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# Predicting Basal Area Using Java Program in Akinyele Local Government Area, Ibadan, Oyo State, Nigeria

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**ABSTRACT**

Individual tree growth models are important decision-making tools in forestry. This study evaluated the predictive ability for basal area of a Java program derived from the algorithm of gamma distribution function. The input value was diameter at a breast height. In generating and testing the program, a stratified random sampling technique was used to select four different age classes of teak plantation, namely: 11, 13, 22, and 59 years-old, respectively. Complete enumeration of trees (n = 433) was done for all the plots selected. Diameter at breast height (DBH) was measured with the aid of diameter girth tape, which was also used for basal area computation. Data obtained were processed into tree and stand levels. Parameters α and β for Gamma Distribution Function (GDF) were estimated from growth data. The Java program was then written based on the algorithm of Gamma distribution function for α, β, and n parameters. Values of diameter at breast height fitted into the Java program shows that it was able to predict the basal area. Therefore, the predictive ability of the developed Java Program for basal area of individual and full stand teak trees demonstrates that it can be used for prediction of yield in the forest stands.

***Keywords*:** Basal area, trees, maximum likelihood, Java program, prediction

## 1. INTRODUCTION

Effective and efficient forest management is only possible when reliable information about the present and future forest condition is available. Research has revealed that modeling growth and yield has been an intrinsic part of forestry research for several years and still remain the area of important and active research (Vanclay, 1994; Porte, Bartelink, 2002). Studies also showed that forest growth models are useful for inventory updating (Garcia, 1994; Amaro *et al.*, 2003). In modeling stand growth, stand variables, such as site index, stand age, stand diameter, stand basal area, stand density index, and number of stems can be considered as functions (Pienaar, Rheney, 1995; Huuskonen, Miina, 2007; Gizachew, Brunne, 2011). Thus stand growth models do not describe the growth dynamics of individual trees, and therefore they are usually applicable only to even aged and homogenous stands. It has been established that basal area growth is highly correlated with volume growth, basal area growth models are preferred to diameter growth models (Wykoff, 1990; Moserud, Sterba 1996; Schroder *et al.*, 2002; Andreasen, Tomter, 2003; Anta *et al.*, 2006). Also many silvi-cultural and management considerations are based on the measurement and estimation of basal area growth. Furthermore, the curves of mean basal area growth are useful tools for effective management of stands, as they help estimate the time of intermediate and final cuts (Hong-Gang *et al.*, 2007).

The individual tree basal area growth models are so important and can be used to update inventories, predict future field and to explore management alternatives. When compared to stand characteristics such as mean diameter, mean crown diameter and mean height, basal area possesses a high degree of exactness on measurement or prediction. As a result of this, the basal area concept is important and applicable to a wide range of conditions (Hong-gang *et al.*, 2007). The choice of *Tectona grandis* for this study is justified by its unique importance as one exotic species of prominent quality, showing great potentials for good performances under plantation system. It is easily worked upon and has natural oil that makes it suitable for use in exposed locations, where it is durable even when not treated with oil or varnish.

### (1) Java Program

Java programming language is a high level language which requires translation before execution. Java uses a combination of compilation and interpretation. The reasons for Java selection according to James and Michael (1982) are summarized below

- **Portability:** Java programmes can be written on a platform and executed on other platform. The platform here denotes operating system environment. For instance, Java programmes can be written in windows environment and be used on Linux operating system environment. Java has the concept of write anywhere and use anywhere. Java Programmes can be ported to any machine, regardless of the operating system and hardware architecture.
- **Object-oriented:** Java is an object-oriented programming language. In this regard, programming is simplified by developing codes as object that can be reused as many times as possible. It also advocates modularization, in which programming can be written in modules. It is powerful, because it facilitates the definition of interfaces and makes it possible to provide reusable "software ICs".
- **Efficiency:** Java programming language is very effective in solving mathematical problems because Java came with a lot of mathematical methods.
- **Simple:** Java is used to build a system that could be programmed easily without a lot of esoteric trainings and which leveraged today's standard practice.
- **Network-savvy:** Java has an extensive library of routines for coping easily with TCP/IP protocols like HTTP and FTP. This makes creating network connections much easier than in C or C++.

- **Robust:** Java is intended for writing programmes that must be reliable in a variety of ways. Java puts a lot of emphasis on early checking for possible problems, later dynamic (runtime) checking, and eliminating situations that are error prone.
- **General-purpose:** Java can be used to develop any form of applications, ranging from mobile phone applications to the ones that run on servers. In addition, Java has capabilities for developing scientific, business, and military applications, therefore is a language suitable for research.
- **Rich Application Programming Interfaces (APIS):** Java has in-built APIS for solving mathematical and scientific problems without re-writing them.

The application of gamma distribution function was created using Java programming language because of the following reasons profitability which implies that Java program can be written on a platform, and executed on other platform, object oriented. In this regard, programming is simplified by developing codes as the object that can be reused as many times as possible. Efficiency-Java programming language is very effective in solving mathematical problems because Java comes with a lot of mathematical methods. This study tries to evaluate the predictive ability of the Java Program for basal area of the teak plantation in Akinyele Local Government Area.

## 2. MATERIALS AND METHODS

The study was carried out in Akinyele Local Government Area. It is located approximately 7°23′30'N and 3°54′30'E. *Tectona grandis* plantations, selected for study in Akinyele Local Government, Oyo State, include U.I. second gate plantation established in 1952, Falao in 1989, Obegimo/Balogun and Baba Agba in 1998 and 2000, respectively.

A total of thirty-one (31) sample plots were used in this study. A stratified random sampling method was used. The sampling units differ in terms of age constituting the strata. The random selection of sample plots, done within each stand, is to ensure the validity of the usual test of significance of the final equation (Weisberg, 1985). Each sample plot was 20 m × 20 m (*i.e*. 0.04 ha) in size.

The maximum likelihood estimate was used to obtain the estimate of α and β parameters which were inputted in the Java program. The tree variable measured in each sample plot was at Diameter breast height (Dbh) overbark of all trees (cm). This was measured at a standard position of 1.3 m above the ground. Based on the algorithm of the gamma distribution function, an attempt was made to build the program. The program was written using Java programming language in order to evaluate its predictive ability and the model was implemented in object-oriented manner.

## 3. RESULTS AND DISCUSSION

The summary of the growth data for *Tectona grandis* in Akinyele Local Government Area, Oyo State, is shown in **Table 1**, below. The ranges of the summary of the growth data indicate that *Tectona grandis* in this local Government are doing well. The Table 1 shows that the growth performance is positive. **Table 2** (side 128) shows the results of the values α and β, which were estimated using maximum likelihood estimator.

**Table 1.** Summary of growth data for *Tectona grandis* in Akinyele Local Government, Oyo State.

| Age, (years) | Number of stem per hectare (N) | Mean Diameter at breast height (cm) | Basal area/Hectare $m^2$/ha |
|---|---|---|---|
| 27 | 500 | 32.39 | 1.52 |
| 22 | 510 | 20.38 | 1.32 |
| 33 | 600 | 18.33 | 0.98 |
| 11 | 605 | 18.05 | 0.82 |

Table 2 (side 128) showed that plantation age 22 had the lowest standard error and plantation age 59 had the highest standard error. Greater values of β had larger standard error values and *vice versa* which implies that error value is minimized with smaller β values. The parameter estimates of α and β for gamma distribution function calculated by maximum likelihood method were accurate. The results agreed with those of Chang and Tang (1994).

The results of the Java program, written using the algorithm of gamma distribution function when the values for α and β were fitted into the program showed, that it has a good predictive ability both at individual and stand levels as it was able to predict the basal area of a tree at a given diameter at breast height, since there was no significant difference between the observed and predicted values obtained. This is in line with Liu *et al.*, (2002) who stated that gamma distribution has the ability to fit various empirical distributions.

The observed and predicted values of the basal area from the Java program written, are summarized in **Tables 3** and **4** (side 129).

**Table 3.** Basal area estimates of α and β at stand level.

| Year | Mean Basal Area ($m^2$) | Standard Error | α | β |
|---|---|---|---|---|
| 2000 | 2.76 | 8.64 | 2.67 | 1.05 |
| 1998 | 2.55 | 8.79 | 1.04 | 2.34 |
| 1989 | 3.47 | 7.64 | 2.90 | 1.54 |
| 1952 | 3.69 | 11.98 | 1.14 | 3.11 |

There is no significant difference in the observed and predicted basal area values both at individual tree and stand level.

Trees with greater basal area have lower error rate in the predicted values and lower with greater precision in larger trees. Trees with larger diameter have a decisive effect on the formation of forest microclimate and creation of patches. Their presence frequently determines qualification of stands into definite stage and phase of development. An important and logically convincing idea to check model compatibility is based on predictive simulations, which suggests that a model is compatible if it provides the prediction in accordance with the patterns given in the observed data.

The result of the Java program written, based on the algorithm of gamma distribution function showed, that it has good predictive ability as it was able to predict basal area of a tree at a given diameter at breast height both at individual tree and at stand levels, *i.e*. the observed and predicted values were not significantly different. Therefore, it is recommended for use in the forest reserve.

**Table 5.** Observed and predicted basal area at Stand level

| Year | Observed Mean Basal Area ($m^2$) | Predicted Basal Area ($m^2$) | Error rate % |
|---|---|---|---|
| 2000 | 2.76 | 2.79 | -1.04 |
| 1998 | 2.55 | 2.58 | -0.98 |
| 1989 | 3.27 | 3.46 | 0.38 |
| 1952 | 3.69 | 3.69 | -0.10 |

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**Table 2.** Basal area estimates of α and β at individual tree level

| PLOT NO. | YEAR 2000 | | | | YEAR 1998 | | | | YEAR 1989 | | | | YEAR 1952 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean Basal Area ($m^2$) | Standard error | α | β | Mean Basal Area ($m^2$) | Standard error | α | β | Mean Basal Area ($m^2$) | Standard error | α | β | Mean Basal Area ($m^2$) | Standard error | α | β |
| 1 | 2.88 | 39.70 | 0.56 | 5.01 | 2.98 | 19.56 | 2.32 | 1.28 | 3.43 | 20.43 | 2.81 | 1.21 | 3.08 | 19.44 | 1.67 | 1.84 |
| 2 | 2.57 | 40.87 | 0.44 | 5.84 | 2.85 | 48.16 | 0.35 | 8.14 | 3.37 | 26.91 | 0.39 | 2.14 | 3.44 | 36.46 | 0.89 | 3.85 |
| 3 | 2.60 | 27.67 | 0.80 | 3.23 | 3.27 | 29.98 | 1.08 | 3.01 | 3.08 | 30.76 | 1.11 | 2.76 | 3.00 | 33.98 | 0.65 | 4.61 |
| 4 | 2.69 | 19.83 | 1.42 | 1.89 | 2.98 | 15.93 | 2.61 | 1.23 | 3.30 | 14.09 | 4.58 | 0.72 | 4.51 | 39.23 | 0.94 | 4.77 |
| 5 | 2.49 | 23.03 | 0.83 | 2.98 | 2.62 | 17.90 | 1.95 | 1.34 | 3.71 | 15.09 | 6.07 | 0.61 | 4.27 | 45.81 | 0.72 | 5.89 |
| 6 | 2.74 | 16.08 | 2.08 | 1.32 | 1.75 | 26.39 | 0.36 | 4.77 | 3.33 | 20.58 | 2.01 | 1.65 | 3.84 | 24.83 | 1.84 | 2.08 |
| 7 | 3.13 | 8.86 | 10.44 | 0.30 | 1.96 | 29.09 | 0.45 | 4.31 | 3.65 | 29.70 | 1.52 | 2.41 | 4.26 | 55.15 | 0.54 | 7.84 |
| 8 | | | | | 2.49 | 14.10 | 2.41 | 1.03 | 3.93 | 17.18 | 4.75 | 0.82 | 3.10 | 20.66 | 1.87 | 2.04 |

**Table 4.** Observed and Predicted Basal area at individual tree level

| PLOT NO. | YEAR 2000 | | | YEAR 1998 | | | YEAR 1989 | | | YEAR 1952 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Observed Mean Basal Area ($m^2$) | Predicted Basal Area ($m^2$) | Error rate % | Observed Mean Basal Area ($m^2$) | Predicted Basal Area ($m^2$) | Error rate % | Observed Mean Basal Area ($m^2$) | Predicted Basal Area ($m^3$) | Error rate % | Observed Mean Basal Area ($m^2$) | Predicted Basal Area ($m^2$) | Error rate % |
| 1 | 2.82 | 3.04 | -7.70 | 2.98 | 2.83 | 4.84 | 3.43 | 3.34 | 2.55 | 3.08 | 3.19 | -3.50 |
| 2 | 2.57 | 2.97 | -15.45 | 2.85 | 3.28 | 15.27 | 3.37 | 3.84 | -13.76 | 3.44 | 3.43 | 0.26 |
| 3 | 2.60 | 2.85 | -9.59 | 3.27 | 3.49 | -6.70 | 3.08 | 3.79 | -23.09 | 3.00 | 3.36 | 12.14 |
| 4 | 2.69 | 2.81 | -4.16 | 2.98 | 2.83 | 5.03 | 3.30 | 3.11 | 5.88 | 4.51 | 4.29 | 4.99 |
| 5 | 2.49 | 2.45 | 1.64 | 2.62 | 2.70 | -3.19 | 3.71 | 3.67 | 1.13 | 4.27 | 4.31 | -0.88 |
| 6 | 2.74 | 2.81 | -2.42 | 1.75 | 1.55 | 11.03 | 3.33 | 3.18 | 4.33 | 3.84 | 3.81 | 0.93 |
| 7 | 3.13 | 3.18 | -1.34 | 1.96 | 2.10 | -7.02 | 3.65 | 3.70 | -1.37 | 4.26 | 4.10 | 3.73 |
| 8 | | | | 2.49 | 2.40 | 3.54 | 3.93 | 3.98 | -1.43 | 3.10 | 3.54 | -14.35 |