



Faculty of Engineering

**BIOMASS CONVERSIONS FROM AGRICULTURE WASTES;  
POTENTIAL OF BIOMASS RESOURCES IN SARAWAK**

Liew Fui Fath

TP  
339  
L722  
2006

Bachelor of Engineering with Honours  
(Mechanical Engineering and Manufacturing Systems)  
2006

**BORANG PENGESAHAN TESIS**

**Judul: BIOMASS CONVERSIONS FROM AGRICULTURE WASTES;  
POTENTIAL OF BIOMASS RESOURCES IN SARAWAK.**

**SESI PENGAJIAN: 2005 - 2006**

**Saya** LIEW FUI FATH

(HURUF BESAR)

mengaku membenarkan tesis ini disimpan di Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dengan syarat-syarat kegunaan seperti berikut:

1. Hakmilik kertas projek adalah di bawah nama penulis melainkan penulisan sebagai projek bersama dan dibiayai oleh UNIMAS, hakmiliknya adalah kepunyaan UNIMAS.
2. Naskhah salinan di dalam bentuk kertas atau mikro hanya boleh dibuat dengan kebenaran bertulis daripada penulis.
3. Pusat Khidmat Maklumat Akademik, UNIMAS dibenarkan membuat salinan untuk pengajian mereka.
4. Kertas projek hanya boleh diterbitkan dengan kebenaran penulis. Bayaran royalti adalah mengikut kadar yang dipersetujui kelak.
5. \* Saya membenarkan/~~tidak membenarkan~~ Perpustakaan membuat salinan kertas projek ini sebagai bahan pertukaran di antara institusi pengajian tinggi.
6. \*\* Sila tandakan (✓)

SULIT

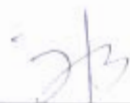
(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972).

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan).

TIDAK TERHAD

Disahkan oleh



(TANDATANGAN PENULIS)



(TANDATANGAN PENYELIA)

Alamat

tetap: NO. 45, JALAN SEBUKU,

94000 BAU, SARAWAK.

PUAN SHANTI FARIDAH SALLEH

( Nama Penyelia )

Tarikh: \_\_\_\_\_

Tarikh: 28/05/06

CATATAN \* Potong yang tidak berkenaan

\*\* Jika Kertas Projek ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa organisasi berkenaan dengan menyertakan sekali tempoh kertas projek. Ini perlu dikelaskan sebagai SULIT atau TERHAD.

# SUPERVISOR APPROVAL SHEET

The following Final Year Project Report:

**Title: BIOMASS CONVERSIONS FROM AGRICULTURE  
WASTES; POTENTIAL OF BIOMASS RESOURCES IN  
SARAWAK.**

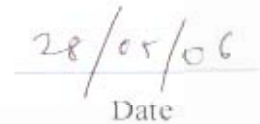
Name of the author: LIEW FUI FATH

Matrix number: 8490

Has been read and approved by:



Mdm. Shanti Faridah Salleh



Date

(Project Supervisor)

611256928

P.KHIDMAT MAKLUMAT AKADEMIK  
UNIMAS



1000165993

Pusat Khidmat Maklumat Akademik  
UNIVERSITI MALAYSIA SARAWAK.

**BIOMASS CONVERSIONS FROM AGRICULTURE WASTES;  
POTENTIAL OF BIOMASS RESOURCES IN SARAWAK**

**LIEW FUI FATH**

**Thesis Submitted to the Faculty of Engineering,  
University Malaysia Sarawak  
as a partial fulfillment of the Degree of  
Bachelor of Engineering with Honours  
(Mechanical Engineering and Manufacturing System)**

**2006**

To my beloved parents and family members.

# ACKNOWLEDGEMENTS

First of all, my deepest gratitude to the Faculty of Engineering, UNIMAS for giving me the opportunity to complete this final year project as the prerequisite for my graduation in Bachelor Degree of Engineering (Honors) in Mechanical Engineering and Manufacturing System.

I would like to take this opportunity to express my deepest thanks to my project supervisor, Madam Shanti, for her valuable advices and guidance throughout the process of completing this project.

Thanks also to the staffs in the Engineering Department and all the laboratory technicians, especially to Mr. Wahab for providing helps and advices when the experiment is being performed.

Deepest thanks to my beloved family, for the unconditional support both morally and financially over the years.

To all my friends and those who helped in making this project a reality, my deepest appreciation goes to all.

# ABSTRACT

Biomass is a naturally renewable resource from biological origin that appears naturally and repeatedly in the earth's surface is considered as a form of stored solar energy through the photosynthesis process in the growing plants. Biomass industries can revitalize rural economies, increasing energy independence, reducing pollution and created job opportunity in the rural area. Malaysian 5<sup>th</sup> Fuel Policy can be achieved, especially in Sarawak due to its abundant large amount of biomass resources mainly from agriculture waste and forestry residues. The potential biomass resources in Sarawak are wastes generate from oil palm, cocoa, paddy, coconut and residues from forestry residues such as woodchips. This project is about the biomass conversions from agriculture wastes and the potential biomass resources in Sarawak. The main concern of this project is to find out the potential biomass resources in Sarawak based on the statistic from the Department of Agriculture Sarawak. The heat value and moisture content of the selected samples is then determined by using bomb calorimeter. The result of the laboratory work could be a useful data to estimate the total potential biomass energy derived from these selected samples. These results also provide useful data as a criterion for the selection of suitable biomass conversions routes which could optimum the bioenergy conversion efficiency.



## ABSTRAK

Biomass adalah sumber tenaga semula jadi yang boleh diperbaharui yang muncul di permukaan bumi. Biomass adalah sejenis simpanan sumber tenaga matahari dalam tumbuhan melalui process fotosintesis. Industri Biomass boleh merangsang ekonomi kawasan luar bandar, mengurangkan kebergantungan kepada sumber tenaga tidak boleh diperbaharui, mengurangkan pencemaran dan menyumbang peluang perkerjaan. Polisi Tenaga Kelima Malaysia boleh dicapai, terutamanya di Sarawak yang mempunyai sumber biomass yang banyak. Sumber biomass yang berpotensi di Sarawak adalah sisa-sisa daripada kelapa sawit, kelapa, koko, padi dan sepihan kayu. Projek ini adalah tentang teknologi petukaran sumber biomass daripada sisa-sisa pertanian dan potensi sumber biomass di Sarawak. Objektif projek ini ialah mengenal pasti sumber biomass yang berpotensi di Sarawak dengan berbandukan statistic daripada Jabatan Pertanian Sarawak. Sumber biomass yang terpilih akan dibawa untuk menentukan 'heat value' serta kandungan kelembapan di dalamnya dengan menggunakan 'bomb calorimeter'. Keputusan eksperimen ini boleh memberi informasi yang berguna untuk mejangka tenaga biomass di Sarawak. Keputusan ini juga memberi informasi berguna sebagai panduan biomass penukaran teknologi yang sesuai untuk sisa-sisa buangan pertanian, di mana pemilihan biomass penukaran teknologi yang sesuai akan mengoptimumkan tenaga biomass.



# TABLE OF CONTENTS

	Page
DEDICATION	i
ACKNOWLEDGEMENTS	ii
ABSTRACT	iii
ABSTRAK	iv
TABLE OF CONTENTS	v
LIST OF FIGURES	viii
LIST OF TABLES	x
<b>CHAPTER 1 INTRODUCTION</b>	
1.1 INTRODUCTION TO BIOMASS	1
1.2 AGRICULTURE AND FORESTRY ACTIVITIES IN MALAYSIA AND SARAWAK	3
1.3 PROBLEM STATEMENT	10
1.4 OBJECTIVE	11
<b>CHAPTER 2 LITERATURE REVIEW</b>	
2.1 BIOMASS RESOURCES: SUSTAINABLE AND RENEWABLE	13
2.2 BIOMASS CONVERSION ROUTES	16
2.2.1 DIRECT COMBUSTION	17
2.2.2 GASIFICATION	18
2.2.3 PYROLYSIS	19
2.2.4 FERMENTATION	19

2.3	CHARACTERISTICS OF BIOMASS RESOURCES	20
2.4	BIOMASS RESOURCES AND BIOMASS ENERGY	22
2.5	BACKGROUND OF AGRICULTURE AND FORESTRY ACTIVITIES IN SARAWAK.	26
2.6	POTENTIAL OF BIOMASS ENERGY IN MALAYSIA	30
<b>CHAPTER 3 METHODOLOGY</b>		
3.1	INTRODUCTION TO METHODOLOGY	34
3.2	DATA COLLECTION	35
3.3	SAMPLES JUSTIFICATION AND SELECTION	36
3.4	SEARCH AND PREPARATION OF SAMLES	37
3.5	LABORATORY WORK AND CALCULATION OF HEAT VALUE AND MOISTURE CONTENT	39
<b>CHAPTER 4 RESULTS AND DISCUSSIONS</b>		
4.1	POTENTIAL OF BIOMASS RESOURCES	41
4.2	THE CALCULATION OF HEAT VALUE	42
	4.2.1 ULTIMATE ANALYSIS	43
4.3	RESULTS FROM LABORATORY WORK	45
	4.3.1 RESULTS FROM CALORIMETRY	45
	4.3.2 MOISTURE CONTENT	49
<b>CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS</b>		
5.1	Conclusion	52
5.2	Recommendations	53

**REFERENCES**

55

**APPENDICES**

- Appendix A : HEAT VALUE OF SELECTED SAMPLES IN DRY BASIS  
Appendix B : Equipment used in Laboratory

# LISTS OF FIGURES

FIGURE NUMBER	PAGE
Figure 1.1: Schematic Representation of Synfuel Production From Biomass.	2
Figure 1.2: Exports of Principal Products in Sarawak (Tonne), 1998-2003	6
Figure 1.3: Production of Crude Palm Oil in Sarawak (Tonne), 1998-2003.	7
Figure 1.4: Estimated Area By Crops in Sarawak (Ha), 1997-2001	8
Figure 1.5: Exports of Rubber, Pepper, Cocoa and Palm Kernel in Sarawak, 1998-2003.	9
Figure 2.1: The Carbon Dioxide (CO <sub>2</sub> ) Cycle	14
Figure 2.2: Photosynthesis Process- The Origin of Biomass	14
Figure 2.3: Main Bioenergy Conversion Routes.	
Figure 3.1: Work Flow Diagram Shows The Sequences of Task To Be Accomplished.	34
Figure 3.2: A Blender, a Gellenkamp Briquette Presser And An Oven.	37
Figure 3.3: Bomb Calorimeter	38
Figure 3.4: Schematic Diagram for Bomb Calorimeter	39

<b>Figure 4.1: Heat Value of Agriculture Wastes and Forestry Residues Obtain From Laboratory Work.</b>	<b>47</b>
<b>Figure 4.2: Moisture Content of Selected Agriculture Wastes And Forestry Residues</b>	<b>50</b>

# LISTS OF TABLES

TABLE NUMBER	PAGE
Table 1.1: Export of Principal Agriculture Products in Sarawak (Tonne), 1998-2003	4
Table 1.2: Planted Area of Main Crops in Sarawak (Ha), 1997-2002	5
Table 2.1: Coal and Waste fuel Properties	21
Table 2.2: Heat Content and CO <sub>2</sub> Emissions of Coal, Oil, Natural Gas and Air-Dry Wood.	22
Table 2.3: Average Heat Content of Selected Fuels	23
Table 2.4: Heat Value of Selected Agriculture Wastes	24
Table 2.5: Estimated Area Distribution by Crop (Ha) in Sarawak, 1998-2002	27
Table 2.6: Forestry Production in Sarawak (000 m <sup>3</sup> ), 1998-2002	27
Table 2.7: Export of Principal Agriculture Products in Sarawak (Tonne), 1998-2003	28
Table 2.8: Potential Bioenergy From Agriculture Wastes And Wood Residues in Malaysia	29
Table 2.9: Potential Biomass Resources from Agro-processing Industrial in 1999	31
Table 4.1: Energy Conversions of Different Units	42



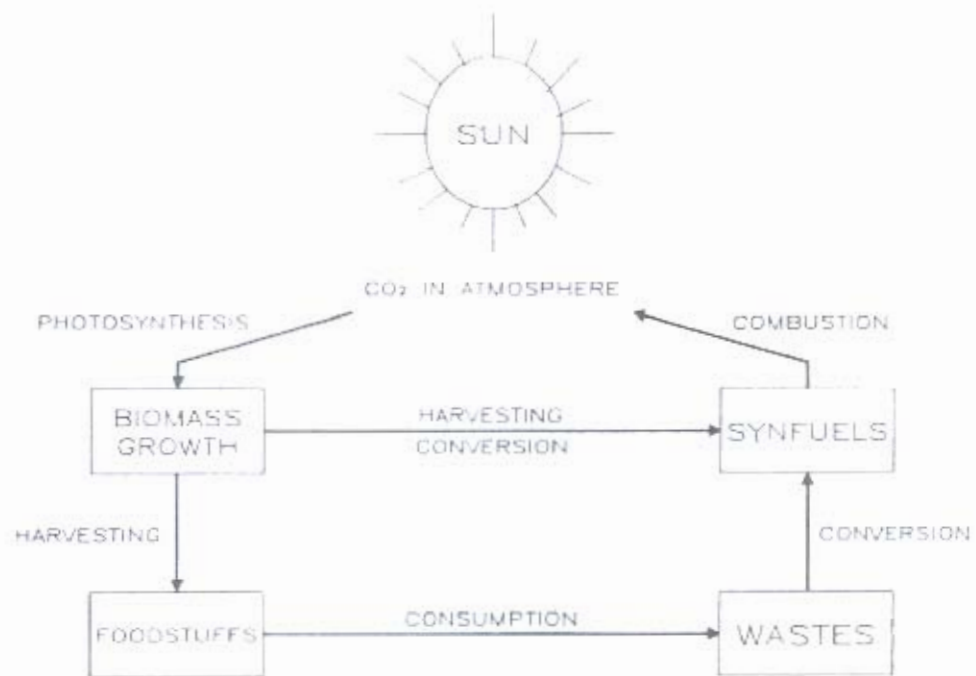
<b>Table 4.2: Ultimate Composition of The Selected Agriculture Wastes</b>	<b>43</b>
<b>Table 4.3: Comparison of the Heat Value of Selected Agriculture Wastes And Forestry Residues in Natural State, Dry Basis and Establish Results Done by Previous Researchers.</b>	<b>46</b>
<b>Table 4.4: Moisture Content of Selected Agriculture Wastes And Forestry Residues.</b>	<b>48</b>

# CHAPTER 1

## INTRODUCTION

### 1.1 INTRODUCTION TO BIOMASS

Biomass, a very broad term is defined as a form of renewable energy from the biological origin material especially the organic matter from growing plants, animal manure, municipal solid waste (MSW) and industrial and forestry residuals on the Earth's surface. According to G.N Tiwari & M.K Ghosal [1], biomass is a naturally renewable resource which implies that it is the part of the flow of resources occurring naturally and repeatedly in the environment. In many ways biomass can be considered as a form of stored solar energy through the photosynthesis process in the growing plants. The term bioenergy is referring to the energy derived from biomass resources such as wood, straw and animal wastes. A fuel is any material that can be burned to release thermal energy and biofuel is the fuel that derived from the biomass resources. The concept of production of synfuel derived from biomass resources is represented in **Figure 1.1** below.



**Figure 1.1: Schematic Representation of Synfuel Production From Biomass. [2]**

As fossil fuels prices increase and global warming due to excessive emission of greenhouse gas from coal power plant, finding new energy sources became increasingly important. Moreover these fossil fuels will be exhausted very soon. Therefore, technologies on renewable energy such as bioenergy, wind energy, solar energy, geothermal and hydro energy have to develop.

Biomass can be converted to useful energy through various biomass conversion technologies, such as direct combustion, fermentation, gasification and pyrolysis. Biomass can be burned to produce steam for making electricity, or to provide heat to industries and homes. Biomass also can be converted to other usable forms of energy

called biofuel like methane gas or transportation fuels like ethanol and biodiesel through various biomass conversions technologies such as gasification and fermentation.

Biomass is an important source of energy in developing countries. In ASEAN (Association of South East Asian Nations), energy from biomass such as wood and agricultural residues represents about 40% of its total energy consumption. According to Food and Agriculture Organization of United Nations (FAO) [3], for the five ASEAN countries (Indonesia, Malaysia, Philippines, Thailand and Vietnam) biomass consumption increased on average 2% per year between 1985 and 1994, due mainly to population growth. Despite this growth, the share of biomass energy in total energy consumption in ASEAN nations has been decreasing due to the great depends on fossil fuel.

In the Eighth Malaysian Plan, Malaysian Government has commended formulating a new energy policy to include utilizing renewable energy (excluding hydroenergy) as a fifth energy resource[4]. Biomass energy has the potential to supply a significant portion of Malaysia's energy consumption since Malaysia produce million tones of wastes annually, mainly from the agriculture wastes and forestry residues. Moreover, with proper management, biomass industries can revitalize rural economics, increasing energy independence, reducing pollution and created job opportunity in the rural area.

## 1.2 AGRICULTURE AND FORESTRY ACTIVITIES IN MALAYSIA AND SARAWAK

Malaysia is well known for its agriculture activities and agro-industrial business. Malaysia is the largest palm oil producer in 1994, produced about 51% of the of world production of palm oil. Sarawak as the largest state in Malaysia, have the largest agriculture land use. Major agriculture commodities in Sarawak are oil palm, rubber, coconut, cocoa, paddy and pepper. The major export of principal agriculture products from Sarawak and the planted area of main crops in Sarawak are shown in the **Table 1.1** and **Table 1.2**.

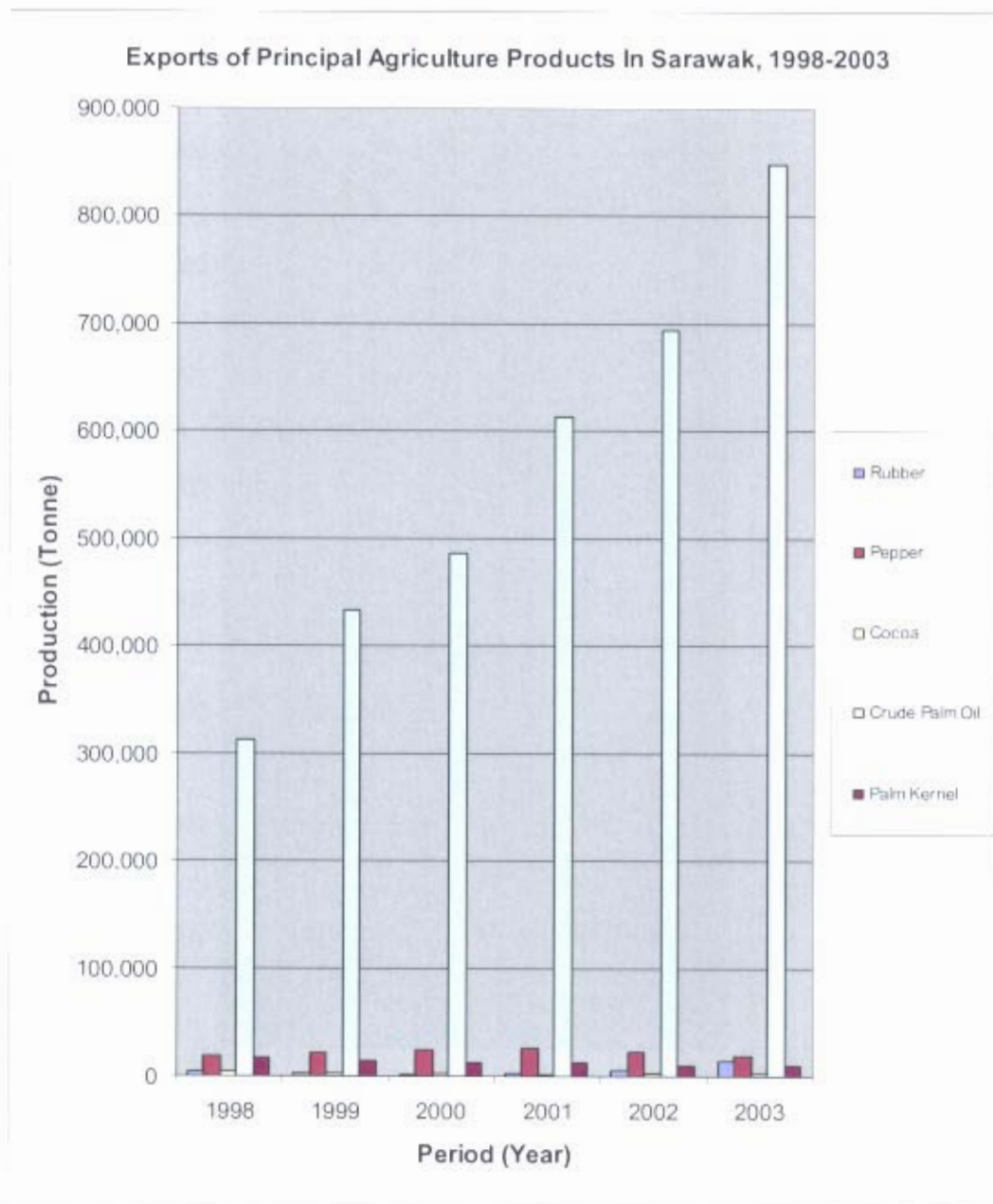
**Table 1.1: Export of Principal Agriculture Products in Sarawak (Tonne), 1998-2003.**

Year	Rubber	Pepper	Cocoa	Crude Palm Oil	Palm Kernel Oil
1998	4688	18888	4467	313469	17767
1999	2731	22131	3583	433768	14591
2000	1808	24033	3176	487640	13001
2001	2704	25897	1518	613410	12369
2002	5247	23225	2496	694144	9787
2003	15049	19023	2583	847818	10417

**Table 1.2: Planted Area of Main Crops in Sarawak (Ha), 1997-2002**

Main Crops	1997	1998	1999	2000	2001	2002
Rubber	173567	174993	170172	168523	169542	149729
Pepper	10178	11373	12196	13327	13555	13644
Paddy	126500	127614	131608	130881	124644	127634
Sago	59467	58041	60550	60709	61523	
Coconut	25590	25683	26334	25578	25186	24847
Oil Palm	147007	248430	320476	330387	374828	414260
Cocoa	16031	13283	10895	6832	5731	4688
Fruits	34944	36714	36538	36997	35455	
Vegetables	4639	4627	4456	3045	2827	





**Figure 1.2: Exports of Principal Products in Sarawak (Tonnes), 1998-2003**

Production of Crude Palm Oil in Sarawak, 1998-2003

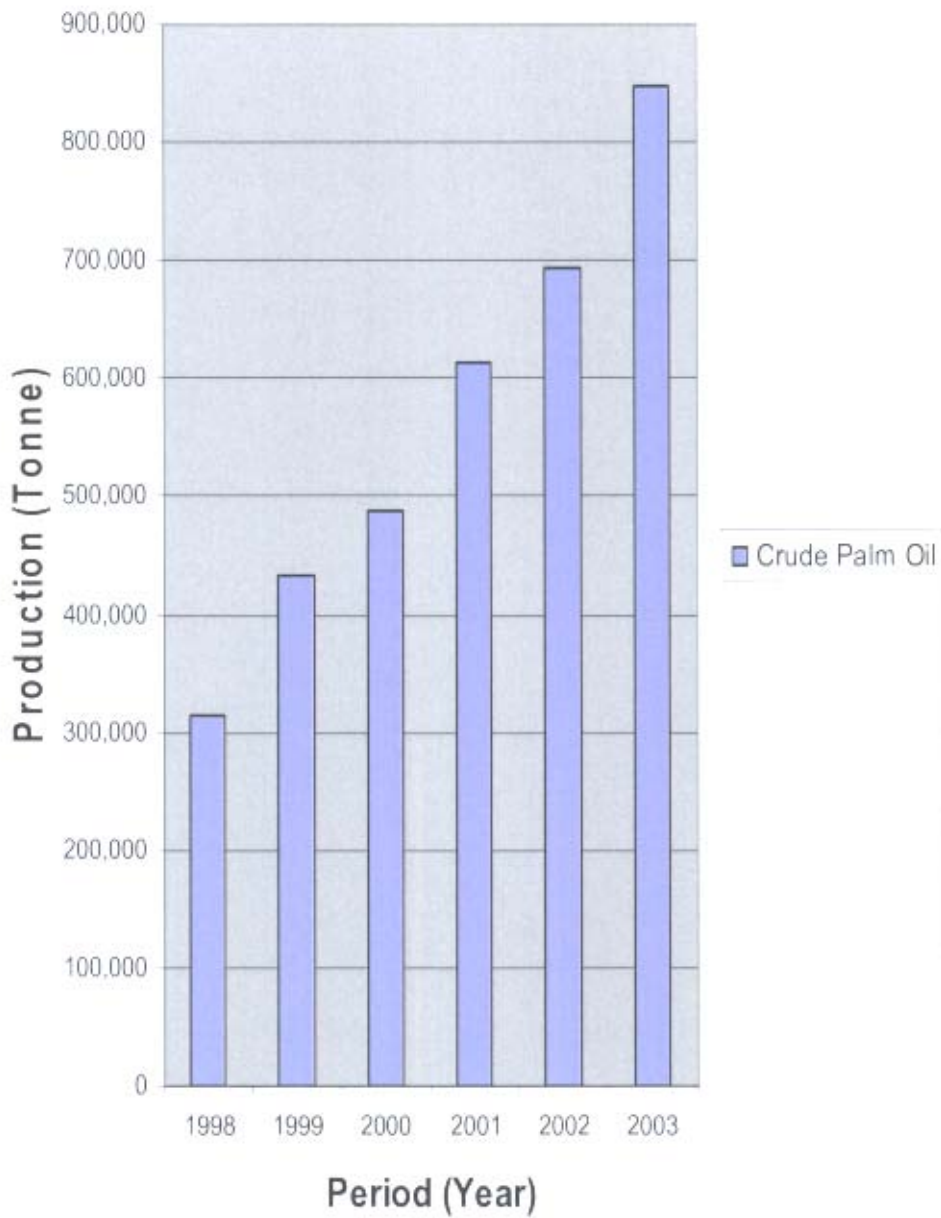


Figure 1.3: Production of Crude Palm Oil in Sarawak (Tonne), 1998-2003.

Estimated Area By Crops In Sarawak From 1997 To 2001

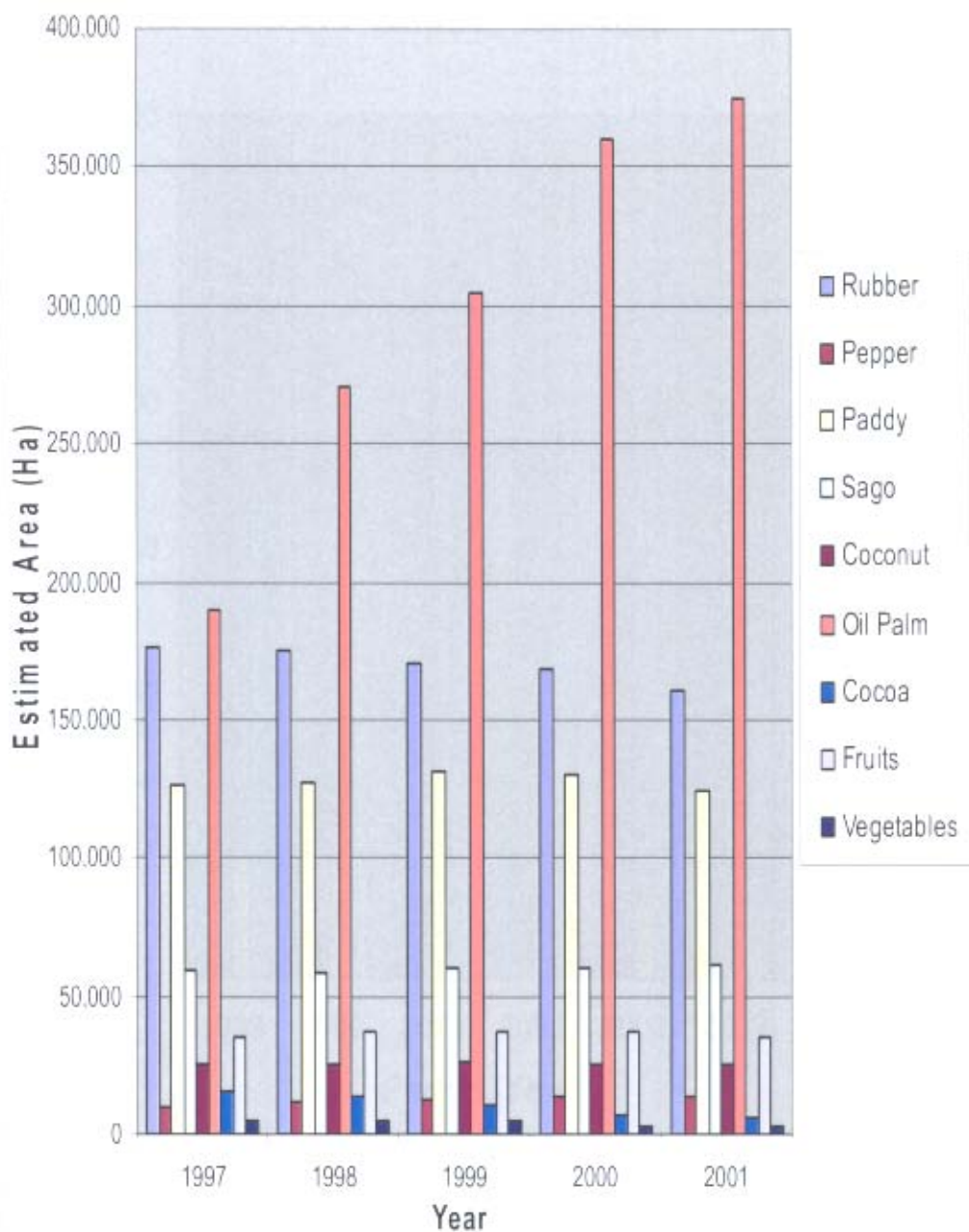


Figure 1.4: Estimated Area By Crops in Sarawak (Ha), 1997-2001

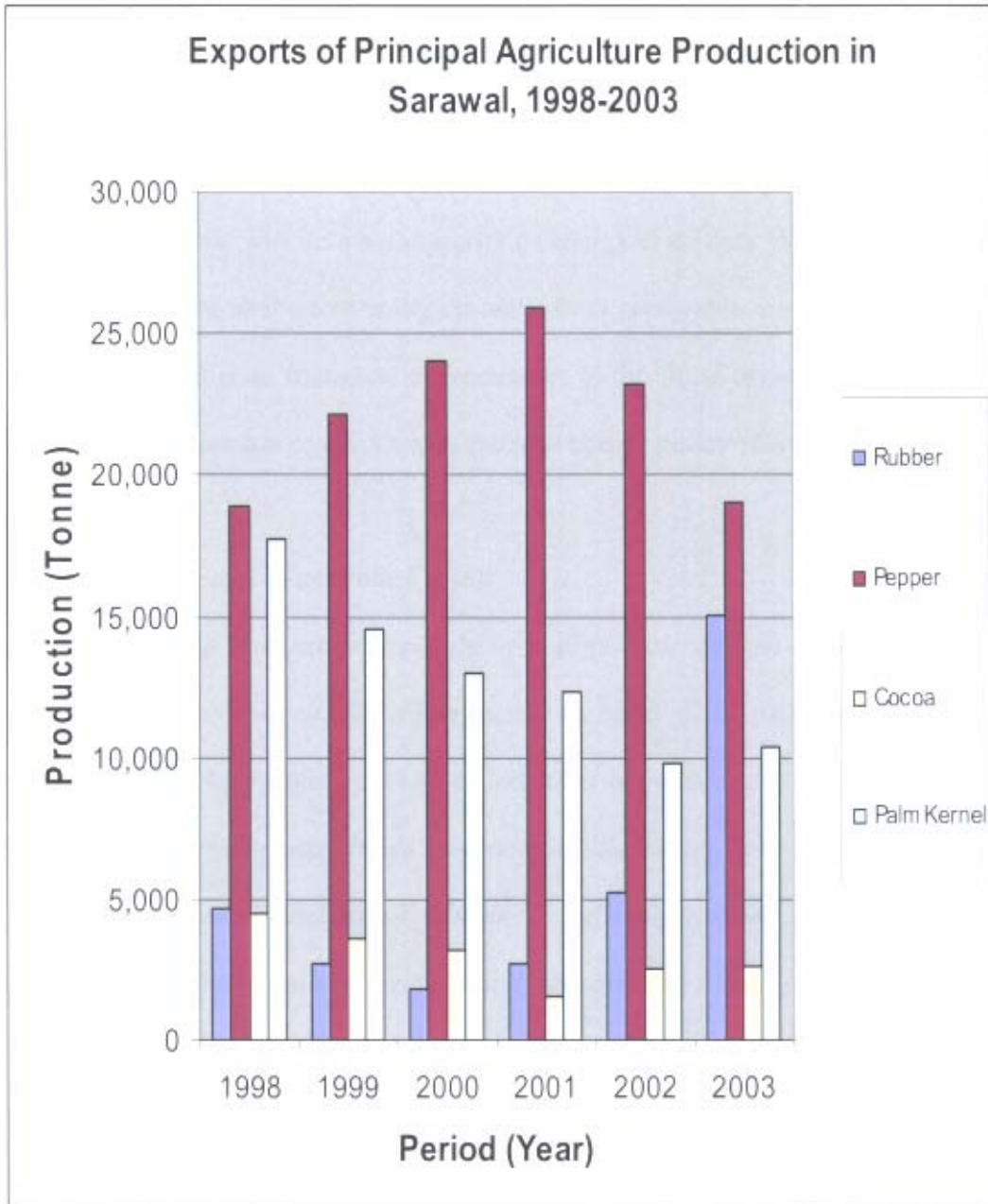


Figure 1.5: Exports of Rubber, Pepper, Cocoa and Palm Kernel, 1998-2003.

Sources: Statistical Year Book, Department Of Agriculture Sarawak, 2003