



**ANALYSIS OF TREE VOLUME EQUATIONS FOR  
CHERUL FOREST RESERVE, TERENGGANU**



**MASTER OF SCIENCE IN  
INFORMATION AND COMMUNICATION TECHNOLOGY**

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## **Faculty of Information and Communication Technology**



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**Master of Science in Information and Communication Technology**

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CHERUL FOREST RESERVE, TERENGGANU**

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## DECLARATION

I declare that this thesis entitled “ Analysis of Tree Volume Equations for Cherul Forest Reserve, Terengganu ” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 23 September 2021

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## APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Information and Communication Technology.

Signature :   
Supervisor Name : Associate Professor Dr. Sharifah Sakinah  
Binti Syed Ahmad  
Date : 23 September 2021

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## DEDICATION

I dedicate this research work to my backbone, Tukiah Sulaiman and Mohd Mushar Mohd Tabree, and my fiancée for the endless support and unconditional love that keeps me standing firm until today. Distance does not matter as their prayers accompany me throughout this journey, especially the power of my Mother's duas that are getting me through it all in this world. May Allah bless them endlessly.



## ABSTRACT

With the forestry and logging activities contributing to 5.4% of the agricultural sector in the Malaysia's 2019 GDP growth, this had thus implied the forest as having a significant role in national growth and the critical need of a precise tree volume estimation. Other than that, the forest also plays a pivotal role in forest management and administration as the tree volume assessment is a key element in the establishment of an efficient forest management plan for long-run sustainability. It has been highlighted in the 38th Majlis Urusan Hutan dan Silvikultur (MAJURUS) where each Forest Management Unit (FMU) is preferable to have their own local volume table. Research has therefore been conducted to be align with the issue highlighted by MAJURUS as the current practice by the Forestry Department Peninsular Malaysia (FDPM) is that the same volume table been used throughout all forest reserves in Malaysia and there is also a limited number of study performed on developing a volume table. Therefore, this research is to fill the gap by performing the development and validation of local and standard volume model for Malaysia's forest reserve. Briefly, a volume table can be developed through several ways and one of it is by deriving from the volume function. In this research, the performance of several log formulas against several log sectional lengths will be tested. Results of the assessment show that Huber of 2 m log sectional length is the best as it recorded the least bias and lowest value of mean square error (MSE). The development of local and standard volume model is then performed by using one of the most powerful tools in analyzing the data of natural and physical sciences, which is regression analysis. The regression analysis consists of two phase which is relationship testing and volume equation modelling. 15 volume models were tested and the performance of each model will be assessed from the result of several statistical tests. The developed local and standard volume model is then validated against the current volume table practiced by the FDPM and developed volume table by the previous scholar for one of the secondary growth forest in Malaysia. The finding from the research found that the current volume table practiced by the FDPM tends to overestimate the estimation for diameter at breast height (DBH) that is greater than 40 cm which represented by 89.16% while the constructed volume models in this study have a higher accuracy level than the previous scholar as it records 0.1565 of root mean square error (RMSE) lower than the previous scholar. Hence, this is clearly shown that the current volume table practiced by the FDPM is less reliable to be used for all forest reserves in Malaysia and there is a significant difference between the volume model developed for a different forest reserve. This is therefore in alignment with the issue highlighted by the MAJURUS.

**ANALISIS PERSAMAAN ISIPADU POKOK UNTUK  
HUTAN SIMPAN CHERUL, TERENGGANU**

**ABSTRAK**

*Dengan aktiviti perhutanan dan pembalakan yang telah menyumbang sebanyak 5.6% daripada sektor pertanian dalam pertumbuhan KDNK 2018 di Malaysia jelas menunjukkan bahawa hutan mempunyai peranan yang penting dalam pertumbuhan negara dan keperluan terhadap anggaran jumlah isipadu pohon yang tepat adalah sangat penting. Selain itu, hutan juga memainkan peranan penting dalam pengurusan hutan dan pentadbiran kerana penilaian isipadu pokok yang tepat merupakan kunci utama dalam penubuhan pelan pengurusan hutan yang cekap untuk kemampuan jangka panjang. Telah diketengahkan juga di dalam mesyuarat Majlis Urusan Hutan dan Silvikultur (MAJURUS) yang ke-38 di mana setiap Unit Pengurusan Hutan (FMU) disarankan untuk mempunyai jadual isipadu balak yang tersendiri. Oleh hal yang demikian, penyelidikan telah dijalankan dan mendapati bahawa amalan semasa adalah bertentangan dengan saranan pihak MAJURUS di mana, Jabatan Perhutanan Semenanjung Malaysia (FDPM) telah menggunakan jadual isipadu balak yang sama terhadap kesemua hutan simpan di Malaysia dan bilangan kajian pembangunan jadual isipadu balak adalah sangat terhad. Oleh itu, kajian ini adalah untuk mengisi jurang yang ada dengan melaksanakan pembangunan dan pengesahan model isipadu tempatan dan standard untuk hutan simpan di Malaysia. Secara ringkasnya, jadual isipadu balak boleh dibangunkan melalui beberapa cara dan salah satunya adalah dengan memperoleh daripada fungsi kelantangan. Dalam penyelidikan ini, prestasi beberapa formula balak terhadap beberapa panjang keratan balak akan diuji. Hasil kajian menunjukkan bahawa formula Huber dengan 2 m panjang keratan balak adalah yang terbaik kerana ia mencatatkan nilai bias yang paling kecil dan nilai MSE yang terendah. Pembangunan model isipadu tempatan dan standard dilakukan dengan menggunakan salah satu alat yang paling kuat dalam menganalisa data sains alam dan fizikal iaitu analisis regresi. Analisis regresi terdiri daripada dua fasa iaitu pengujian perhubungan dan pemodelan persamaan kelantangan. 15 model isipadu telah diuji dan prestasi setiap model isipadu ini akan dinilai daripada beberapa ujian statistik. Model isipadu tempatan dan standard yang dibangunkan kemudiannya divalidasi terhadap jadual isipadu balak semasa yang digunakan oleh pihak FDPM dan juga jadual isipadu balak yang telah dibangunkan oleh sarjana terdahulu untuk salah satu hutan pertumbuhan menengah di Malaysia. Hasil daripada penyelidikan mendapati bahawa jadual isipadu balak semasa yang diamalkan oleh FDPM adalah cenderung untuk berlebihan dalam anggaran isipadu bagi pokok yang mempunyai ukurlilit (DBH) yang lebih besar daripada 40 cm yang diwakili oleh 89.16%, manakala model isipadu yang dibina dalam kajian ini mempunyai tahap ketepatan yang lebih tinggi daripada sarjana terdahulu kerana ia mencatatkan nilai RMSE yang lebih rendah daripada sarjana terdahulu sebanyak 0.1565. Justeru, ini jelas menunjukkan bahawa jadual isipadu balak semasa yang diamalkan oleh FDPM untuk kesemua rizab hutan di Malaysia adalah kurang tepat dan terdapat perbezaan yang ketara antara model isipadu untuk simpanan hutan yang berlainan. Oleh itu, ini adalah sejajar dengan isu yang diketengahkan oleh MAJURUS.*



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## LIST OF SYMBOLS AND ABBREVIATIONS

CFC		Cherul Forest Concession
CPRF	-	Cherul Permanent Forest Reserve
D, d	-	Diameter
Dip	-	Dipterocarp
DBH	-	Diameter at Breast Height
FAO	-	Food and Agriculture Organization of the United Nations
FI	-	Furnival's Index
FDPM	-	Forestry Department Peninsular Malaysia
FMU	-	Forest Management Unit
FRIM	-	Forest Research Institute Malaysia
H, h	-	Log Length
MAJURUS	-	Majlis Urusan Hutan dan Silvikultur
ML	-	Machine Learning
MSE	-	Mean Square Error
Non-dip	-	Non-dipterocarp
PRF	-	Permanent Forest Reserve
SD	-	Standard Deviation
SE	-	Standard Error
V, v	-	Volume

## LIST OF PUBLICATIONS

### Journal with Impact Factor

Mushar, S.H.M., Ahmad, S.S.S., Kasmin, F. and Kasmuri, E. 2019. Flood Damage Assessment: A Preliminary Study. *Environmental Research, Engineering and Management*, 75(3). (Scopus indexed, Q4, IF = 0.19 (2019))

### Indexed Journal

N/A

### Non-Indexed Journal

Mushar, S.H.M., Ahmad, S.S.S., Kasmin, F. and Shari, N.H., 2019. A Comparative Study of Log Volume Estimation by Using Statistical Method. *EDUCATUM Journal of Science, Mathematics and Technology (EJSMT)*, 7(2).

### Conference Proceedings

Mushar, S.H.M., Ahmad, S.S.S., Kasmin, F. and Shari, N.H., 2019. Machine Learning Approach for Estimating Tree Volume. In *Journal of Physics: Conference Series* (Vol. 1449). IOP Publishing.

## CHAPTER 1

### INTRODUCTION

#### 1.1 Research background

The United Nations Environmental Programme (UNEP) and Food and Agriculture Organization of the United Nations (FAO) (2020) reported that in 2020, 30.8% of the world's terrestrial surface was covered by forest. However, surprisingly, in a recent study conducted by FAO towards global forests, resources reported that there is a gradual decline in the number of world forest areas between 1990 and 2020. This issue has received considerable critical attention by the United Nation Framework Convention on Climate Change (UNFCCC). In 2014, UNFCCC constructed the Reducing Emission from Deforestation and Forest Degradation (REDD+) program introducing two new mechanisms, one being the management of forest issues (United Nations Framework Convention on Climate Change (UNFCCC), 2014).

A vast amount of literature has also been published on the importance of forests. Henry et al. (2011), Kuyah et al. (2012), Xia et al. (2013), Mugasha et al. (2013) and Brearley et al. (2017) emphasise that forests are one of the important components in the terrestrial ecosystem, which plays a major role in regulating the climate and mitigating against natural disasters. It has also been conclusively shown that forests constitute the largest carbon pools with an estimated amount exceeding 650 billion tons including the carbon content of biomass, deadwood, litter as well as in the soil (United Nations Environmental Programme (UNEP) and Food and Agriculture Organization of the United Nations (FAO), 2020) where green plants consume carbon dioxide for photosynthesis. Hence, the absorption of carbon dioxide will reduce the amount of carbon dioxide gas in the atmosphere and indirectly reducing the risk of the ozone layer thinning and other natural disasters. Besides as a carbon sinker, forests play a pivotal role in the national growth of these

products or any potentially tradable forest activities which not only benefits rural society but the whole country (Food and Agriculture Organization of the United Nations (FAO), 1997; Xia et al., 2013; Brearley et al., 2017).

Along with the growth of forest activities, there should also be increasing concern placed over forest management plans in all countries, including Malaysia. Malaysia, as a tropical country, is characterised by having moist tropical forests. Statistics released depicting Malaysia's primary industry sector in 2019 showed that 54.82% of the country's land area was covered by forest. The timber grown in Malaysia has high commercial value amongst Southeast Asian countries and reports show that the revenue gained from the export activities in 2019 was around RM 7.51 billion (Forestry Department Peninsular Malaysia (FDPM), 2019). Regarding the significance of the timber, the Sustainable Forest Management (SFM) system adopted by Malaysia in 1901, maintains this sustainable resource from disturbance or even worst, from depletion (Malaysian Timber Council, 2016). The Selective Management System (SMS) is one of the framework constructs under SFM, which plays a key role in optimising the country's expenditure in preserving forests, but at the same time, gaining value from this resource.

The previous study by Van Tuyl et al. (2005) (as cited in Sisay et al., 2017) highlighted that there are several ways to evaluate the feasibility of forests, part of it is the evaluation through the value of its volume, biomass and net primary production (NPP). The volume of wood is the quantification of either an individual log, tree or group of trees in cubic value (Food and Agriculture Organization of the United Nations (FAO), 1997). The emphasis in having a precise value of tree volume is highlighted by Jr. and Wood (1993), Shari et al. (2010) and Mate (2016) where it plays a vital role in forest management and administration. As such, in-depth knowledge of volume table development is vital for sustainable forest management because forests are widely acknowledged as one of the main contributors to economic development. Dilworth (1980) define volume table as the quantification of the mean content of a tree or even the entire community of tree species based on the provided tree dimensions such as the diameter and height which is

represented in a tabular form. Accordingly, the volume table is seen as one of the important elements in assessing the current economic condition of one's country (Sandrasegaran, 1972; Kumar, 2015).

However, despite the importance of the volume table, there remains scant research on volume table development, although there are some cases where the volume table adopted by some countries are out-dated. The issues experienced in Korea are highlighted in the study by Lee (2015), where the volume table, widely used in Korea, has been developed by the Korea Forest Research Institute in 2012. Interestingly, China is also facing similar problems as Korea. Xia et al. (2013) highlighted that the volume table used as a reference by the timber industry in China, are those that were constructed in the past three decades and more precise, it was developed in the late 1970s as mentioned by Liu et al. (2019). However, the urgency in developing a new volume table is also driven by the fact that the forest structure will change over time with a high probability of underestimation or overestimation in the volume assessed. This fact was also highlighted by Kang et al. (2015) towards *Pinus rigida* Miller, the third-largest species planted in South Korea, which illustrates just how important the volume table is. Meanwhile, in the paper written by Liu et al. (2019) did mentioned that the volume table assessment should be re-visit once in every two decades as per regulated by the China government. This is to corroborate the veracity of the volume table as there will be difference in the climate and site condition between now and 20 years later.

Malaysia is facing the same problem as China and Korea. According to experts, the volume table used in Malaysia is the same one that was developed several decades ago and continues to be used throughout all states in Malaysia. Some of Malaysia's forests have approached their second rotation felling such as the Tekam Forest Reserve, Pahang and Keledang Saiong Forest Reserve in Perak. The analysis undertaken throughout the development of the volume table in Malaysia discovered that there are two recent published volume table developed for Panti Forest Reserve, Johor (Shari et al. 2010) and Sungai Merbok Forest Reserve, Kedah (Aman and Parlan, 2020).

Given the forest structure will change over time, the volume assessment using the existing volume table will have a high probability of underestimation or overestimation.

Accordingly, based on the above discussion, the focus of this research is on the construction of a local volume table applied at one of the permanent forest reserves in Terengganu, the Cherul Permanent Forest Reserve (CPFR). In 2019, Terengganu gained a total revenue of RM 34.6 million from the forestry sector (Terengganu State Forestry Department, 2019). CPFR is a secondary growth type forest located in the southern part of Terengganu, representing around 6.84% of the total volume of the permanent forest reserve area in Terengganu (Terengganu State Forestry Department, 2019).

The figure below shows the location of the permanent forest reserves for Cherul.

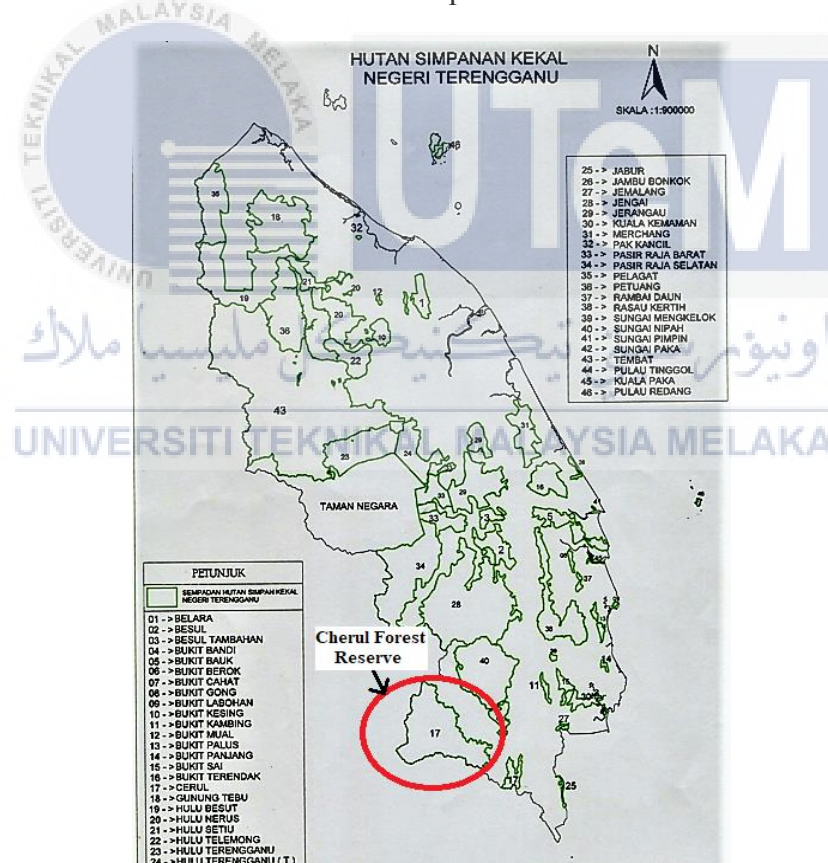


Figure 1.1 : Position of the Cherul Permanent Forest Reserve (CPFR) in Terengganu

## 1.2 Problem statement

The assessment of tree volume is a key element in the establishment of the annual allowable cut (AAC) since it will indicate the production yield and standing of a particular forest (Shari et

al., 2010; Mohd. et al., 2015). The need to have a precise value of tree volume is highlighted by Shari et al. (2010), where it plays a vital role in forest management and administration.

There has been growing interest in the research for tree volume, but at this stage, limited studies have been undertaken on the development of the volume table for Malaysian rainforests. Simply put, a volume table is a tabulation of the mean volume of trees, logs or even sawn timber against one or more features which can be derived from the volume functions. Mohd et al. (2015) highlighted the importance of the volume table given it plays a significant role in structuring the forest management plan and forest harvesting. As a country located at the equatorial latitude lines, Malaysia, as with several other countries has moist tropical rainforests with total rainfall up to 3900 mm for Peninsular Malaysia and 3100 mm and 4600 mm for Sabah and Sarawak respectively (Malaysian Meteorological Department, 2019). These factors drive the need of having a volume table, as a precise method in the assessment of tree volume, as claimed by Shari et al. (2010). However, the structure of trees in these tropical rainforests, having dense vegetation, will consequently increase the difficulty in quantifying the tree data.

The significance of the volume table has also been emphasised by Majlis Urusan Hutan dan Silvikultur (MAJURUS) in its 38<sup>th</sup> meeting where each Forest Management Unit (FMU) should have their own local volume table (Shari et al., 2010). This is also because each forest differs from another forest in terms of its forest type, and each forest type is different in terms of their corresponding altitude, flora composition, climate, soil and biotic (Yusof et al., 2010).

In brief, MAJURUS is the highest technical forum in Forestry Department Peninsular Malaysia (FDPM) that is responsible for reviewing and formulating forestry and silvicultural management techniques for the sake of uniform implementation in Peninsular Malaysia. The council will meet at least once a year and it will be led and secretarise by the deputy director-general of forestry (operations) and director of the Silviculture & Forest Biodiversity Conservation unit of the state forestry office respectively. The members are comprises of the following:

- i- the director of forest management unit