UNIVERSITI PUTRA MALAYSIA

STATE LEVEL LOG PRODUCTION PLANNING USING LINEAR PROGRAMMING

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By

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LIST OF ABBREVIATIONS

Abbreviation

AIFM	: ASEAN Institute of Forest Management
cu. m	: cubic meter
cm	: Centimeter
dbh	: Diameter Breast Height
FAO	: Food and Agriculture Organization
FDPM	: Forestry Department Peninsular Malaysia
FFIDP	: Forestry and Forest Industries Development Project
GF	: Good Forest
GI	: Growth Index
G.Vol.	: Gross Volume
ha	: Hectare
IBM	: International Business Machine
IUFRO	: International Union of Forest Research Organization
LOGPROD	: Log Production Planning Model
LP	: Linear Programming
LPPM	: Log Production Planning Method
LRSY	: Long Range Sustainable Yield
MEM	: Malaysian Economic Model
MF	: Moderate Forest
MIDA	: Malaysian Industrial Development Authority
MR	: Malaysian Ringgit
NFI II	: National Forest Inventory II

PF : Poor Forest

PFE : Permenent Forest Estate

SF : Superior Forest

SLF : Stateland Forest

SR : Survival Rate

STANDPROJ: Stand Projection Model

sq. m : Square meter

UNIDO : United Nations Industrial Development Organization

YEAL : Year Elapsed After Logging

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This study aims to develop a log production planning model and to apply it at State-level planning. In the near future, Malaysia will have to rely more and more on the Permanent Forest Estate (PFE), after the Stateland forests have all been converted for agricultural development. A more efficient and effective log production planning model is essential to ensure that the forestry sector continues to contribute to the socio-economic development of the country.

A Log Production Planning Model (LPPM) was developed, consisting of a stand projection (STANDPROJ) model and a Linear Programming (LP) (LOGPROD) model. Data for the models were

collected from the State of Negeri Sembilan. STANDPROJ estimates forest yield which are used, together with forest areas and forest management policies, to generate an LP problem matrix in LOTUS spreadsheet. The matrix is accessed and solved by an LP optimizer. The optimizer also transmits the solution back to LOTUS which acts both as a matrix generator and report writer.

LPPM forecasted that the annual log production for Negeri Sembilan would decline from 660,000 cu. m in 1980-1989 period to 460,000 cu. m in period 1 (1990-2000), then declining at 20 percent per decade until period 4. From periods 5 to 7, production fluctuates ±10 percent around a long range sustainable yield (LRSY) of 210,000 million cu. m per year. Inclusion of an additional cutting cycle of 40 years increased log production. Additional information from the LP solution includes the relative importance of the forest types and the lower and upper limit of their sizes for the LP solution to remain valid.

LPPM provides a fast and efficient method of analysing log production and is able to produce a more favorable trend of log production. The model is recommended for implementation at State level. The forecasted log production for Negeri Sembilan shows a declining trend, and additional supply of log production needs to be obtained from forest and rubber

plantations and forests in other States to cater for the State wood-based industry.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi sebahagian daripada syarat keperluan ijazah Master Sains

PERANCANGAN PENGELUARAN KAYU BALAK DI PERINGKAT NEGERI MENGGUNAKAN PROGRAMAN LINEAR

Oleh

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Kajian ini bertujuan untuk menyediakan satu model perancangan pengeluaran kayu balak bagi digunakan di peringkat Negeri. Di masa akan datang pengeluaran kayu balak akan bergantung kepada kawasan Hutan Simpanan Kekal bila Hutan Tanah Kerajaan habis dibangunkan untuk pertanian. Satu model perancangan pengeluaran kayu balak yang cekap dan berkesan diperlukan supaya sektor perhutanan terus menyumbangkan kepada pembangunan sosio-ekonomi negara.

Satu Model Perancangan Pengeluaran Kayu Balak (MPPKB) telah diajukan, mengandungi Model Unjuran Dirian Hutan dan Model Perancangan Pengeluaran Kayu Balak Menggunakan Programan Linear (LP). Maklumat-maklumat bagi model-model tersebut

diperolehi dari Negeri Sembilan. Model Unjuran Dirian Hutan menganggarkan hasil dirian hutan. Hasil ini digunakan bersama keluasan hutan dan polisi pengurusan hutan untuk membentuk matriks masalah LP menggunakan program LOTUS. Masalah ini selanjutnya diselesaikan dengan menggunakan 'optimizer' LP yang juga memasukkan hasil penyelesaian ke dalam LOTUS. Program LOTUS bertindak sebagai 'Penyedia Matriks' dan juga 'Penulis Laporan'.

MPPKB mengunjurkan pengeluaran kayu balak bagi Negeri Sembilan akan menurun dari 660,000 meter padu setahun bagi tempoh 1980-1989 kepada 460,000 meter padu setahun bagi tempoh 1 (1990-2000), dan seterusnya menurun pada kadar 20 peratus sedekad sehingga tempoh 4. Dari tempoh 5 hingga 7, pengeluaran berubah-ubah dalam lingkungan kadar $\pm$10 peratus dari PBJ (Pengeluaran Berkekalan Jangkapanjang) sebanyak 210,000 meter padu setahun. Penggunaan pusingan tebangan tambahan 40 tahun meningkatkan lagi pengeluaran. Maklumat lain yang diperolehi dari MPPKB ialah perbandingan kepentingan jenis-jenis hutan dan had keluasan hutan yang boleh digunakan supaya penyelesaian LP tidak berubah.

Model yang diajukan ini boleh menganalisis pengeluaran balak dengan cepat dan cekap, dan menghasilkan tren pengeluaran balak yang lebih sesuai. Model ini disyorkan supaya dilaksanakan di peringkat negeri. Unjuran pengeluaran kayu balak yang menurun menunjukkan bahawa Negeri Sembilan perlu

mencari sumber lain seperti ladang hutan dan getah serta kayu balak dari negeri lain bagi menampung keperluan industri berasaskan kayu-kayan di negeri tersebut.

CHAPTER I

INTRODUCTION

Problem Statement

Log production planning involves the determination of the timing and extent of forest areas to be harvested and subsequently to regenerate in order to ensure acceptable log production in the short term and sustainable level in the long run. Log production planning is seen as a part of forest sector planning and involves an analysis of the resource supply. The other part of forest sector planning involves an analysis of the utilization, demand or requirements for the forest resource (FAO, 1974a). Both parts are essential for the sound development of the forestry sector. Other terms used to describe log production planning include Timber Management Planning, Harvest Scheduling, Timber Harvest Scheduling, Forest Regulation and Timber Supply Planning and Log Supply Planning.

Malaysia, as a major supplier of tropical timber, needs an efficient and effective method of log production planning. This is important so that the forestry sector will always continue to contribute to national development.

Planning is necessary to ensure that forestry maintains its contribution to socio-economic development and

environmental protection. The forestry sector is one of the major sectors of the Malaysian economy. It contributes to foreign exchange earnings, employment, State revenues, value added and regional development. The sector also offers intangible contribution such as the maintenance of environmental stability, minimizing damage to rivers and agricultural land by floods and soil erosion and the safeguarding of water supplies and conservation of genetic resources. In Malaysia, the major forestry products which include sawlogs, sawntimber, plywood, veneer and moulding have shown an increasing contribution to the country export value from MR 4.7 billion in 1986 to about MR 6.8 billion in 1987. The sector has also provided employment to about 146,000 people in 1987, accounting for about 3 percent of the country's total employment for that year. In Peninsular Malaysia, the forestry sector has contributed about MR 1.8 billion of foreign exchange earnings and employment for 74,517 people in 1987. In 1988, the sector provided employment for 89,347 people and generated about MR 2.1 billion of foreign exchange earnings.

The planning method needs to be improved to plan log production from a gradually shrinking resource base. Over the years logs were produced from both the Permanent Forest Estates (PFE) and Stateland Forests (SLF) in Peninsular Malaysia. In the future, logs will come mainly from PFE, as the SLF are .pa being developed for agriculture and other uses. The Forest Department Peninsular Malaysia forecasted that the reloggable

SLF of 0.91 million hectares in 1984 would all be harvested by the year 1995, based on the planned conversion of 80,939 hectares per year (Thang, 1985, 1986).

From 1986 to 1993, Peninsular Malaysia is forecasted to produce 8.06 million cu. m of logs per year. The log production is expected to decline to 5.99 million cu. m in 1994 when all SLF are expected to have been completely harvested (Thang, 1985, 1986). Efficient planning method is thus needed in light of this forecasted declining log production.

The current practice of log production planning in Peninsular Malaysia employs manual area-control calculations. It does not incorporate detailed yield estimations for the respective forest types. Forests are grouped into areas managed under 30 and 55 years cutting cycle with current as well as future yield of 61.23 and 77.00 cu. m per ha, respectively.

A model is proposed that would provide some improvements to the current practice. It incorporates a stand projection model to refine estimates of future timber yield from the forests. This component of input data has been identified as being the weakest link in past planning models (Yusuf, 1982). It introduces an intermediate cutting cycle of 40 years in addition to 30 and 50 years to provide flexibility in forest management. Linear Programming (LP) is used to provide for a quick and efficient assessment of log production level. It can

be used to conduct a sensitivity analysis of future log production. The model is recommended to be applied to State planning situation to reflect the real situation in Peninsular Malaysia, where the twelve State Governments have the jurisdiction over the forest resources.

Models such as the one proposed in this study are able to regulate the forest in order to achieve sustainable log production volume. It would be useful if the model can prioritize harvests from the forest, for example, the 'oldest stand' first or trees from the best sites first. However, prioritizing of the harvests from the forest is not possible at the moment in Malaysia because the information on age classes and site index are not readily available.

LP is chosen as a technique because it is an efficient and quick way of analysing log production level. It is able to capture the greater part of problem of log production planning and come up with an optimal solution for a given set of assumptions. The problem of allocating forest areas to several alternative management regimes is a typical problem solved by LP. Several runs of the model with different assumptions would help the planner in making decisions. LP's capability is indicated by its wide application for log production planning in North America, Europe, Japan, Australia and Malaysia.

Log production models employing Linear Programming include MAXMILLIAN (Clutter, 1968), Timber RAM (Navon, 1971),

FORPLAN (Johnson and Jones, 1979) and SAM (Field, Wilson and Flowers, 1980). Variation of these models have been applied in Canada (Errico, 1981), Japan (Konohira, 1981), Chile (Barros and Weintraub, 1980) and Taiwan (Yang, Lin, Chen and Wang 1980). Malaysian applications have been described by Yusuf (1982, 1987); Tieh, 1986); Yusuf, Abd. Rahman and Awang Noor (1988); Chai (1988) and Lim, Ferrie and Sim (1988). LP models have been developed in Malaysia for other forestry purposes. These include log transportation models (FAO, 1975; Sandum, 1988; Liew, 1988; Yusuf, Shukri and Vincent, 1988), and mill location model (Khamurudin and Tonga, 1988).

Objective of the Study

This study aims to develop a planning model incorporating Linear Programming and Stand Projection to analyse log production, and to illustrate the operation of the model by applying it to plan log production for the State of Negeri Sembilan.

Scope of the Study

In this study, the number of ha of forest land to be managed by alternative management regimes is determined based on maximization of total log volume production over a 70-year planning horizon. This physical volume production criterion was used instead of discounted revenues, profits, present net values or costs because of lack of data on the economics of forest operations in Malaysia.

The data used in the study are from Negeri Sembilan. The results, therefore, pertain only to that State. However, data from other States could be used in the model to analyse their log production.

Lack of detailed data permitted the forests to be classified into only four productivity classes as in the National Forest Inventory of Peninsular Malaysia. Data on growth and mortality of trees were equally scanty. The simple nature of the stand projection model is because of this.

Both LP and LOTUS spreadsheet programmes are capable of handling more complex problems. Such problems could be constructed after more detailed data are available.

Organization of the Report

The thesis is divided into six chapters. Chapter II, the review of literature, summarises previous works in log production planning using Linear Programming (LP). Methods of log production planning and log production planning using LP are highlighted. Chapter III describes the methodology of study. Chapter IV presents the result of the study. It describes the structure and operation of the planning model, log production pattern for Negeri Sembilan and the sensitivity of forecasted log production for the state. Chapter V discusses special features of the model, comparison of forecasted log production, areas for further research and and

implications of the forecasted log production. Chapter VI highlights the conclusions and recommendations.

CHAPTER II

REVIEW OF LITERATURE

Methods of Log Production Planning

Methods for log production planning could be classified into two major groups: traditional and the modern methods (Yusuf, 1988). The traditional methods include area control, volume control and combination of area-volume control.

Area Control

This approach requires cutting equal areas annually or periodically. The annual harvest area or annual coupe is the total number of hectare of productive forests divided by the cutting cycle or rotation (Leuschner, 1984; Davies and Johnson, 1987). The advantages of this approach are its simplicity, ease of identification of the area on the ground, and its production of a regulated forest. Its disadvantages are the large fluctuation in the level of log production and the need to combine it with some type of volume control for a more meaningful planning exercise.

This approach is widely used in Malaysia. Using this approach, log supply from Permanent Forest Estate in Peninsular Malaysia is planned by classifying the forest into two components and then applying the corresponding cutting cycle