Mensuration Tool

A smart phone application to automise Mensuration Exercise for Foresters

USER MANUAL

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Author's Preface

Forest mensuration is one of the most fundamental disciplines within forestry and related sciences. It deals with the measurement of trees and stands and the analysis of the resultant information. For the purpose of deriving different relationships between various variables of a tree like relationship between age and height, age and diameter at breast height, diameter at breast height and volume, etc. two main techniques are used. These are *Stump Analysis* and *Stem Analysis.*

For both these techniques, data is collected from the field, processing of which can take few days if done manually. Probationers of Indian Forest Service learn these techniques during a 5 day Mensuration Exercise conducted by Indira Gandhi National Forest Academy Dehradun generally at Kanasar Forests situated in Chakrata Forest Division of Uttarakhand State.

During this exercise of 2015 batch of IFS Probationers, the Authors of this manual came up with the idea to automate this process. Our Course Director and faculty-in-charge for Mensuration Exercise, Shri Uttam Kumar Sharma (IFS MP Cadre 1999 Batch), inspired and guided us to make a smart phone based application which can collect, store and process the field data in the field itself. So now with this application the whole exercise time could be reduced to time being taken to collect the data.

This manual provides the guidance to those who collect the data from the field. At appropriate places, the manual also describes the basic theory of mensuration as well as certain background processes that are taking place.

About the Authors

From Left to Right : Naveen Garg, Mayank Chandiwal and Punit Goyal

Mayank Chandiwal is an IFS Officer of 2015 Batch (Madhya Pradesh Cadre). He has been trained as an Engineer and received his B. Tech. in Mechanical in 2010 from I.I.T. Kharagpur.

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Chapter I : Launch of the Application

Introduction

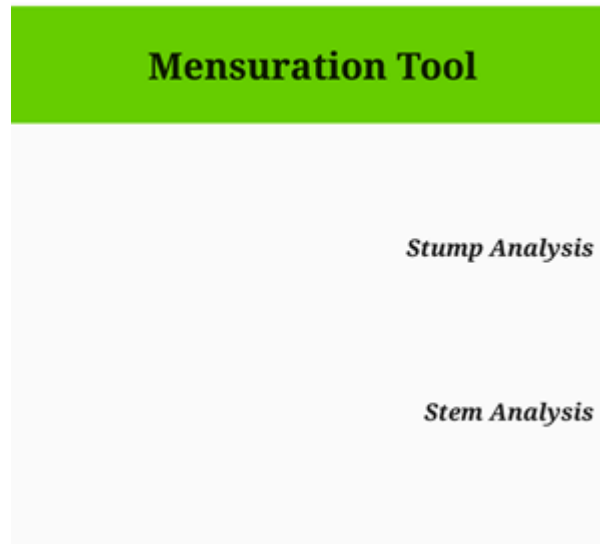On the launch of the application, following layout will be displayed:

Fig 1.1: Layout at the launch of application

Here user gets 2 options

1. Click on Stump Analysis: This will switch the layout where user will be asked to enter the Stump Data.
2. Click on Stem Analysis: This will switch the layout where user will be asked to enter the Stem Data.

Chapter II : Stump Analysis

Introduction:

When the user clicks the Stump Analysis button on the Launch Page, following layout appears:

Fig 2.1: Layout for Stump Analysis

Stump analysis is done to find a relationship between the age of the tree and breast height diameter-overbark (DBH-OB) . For achieving this objective, first a relationship is established between the age of tree and diameter under bark (DUB) at stump height. Later, this DUB will be corrected to breast height

diameter overbark (DBH-OB) using Taper Analysis. For the correction of age at stump height, Seedling Analysis will be done.

Data to be filled:

In the Stump analysis user will enter the following data:

1**. Tree No**.: The Tree No. is an Integer value, which will accept any value between 1 to 10. It is assumed here that, at max 10 stumps will be analysed for the data collection. Though the user has the flexibility to enter Tree No in any order, but it is advisable to enter the Tree No in sequential order from 1 to the last tree (<=10).
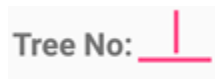
Tree No:

Fig 2.2: Field for entering tree no

2**. Stump Height (cm):** Here the user will enter the Height of the Stump. It should strictly be entered in *centimeter*.
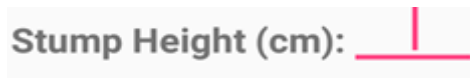
Stump Height (cm):

Fig 2.3: Field for entering stump height

3. **Radii of different decades:** Here the fields given are vertically scrollable. For every decade (From 1st decade to maximum 25th decade) user can fill *upto 4 decadal radii.*

Enter the radii of different decades

Decades	Radii 1	Radii 2	Radii 3	Radii 4
1st	_____	_____	_____	_____
2nd	_____	_____	_____	_____

Fig 2.4: Fields for entering decadal radii

If the user enters say 3 radii only, then average of these 3 radii will taken for that particular decade. The values should strictly be in **_centimeter_**.

What's next?

After filling all these data, user has 2 options i.e. click on either of these 2 buttons:

Submit   Conclude Stump Data

1. Click on **Submit** button: Clicking on this button submits the data for the current tree. On clicking the button, a pop-up window will appear to ask user whether he/she is sure to submit the data for current tree or not.
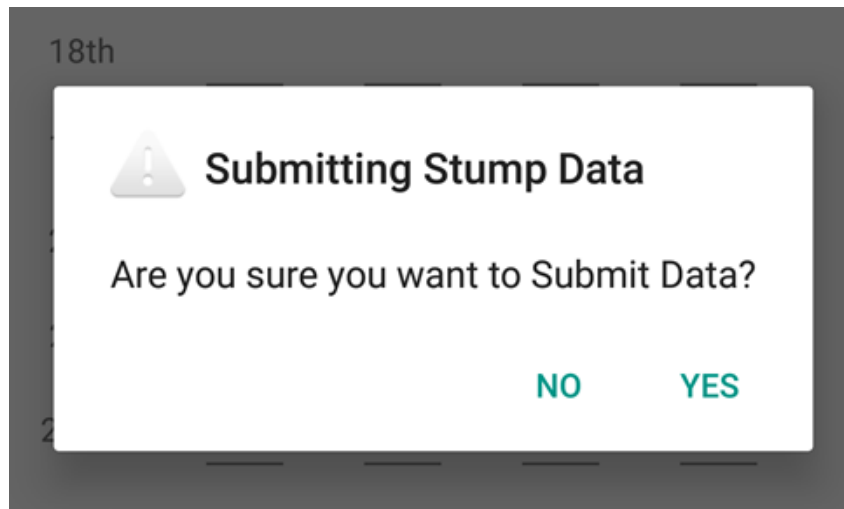
Fig 2.4: Pop-up window to ensure submission of stump data

On clicking **"YES"** on this window, the data for the current tree will be submitted and stored in the database for further processing. Once submitted, if any of the fields for a the tree needs to be altered, the user will have to provide data for all the fields and not just the alterations. So the user should be cautious before clicking "YES" here.

If the user wants to change/modify any of the fields for the current tree, he/she can do it by clicking **"NO"**.

2. Click on **Conclude Stump Data** button: Once the data for all the trees are submitted successfully, user can click on *Conclude* button to switch to "Seedling Analysis" layout. Again a pop-up window will appear to make sure that the *Conclude* button was not clicked by mistake.
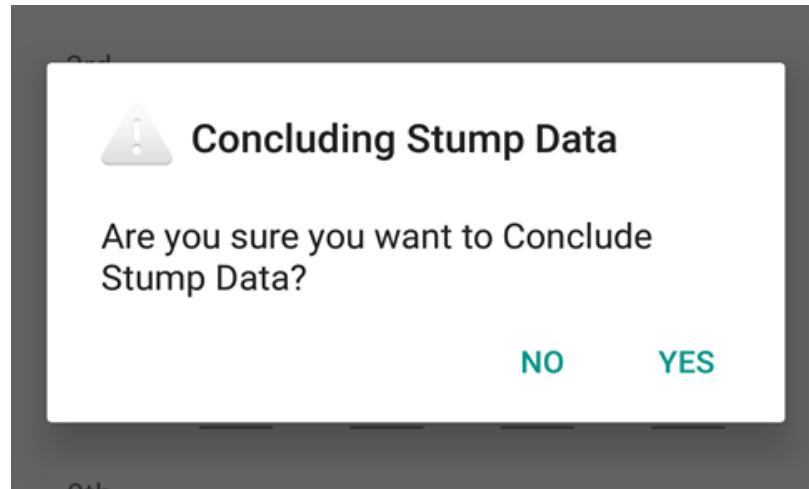
Fig 2.5: Pop-up window to ensure conclusion of stump data

Once the data is submitted for all the trees, the layout for Seedling Analysis will open up. In the background, for every tree, average decadal diameter will be calculated and will be stored along with the tree's stump height in an array. This array is passed on to Seedling Analysis where according to stump height age correction will be applied to the array.

Chapter III : Seedling Analysis

Introduction

In Seedling Analysis, the young seedlings of about 25-30 years of age are cut into sections of 10cm length each. On each section total number of rings are counted. Difference between the no of rings present on consecutive sections, gives us the no of years that the seedling took to grow by 10cm. This fact can be used to plot a curve between age of the tree and its height. From this curve age corrections can be made for different stump heights.

Layout for Seedling analysis is:

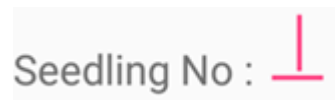*Fig 3.1: Layout for Seedling Analysis*

Data to be filled:

In the Seedling Analysis following information needs to be provided:

1. **Seedling No:** This field takes data for the seedling no i.e. the serial no of the current seedling. It should be an Integer between 1 to 10. It is assumed that, at max 10 seedlings will be analysed to establish a relationship between Age and Height of the Tree.

Seedling No : ⊥

Fig 3.2 : Field for entering data for Seedling No

2. **No. of Rings:** There are 3 columns, in the segment shown below, out of which only one column i.e. "No of Rings" column is editable.Corresponding to each height, user is supposed to enter total no of rings present on that section of the current seedling. This segment is vertically scrollable and user can fill no of rings upto the height of 180cm.

Height (cm)	No of Rings	Age at This Ht
0	———	
10	———	
20	———	
30	———	

Fig 3.3 : Fields for entering data for No of Rings

The 3rd column here, namely "Age at This Ht", gives the no of years that the current seedling took to grow to that height. This information is displayed when the user clicks the "**Check Age**" button below.

What's next?

After filling all these data, user has 2 options i.e. click on either of these 2 buttons:

Submit   Conclude

1. Click on **Submit** button: Clicking on this button submits the data for the current seedling. On clicking the button, a pop-up window will appear to ask user whether he/she is sure to submit the data for current seedling or not.
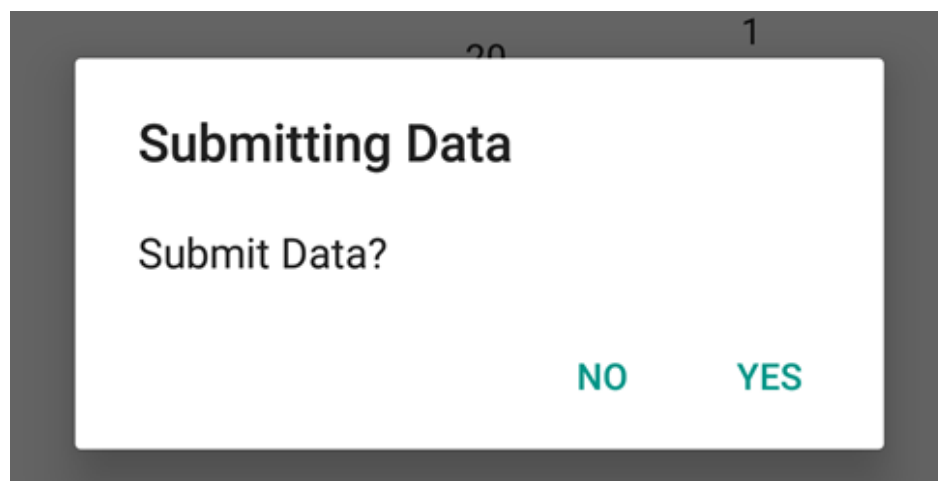

Fig 3.4: Pop-up window to ensure submission of seedling data for the current seedling

On clicking **"YES"** on this window, the data for the current seedling will be submitted and stored in the database for further processing. Once submitted, if any of the fields for a the seedling needs to be altered, the user will have to provide data for all the fields and not just the alterations. So the user should be cautious before clicking "YES" here.

If the user wants to change/modify any of the fields for the current seedling, he/she can do it by clicking **"NO"**.

2. Click on **Conclude** button: Once the data for all the seedlings are submitted successfully, user can click on *Conclude* button to switch to "Taper Analysis" layout. Again a pop-up window will appear to make sure that the *Conclude* button was not clicked by mistake.
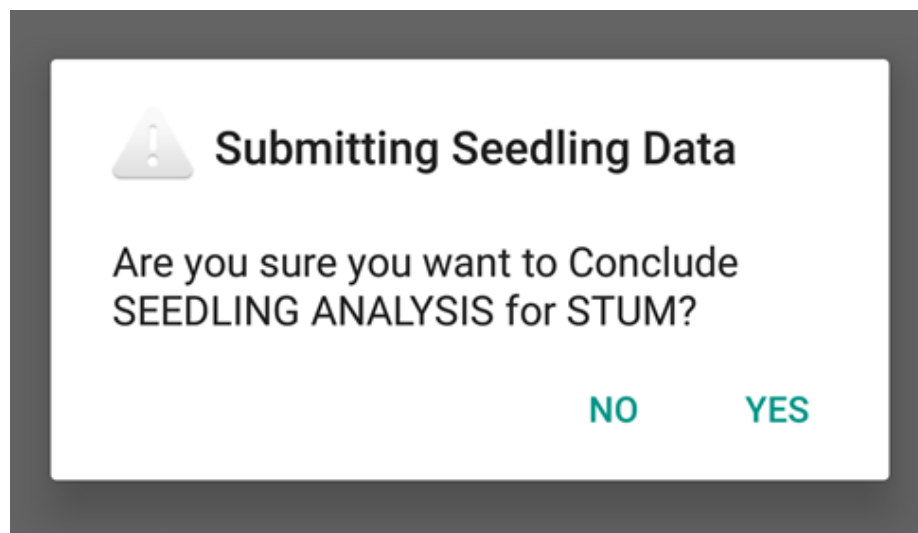

Fig 3.5: Pop-up window to ensure conclusion of stump data

Chapter IV : Taper Analysis

Introduction:

In Taper Analysis, we measure the underbark diameter (DUB) at 15cm, 45cm and 75cm height from the ground and overbark diameter at breast height (DBH-OB) of different standing trees. It is desirable to have 3 trees in each dia class from 0-10 class to 90-100 class. This data helps in establishing a relationship between DUB at a particular height and DBH(OB). On plotting best fit curves for this data on graph taking DUB on x-axis and DBH(OB) on y-axis, we get 3 straight lines one each for 15cm height, 45cm height and 75cm height. Using these 3 straight lines, we can draw another straight line corresponding to a particular stump height. Using this drawn line, we can convert the DUBs in our initial array to DBH(OB).

For collection of Taper Data, following layout will appear:

Fig 4.1: Layout for Taper Analysis

Data to be filled:

The segment for data filling in Taper Analysis is vertically scrollable. There are 10 dia classes from 0-10 cm to 90-100 cm dial class. These dia classes are based on overbark diameter at breast height (DBH-OB). For every dia class there are total 12 fields, arranged in 3 rows and 4 columns. For each dia class user can enter data for maximum 3 trees and minimum 0 tree. *But minimum 1 row each of atleast 2 different dia classes should be filled for the calculation.*

The first entry in each row is of **DBH(OB)**. The next 3 entries in the row is for underbark diameter (DUB) at different heights i.e. **DUB@15cm, DUB@45cm** and **DUB@75cm**. All the entries should strictly be made in *centimeter.*

Dia Class (cm)	DBH(OB) (cm)	DUB @ 15cm	45cm	75cm
70-80	——	——	——	——
	78.4	81.4	80.5	79.4
	81.2	86.4	84.9	83.1
80-90	88.2	92.1	90.9	90.1
	——	——	——	——
	99.7	104.2	102.9	101.1
90-100	——	——	——	——

Fig 4.2: Fields for entering Taper Data

What's next?

After filling all these data, user has 2 options i.e. click on either of these 2 buttons:

Conclude Analysis   Submit

1. Click on **Submit** button: Clicking on this button submits the data for the Taper Analysis .On clicking the button, a pop-up window will appear to ask user whether he/she is sure to submit the data for current seedling or not.
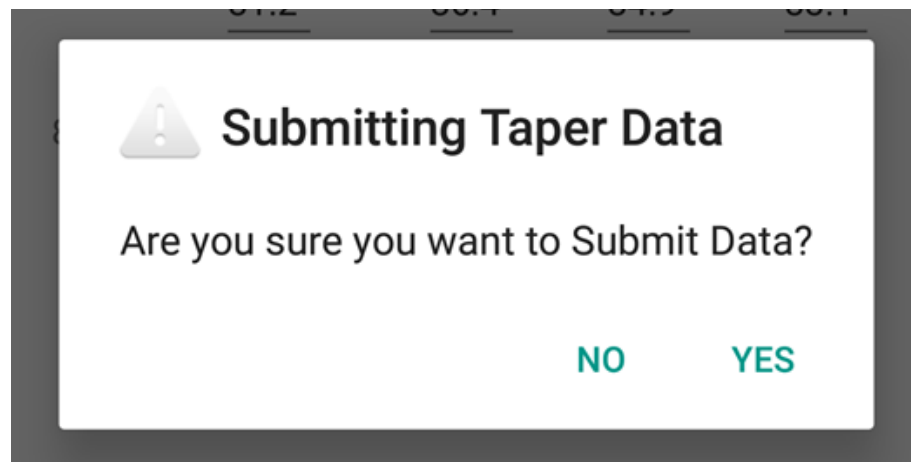
Fig 4.3: Pop-up window to ensure submission of seedling data for the current seedling

On clicking **"YES"** on this window, the data for the Taper Analysis will be Submitted. After this submission all the data will be processed. This processing includes heavy iterations and other calculations for fitting of Age vs DBH(OB) curve for all the trees for which DUB data was provided during Stump Analysis. *This may take few minutes.*

If the user wants to change/modify any of the fields, he/she can do it by

clicking **"NO"**.

2. Click on **Conclude Analysis** button: Clicking on *Conclude Analysis* button generates a pop-up window.
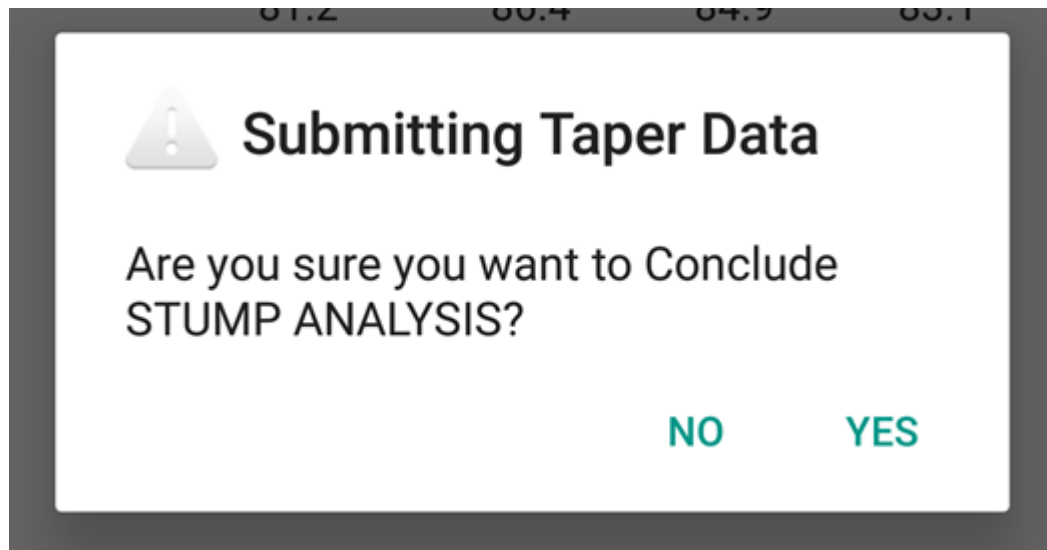

Fig 4.4: Pop-up window to ensure conclusion of Stump Analysis

Clicking **"YES"** here means that user has entered all the necessary data for the complete Stump Analysis. As told earlier, after submitting Taper data, the application does heavy iterations and other calculations. By this time if those processes are not finished, a toast will appear on clicking *"YES"* saying "*Data is being processed. This could take more than a minute. Please wait for a while....*". When user again clicks *Conclude Analysis* after sufficient time, again this pop-up appears. Clicking "*YES*" this time will conclude stump analysis and layout for plotting different graphs will appear after a while.

If the user wants to change/modify any of the fields, he/she can do it by clicking **"NO"**.

Chapter V : Graphs for Stump Analysis

Introduction:

After the Taper Analysis, application does iterations to fit Age vs DBH(OB) curve for the final tree. This again takes about a minute.
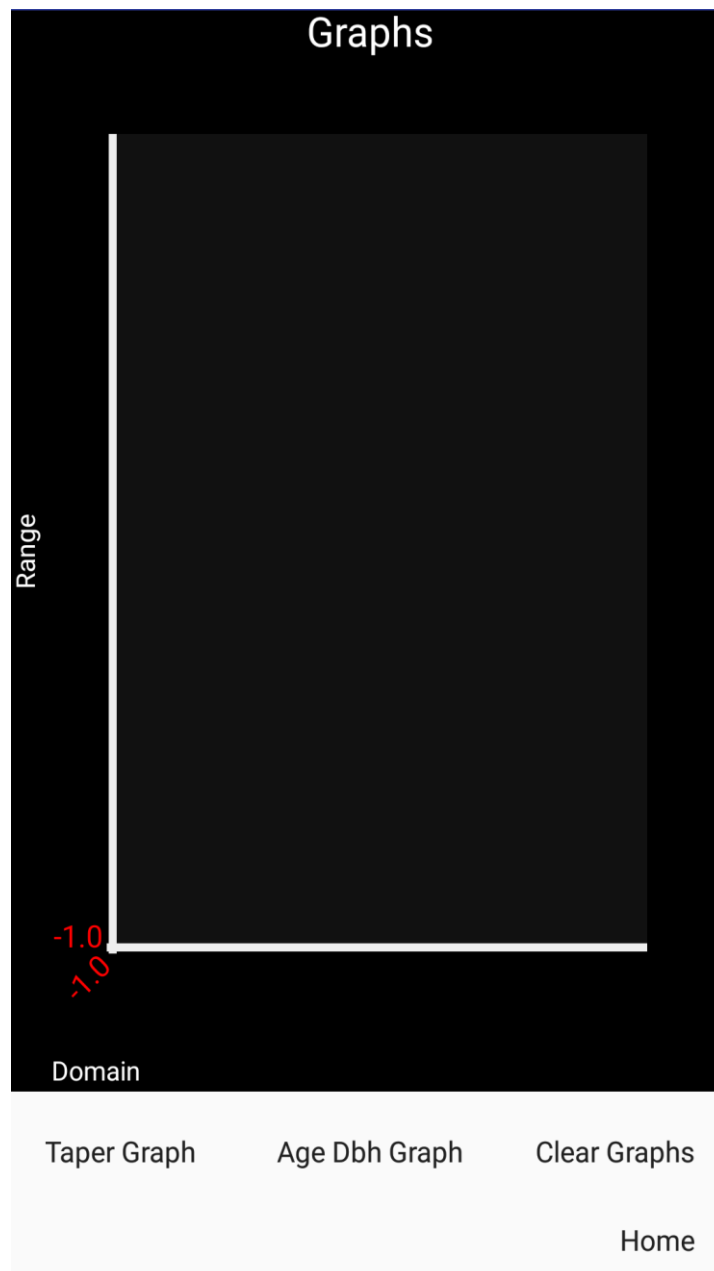

Fig 5.1: Layout for Graphs

As shown in fig. 6.1, the Graph layout has following buttons on the bottom side:

1. **Taper Graph :** Clicking on this button generates graph between DUB (x-axis) at 3 different heights i.e. 15cm, 45cm and 75cm and DBH(OB) (y-axis).
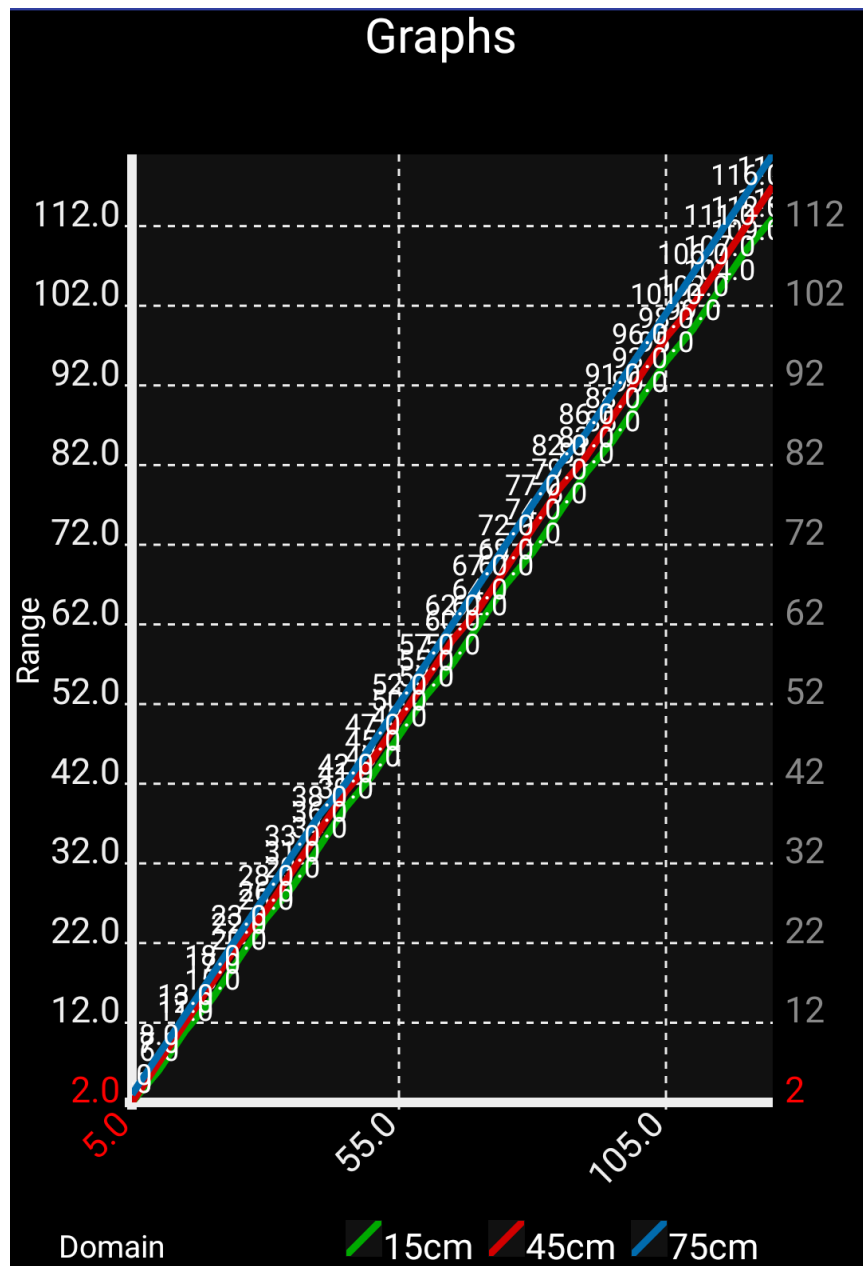

Fig 5.2 : Plot between DUB and DBH(OB)

2. **Age Dbh Graph :** Clicking on this button generates the graph between Age of the tree (x-axis) and its overbark diameter at breast height (y-axis).
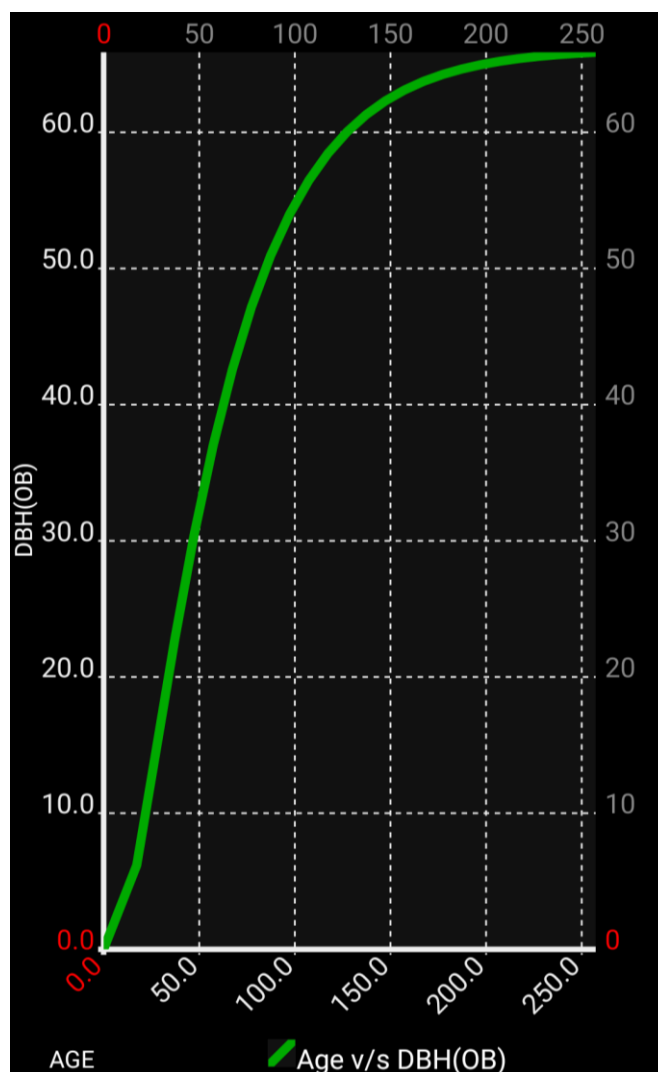

Fig 5.3 : Plot between Age of the tree and DBH(OB)

3. **Home :** Clicking on this button takes the user back to launch screen where he/she can proceed for Stem Analysis.

Chapter VI : Stem Analysis

Introduction:

On the launch screen, if the user clicks on *Stem Analysis* button, following layout will be displayed:

Stem Analysis

Section No. : __|__   Length of Section : _____

Overbark Dia (cm) : _____   Underbark Dia (cm) : _____

Total no of Rings : _____

Please enter Radius at successive decadal marks for current section starting with the LARGEST radius

R1 : _____

R2 : _____

R3 : _____

R4 : _____

R5 : _____

R6 : _____

Conclude Stem Analysis   Next Tree   Next Section

Fig 6.1: Layout for Stem Analysis

In the Stem Analysis, a full grown tree is cut into many sections. The length of the first section is kept as 2.74m so that its mid point coincide with the breast height i.e. 1.37m from the ground.The length of all the other sections, except the last one, is kept as 3m. The last section can be of any length between 1.5m to 4.5m. On midpoints of each of these sections, overbark diameter, underbark diameter, total no of rings and decadal radii are measured and entered into the data form shown above. All these data are averaged to get data for a final representative tree.

First, Age vs Height curve is plotted. Age is determined by counting the rings in subsequent sections and subtracting them with rings in the first section i.e. at breast height. Age correction for DBH is added after seedling analysis.

Then, volume is calculated using smoothened decadal diameters at each section. The last section here is treated as cone while all other sections are treated as cylinders. Using this data, Age vs Volume curve is plotted.

With the provided overbark and under bark diameter, a linear relationship is established between the underbark diameter and the bark thickness. Using this relationship, underbark diameters are converted into overbark diameters for first section i.e. at breast height. Using this data, Age vs DBH(OB) curve is plotted.

Data to be filled:

In the Stem Analysis following information needs to be provided:

1. **Section No:** This field takes integer value for the section no of the current tree. It is the serial no starting from 1 (for the bottom most section) and take a maximum value of 15. It should strictly be in order.

Section No. : _____

Fig 6.2 : Field for entering data for Section No

2. **Overbark Dia (cm)** and **Underbark Dia (cm) :** These 2 fields are filled with overbark and underbark diameter at the midpoint of the current section. This data is used for establishing a relationship between underbark diameter (DUB) and bark thickness (half of the difference between overbark and underbark diameter). The entries should strictly be in *centimeter.*

Overbark Dia (cm) : _____   Underbark Dia (cm) : _____

Fig 6.3 : Fields for entering Overbark and Underbark Diameter for the current section

3. **Total No. of Rings:** In this field total no of rings present on the midpoint of the current section needs to be filled. Now we have total no of rings at different heights of a tree, we can use this data to plot a curve between Age of the tree and its height after certain corrections.

Total no of Rings : _____

Fig 6.4 : Fields for entering Total No of Rings present on the current section

4. **Decadal Radii :** This segment is vertically scrollable. Here the user needs to fill radius of the of the decadal marks (marks to be put at interval of 10 rings) ***starting with the largest radius first.*** This entry should strictly be in ***centimeters.***

Please enter Radius at successive decadal marks for current section starting with the LARGEST radius

R1 : _____

R2 : _____

R3 : _____

R4 : _____

R5 : _____

R6 : _____

Fig 6.5 : Fields for entering decadal radii of the current section

What's next?

After filling all these data, user has following 3 options i.e. click on either of these 3 buttons:

Conclude Stem Analysis   Next Tree   Next Section

- **Next Section -** Clicking on this button submits the data for the given section.Two toasts appear saying "data submitted for the current section" and "Please Enter data for next section". All the fields on the page gets cleared and user needs to enter the data for the next section, if any other section is left.

  Even when user is entering data for the last section, next section button needs to be pressed to submit the data for current section. A toast will appear in this regard saying "Please click on Next Section before moving to Next Tree. User needs to first click on Next Section and then on Next Tree.

  If user has filled wrong data for any section in the current tree, user can alter the data by providing correct section no. and height of the section.

- **Next Tree -** Clicking on this button submits data of all the sections for the present tree. The user can now enter the data for the next tree. On clicking this button, a pop up window will appear to ask user whether he/she is sure to submit the data for current tree or not.
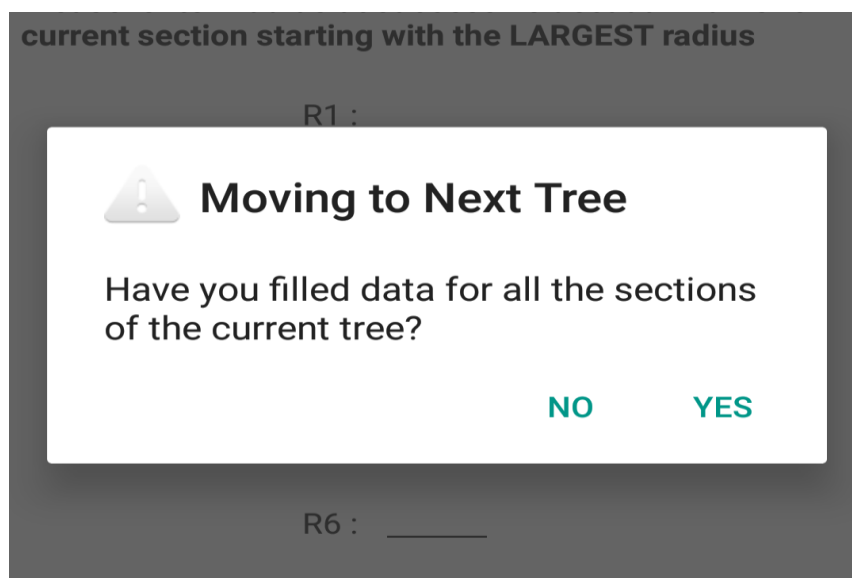

Fig 6.6: to ensure User has submitted data of all sections of the current tree

On clicking "**YES**", data for all the sections would be submitted for the current tree. **User cannot alter the data of a tree once he/she moves to the next tree.** In case wrong data is submitted for any of the sections, user has to start the stem analysis from the beginning. So the user should be cautious before clicking "YES" here.

If the user wants to change/modify any of the fields for the current tree, he/she can do it by clicking **"NO"**.

- **Conclude Stem Analysis -** Once the data for all the trees are submitted successfully, user can click on *Conclude* button to switch to "Seedling Analysis" layout. Again a pop-up window will appear to make

sure that the *Conclude* button was not clicked by mistake. Once the data is submitted for all the trees, the layout for Seedling Analysis will open up.

In the background, for every tree, average decadal diameter will be calculated and will be stored for each section in an array. This array is passed on to Seedling Analysis where age correction at the breast height will be applied to the array for relevant calculations.
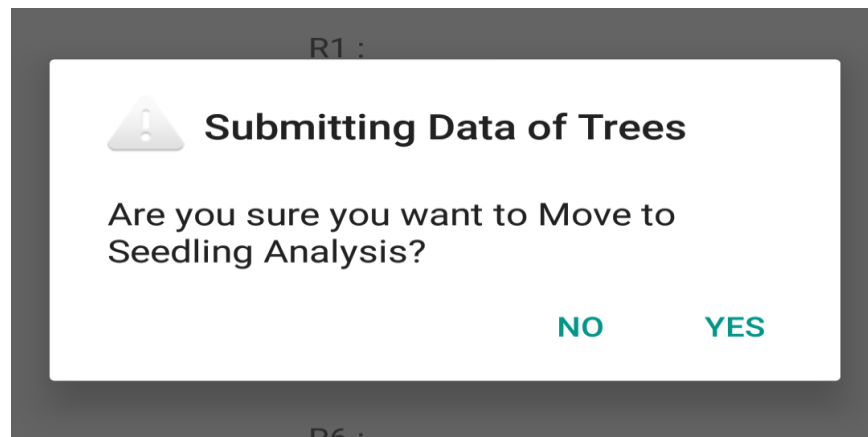

Fig 6.7 - *Pop-up window to ensure conclusion of stem data*

Seedling analysis has been explained in detail in Chapter IV.

Chapter VII: Graphs for Stem Analysis

Introduction:

After Seedling Analysis, application processes the data for final curve display. This takes few seconds and window might go blank for few seconds. Three Buttons for 3 curves are given namely - "Age vs Height", "Age vs DBH(OB)" and "Age vs Vol".

- Clicking "Age vs Height" button generates graph between Age (x-axis) and Height (y-axis).
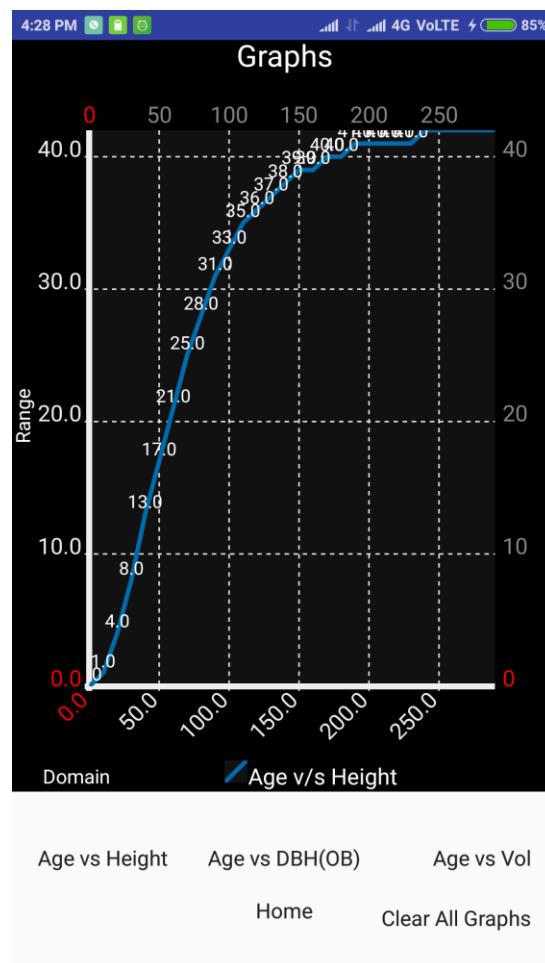

Fig 7.1 - Plot between Age and Height

● Clicking "Age vs DBH(OB)" button generates graph between Age (X-axis) and DBH(OB) (y-axis).
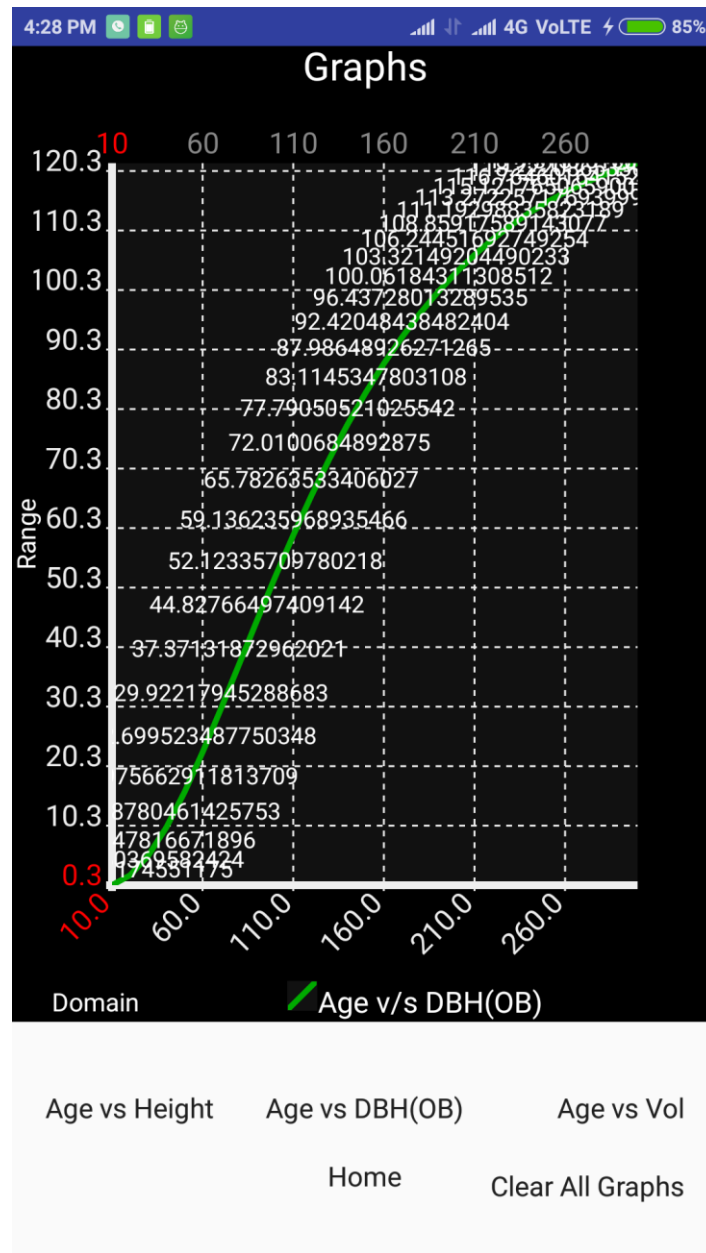

Fig 7.2 - Plot between Age and DBH(OB)

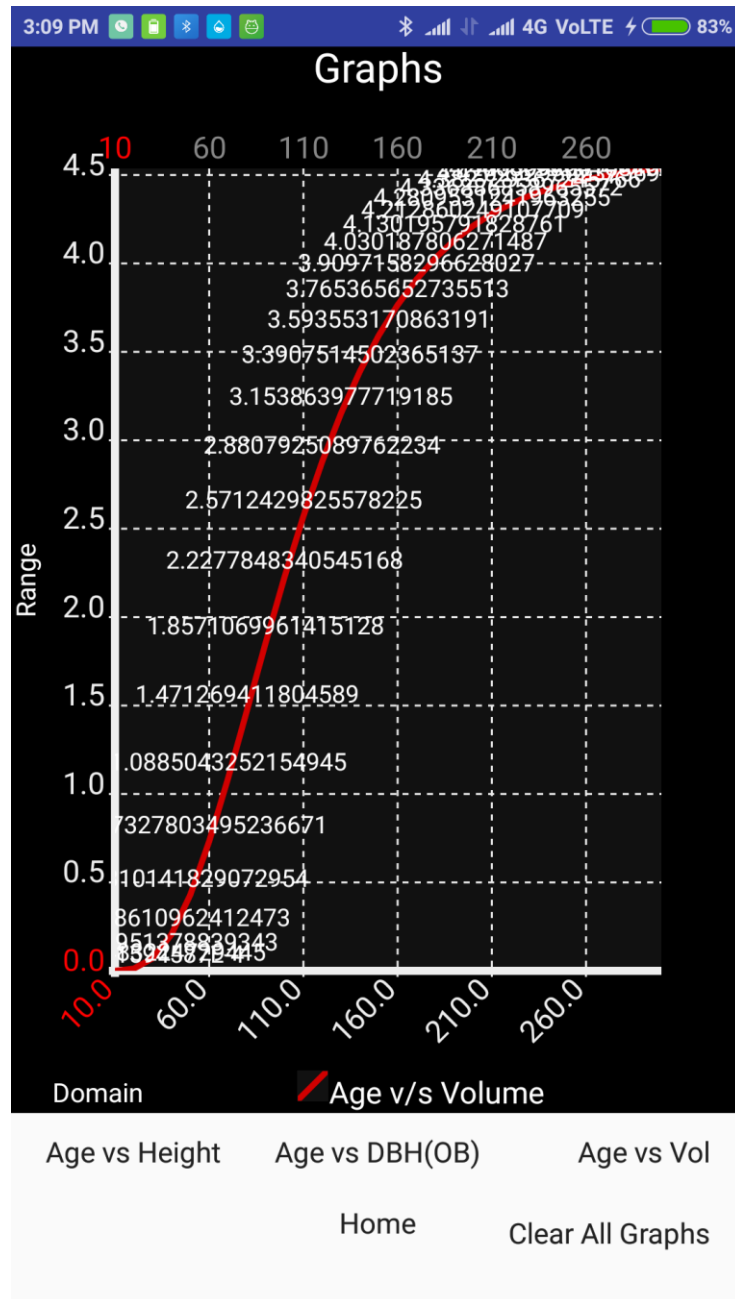- Clicking "Age vs Vol" button generates graph between Age (x-axis) and Volume (y-axis).

Fig 7.3 - Curve between Age and Volume

- **Home :** Clicking on this button takes the user back to launch screen where he/she can proceed for Stump Analysis.