody plants are patchy or the area is not very homogeneous, the length of the belt transect can be increased to either 75 m or 100 m to obtain a more accurate sampling of the vegetation. Figure 3.3 illustrates belts transects with the possibility of adjusting the transect size. The prescribed length and width is available, but other option can be selected. An alternative option for entering the area is also available, but the area should be known.



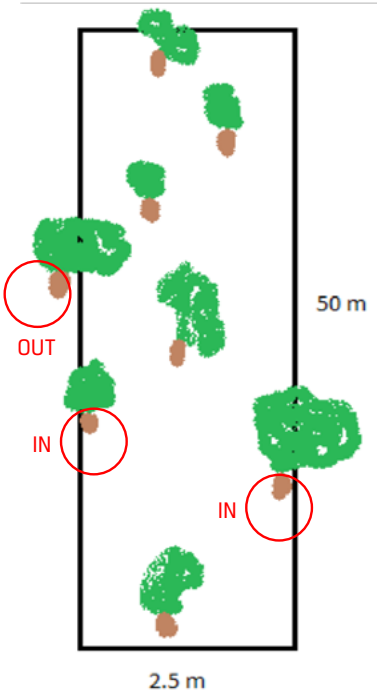


Figure 3.3: An example of a belt transect (50-100 x 2.5 m) demarcated by a tape measure and 2.5 m measuring pole. The diagram on the right illustrates the plants to be counted as "in" when doing a survey.

3.2.2. Survey measurements

The dimensions of all rooted, live woody plants (trees and shrubs) >0.5 m in height must be measured (Figure 3.3) at each survey site within the belt transects. The different measurement options with their measurements are illustrated in Figures 3.4 -3.6. The equipment needed for a field data collection survey is:

- Measuring tape / rope of a reasonable length for marking the belt transect if belt transect will be used or pins / corner marking objects if some other form of sampling area is used,
- Measuring pole / dumpy level measuring bar for measuring the tree dimensions,
- GPS / phone that is able to locate the coordinates where the data collection is done, and
- Data collection sheet with pen / pencil.

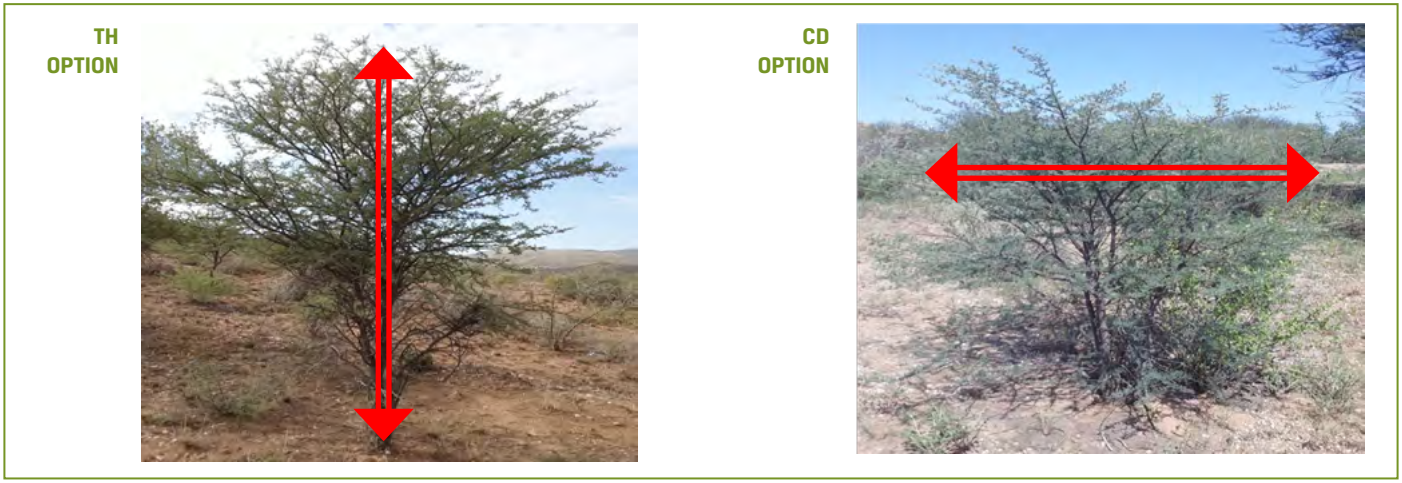
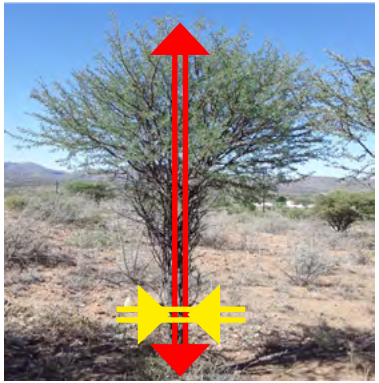


Figure 3.4: Measurement illustrations for the TH (left) and CD measurements during a survey.

TH & SD OPTION



TH & CD OPTION

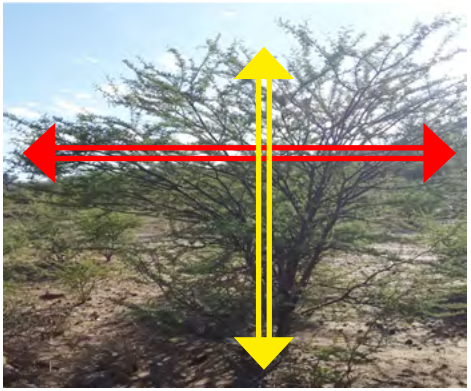
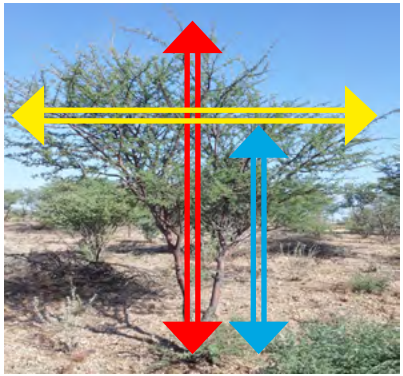


Figure 3.5: Measurement illustrations for the TH & SD (left) and TH & CD measurements during a survey.

TH & CH & CD OPTION



Output Required	Option on Model	Required measurements
Wood	All options	Any
Bush feed	All options	Any
Plants / ha	All options	Any
TE	TH, TH&CD, TH&SD, TH&CH&CD	TH
ETTE	TH&CH&CD	TH, CH, CD

Figure 3.6: Measurement illustrations for the TH & CD & CH (left) and CD measurements during a survey.

The measurements should be done in meters (m). Stem measurements should also be done in meters and only one average reading should be recorded if the plant is multi-stemmed. The exclusion of plants <0.5m in height does not prevent the user from counting them on a species basis and entering them into the model without measurements for a total calculated plants/ha on a species basis, which will add to the usefulness to the survey. Some important aspects to consider when doing the survey are:

- Avoid setting up a transect that includes a large tree which is not representative of the larger population
- Avoid measuring a large tree(s) in a transect that is not representative of the population and knowing that they will not be harvested

Large trees and/or protected species can be counted and entered in the model without their measurements for species composition only.

3.3. Data processing

3.3.1. Data entry into the model

General information tab

The transect dimensions (width and length) is very important on the general information entry as no data can be extrapolated without a transect area. The measurement option is also important as the data entry tab will not be active if no measurement option was selected.

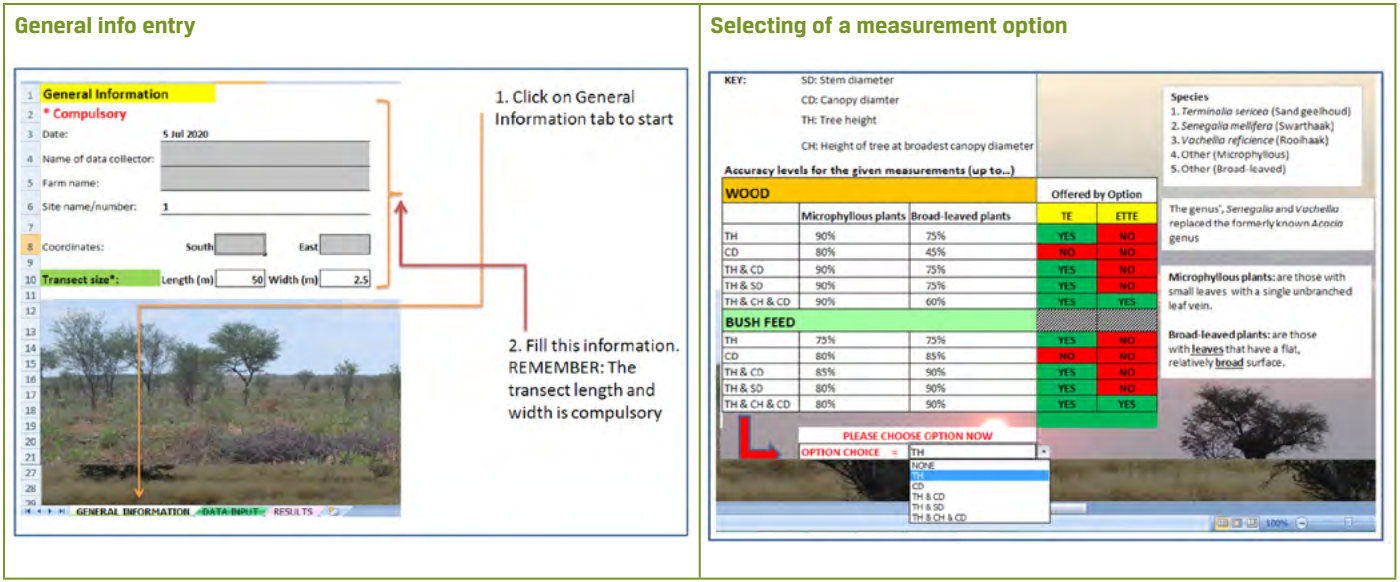


Figure 3.7: General information entry area (left) and tree dimension measurement options with their resultant accuracies, the option of TE and/or ETTE and the drop-down option to choose the selected option from (right).

Data input tab

All collected data from the field survey is entered here. The species names are available from a drop-down list. New species can be added to the tree list. It will appear on the drop-down list once added to the tree list. It is important to choose the code correctly next to the added species for the correct regression equation to the allocated to the species.

The code selection is:

- Microphyllous species = Code 1
- Broad-leaved species = Code 2

If a species is not known then either "Other (Microphyllous)" or "Other (Broad-leaved)" can be selected.

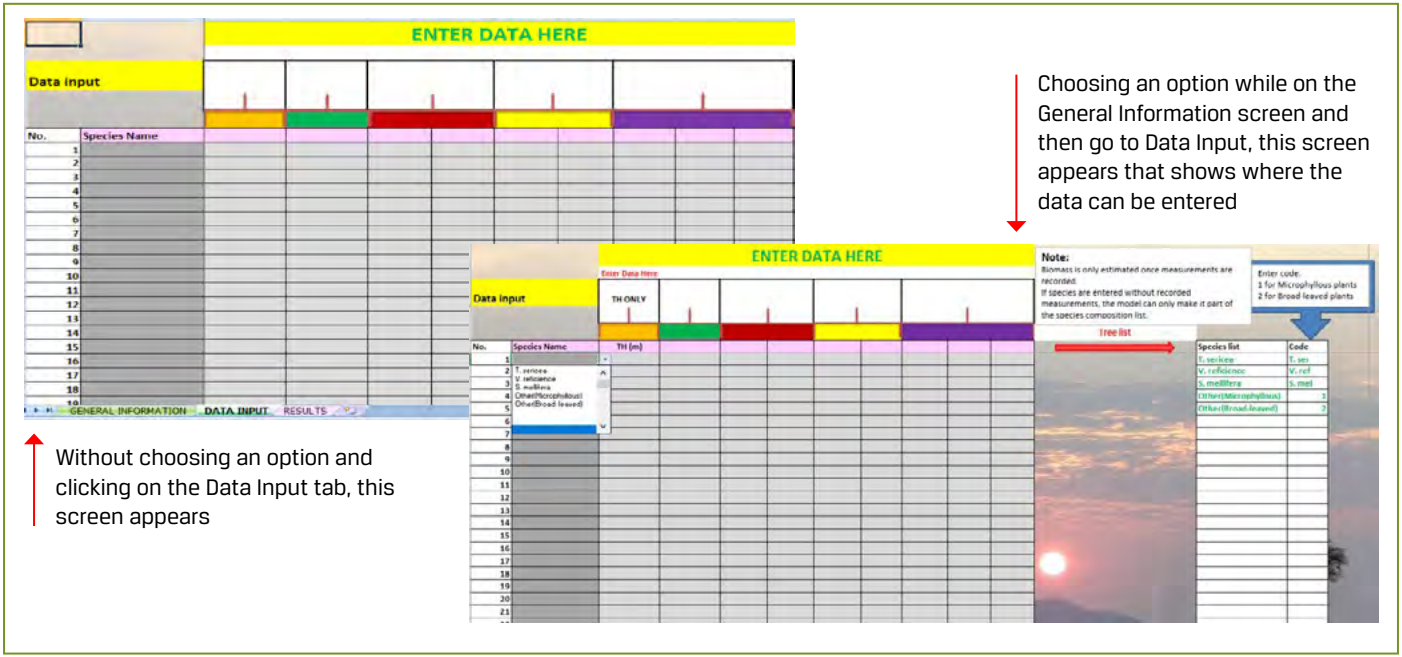


Figure 3.8: The data entry tab, indicating its dependence on the selected measurement option for the activation of those fields where the data needs to be entered.

3.3.2. The results/report

The report is generated from the general information and field data entries and is separated into four (4) main categories:

1. General information
2. Plant densities
3. Wood biomass
4. Bush feed biomass

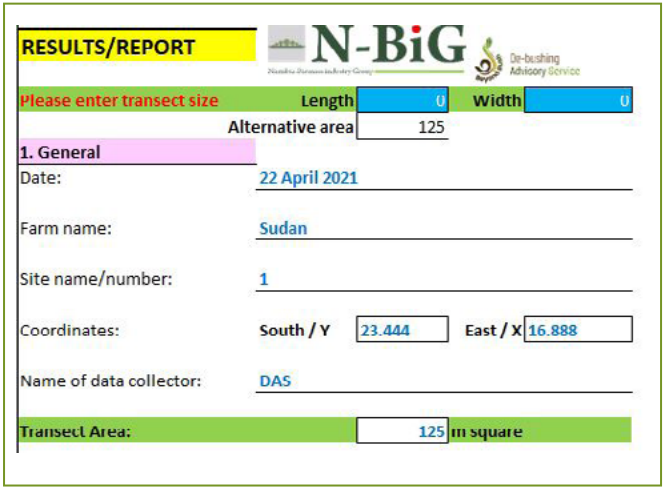
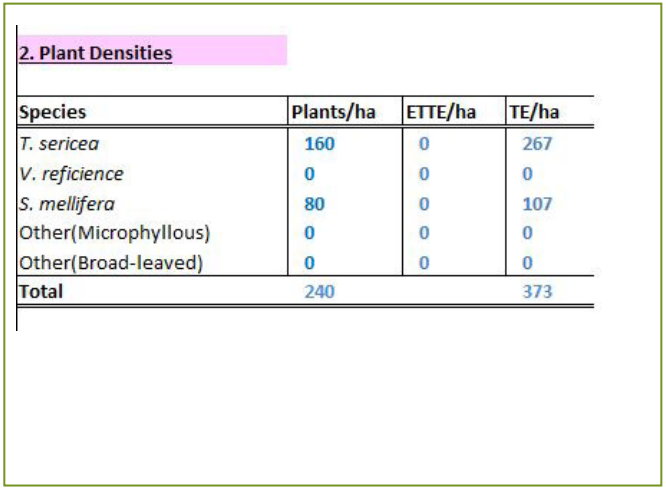


Figure 3.9: General information for report purposes.



2. Plant Densities

Species	Plants/ha	ETTE/ha	TE/ha
T. sericea	160	0	267
V. reficience	0	0	0
S. mellifera	80	0	107
Other(Microphyllous)	0	0	0
Other(Broad-leaved)	0	0	0
Total	240		373

Figure 3.10: Plants densities (total and on a species basis).

The plants/ha is a count of all surveyed plants in the transect, extrapolated to plants/ha on a species basis. The transect area and species entry is key for the calculation plants/ha. A detailed list on extra species added during data entry is also available on a species basis for ETTE, TE, wood and bush feed on a per ha extrapolation.

The calculation of TE and ETTE-values is more complex and requires specific tree canopy measurements for their calculation. TE is calculated in the case of all measurement options where TH is the only required measurement, whereas ETTE requires the calculation of tree canopy volume which is only possible in the TH & CH & CD option. Figures 3.1 and 3.6 illustrate these options.

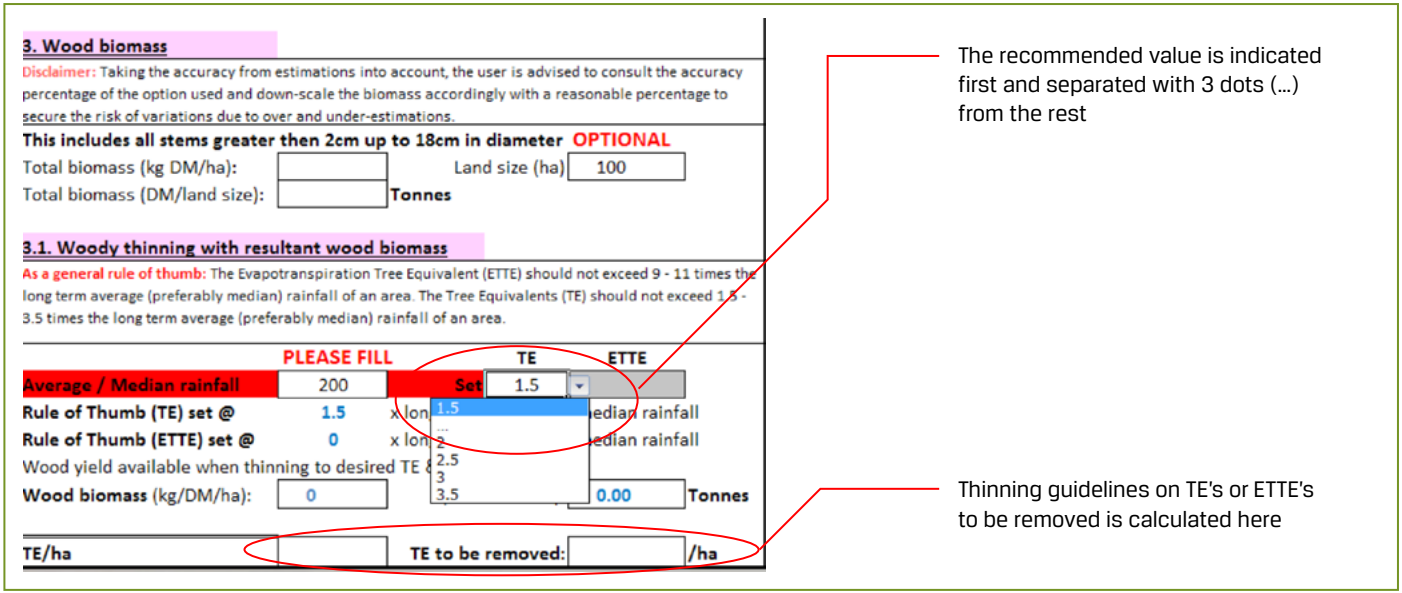


Figure 3.11: Wood biomass (total and from selective thinning)

The calculation of the estimated total wood biomass is possible with all options, but at different accuracy levels depending on the measurement option selected. In general, the more measurements per tree are taken the more accurate the estimations. The biomass wood yield that can be obtained from selective thinning is dependent on rainfall, TE and ETTE and therefore options should be selected accordingly if the users want to know how much wood will be available when thinning to a pre-determined density. The setting of the TE and ETTE options is available from a drop-down list. The model automatically detects which thinning rule to use based on the measurement option selected. The calculation of ETTE requires more tree measurements, but will render more precise predictions compared to the use of TE.

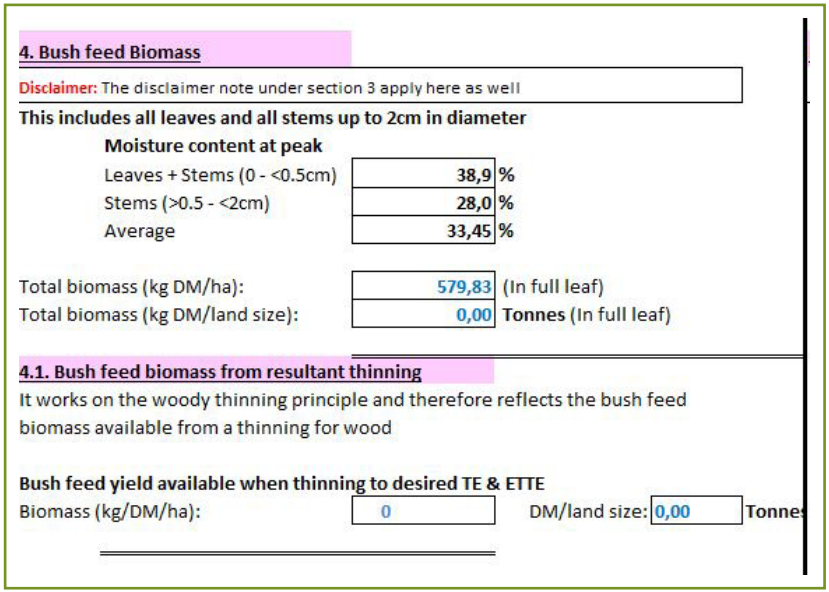
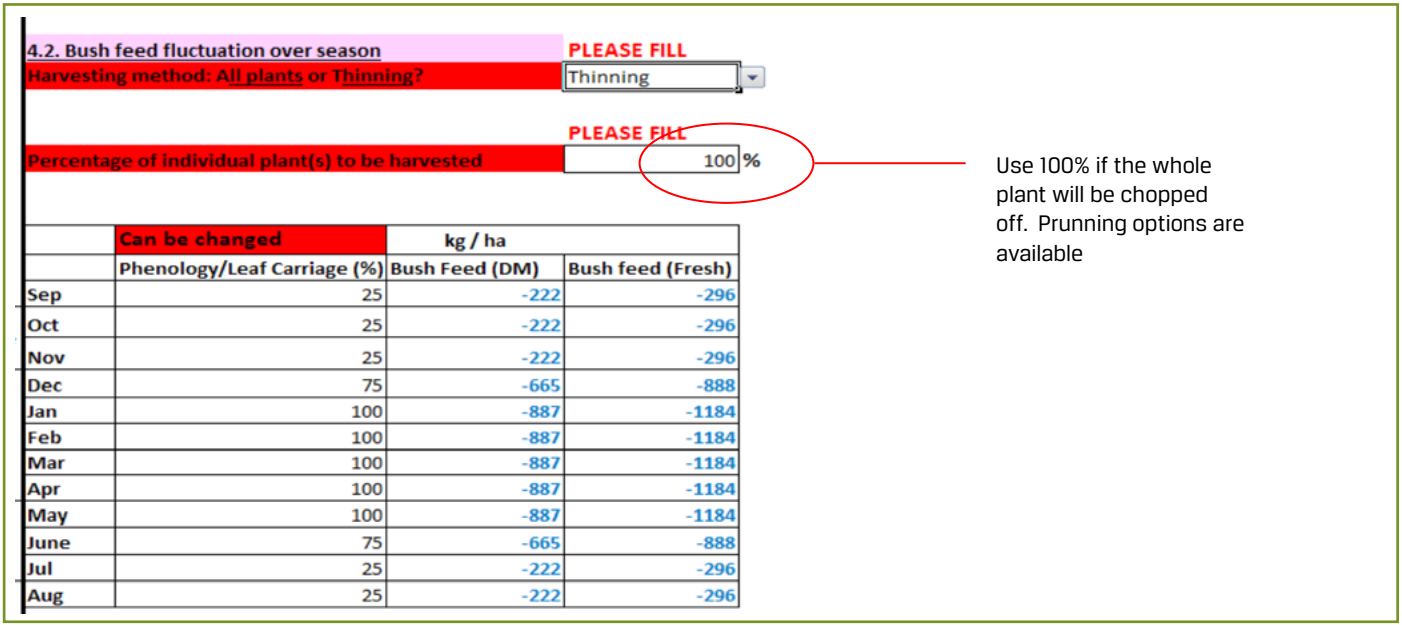


Figure 3.12: Bush feed biomass (total and from selective thinning)

The calculation of the estimated total bush feed biomass is also possible from all measurement options, but at different accuracy levels depending on the option selected. In general, the more measurements per tree are taken the more accurate the estimations. The thinning of bush to a certain pre-determined density with a resultant bush feed biomass is also possible as in the case of wood.



	Can be changed	kg / ha	
	Phenology/Leaf Carriage (%)	Bush Feed (DM)	Bush feed (Fresh)
Sep	25	-222	-296
Oct	25	-222	-296
Nov	25	-222	-296
Dec	75	-665	-888
Jan	100	-887	-1184
Feb	100	-887	-1184
Mar	100	-887	-1184
Apr	100	-887	-1184
May	100	-887	-1184
June	75	-665	-888
Jul	25	-222	-296
Aug	25	-222	-296

Figure 3.13: Bush feed fluctuation available through selective thinning/clearing and percentage of a plant harvested

The fluctuation of bush feed over season due to leaf phenology changes of the winter deciduous bush can also be quantified over months (Figure 3.13). This can be done for total and biomass obtained through selective thinning. An option is also available on the biomass obtainable from harvesting a certain percentage of an individual plant.

The model is supplied with leaf phenology values for each month of the year, but these leaf phenologies can be changed by the user. However, this should be done with great care as it can largely affect the biomass estimated over season.

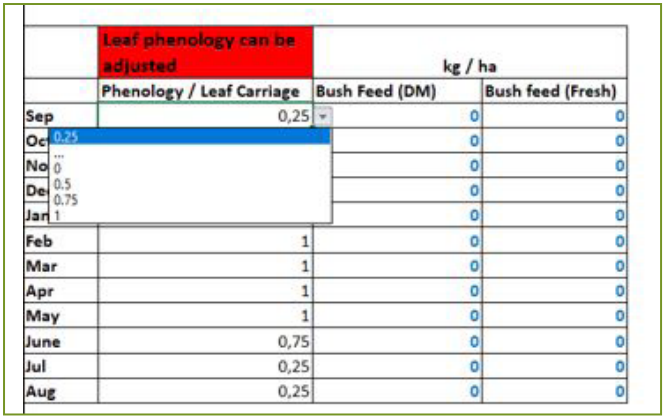


Figure 3.14: Option available for changing leaf phenology values for each month of the year.

A safety mechanism was brought in to separate the original leaf phenology value from the others in a drop-down list. This was done by putting the original value on top every time and separating it with three (3) dots (...) from the rest in order to avoid confusion after a user has changed the leaf phenology and wants change it back to the original.

The option is also available for harvesting only a given quantity of wood and/or bush feed biomass. This requires a field data collection survey before the land area (ha) can be determined that is required for harvesting a given quantity of wood and/or bush feed either through clearing or thinning. Figure 3.15 illustrates the option.

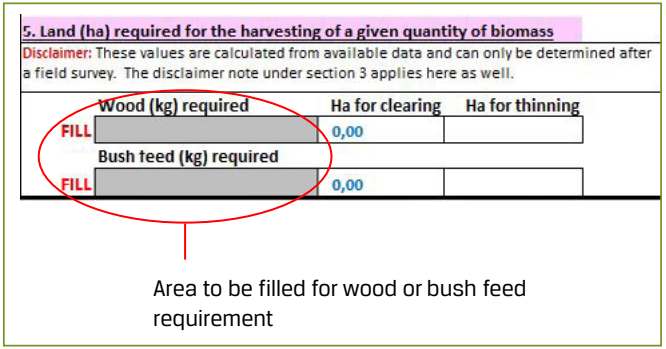


Figure 3.15: Option for land (ha) required for harvesting only a given quantity of wood or bush feed through either clearing or thinning.

This model is particularly designed for the needs of the farmers and researchers within the wood biomass industry, specifically in Namibia, but also elsewhere. It may not precisely suite everyone's needs at the moment, but the idea was to produce this version to stimulate the need for sustainable biomass utilisation of the bush resource by means of a standardised measured quantification of the resource. The model can therefore be expanded with further specific needs that may arise in the bush biomass industry.

4. Appendix

4.1. Data collection sheet

A data collection sheet is attached.

Farm Name.....

Date.....

Site name/number.....

Transect width:.....m, Length.....m

Coordinates: South -....., East.....

All measurements are to be done in meters (m) e.g SD:10cm = 0.1m, 5cm = 0.05m

Species Name	TH	CD	CH	SD