

**DEMAND, SUPPLY AND PRICE OF  
TEAKWOOD IN KERALA**

Thesis submitted to the  
**UNIVERSITY OF CALICUT**  
for the award of the degree of

**DOCTOR OF PHYLOSOPHY**  
IN ECONOMICS

by  
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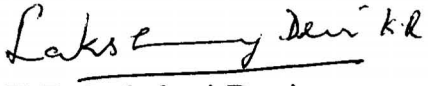
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## CERTIFICATE

The thesis entitled "Demand, Supply and Price of Teakwood in Kerala" is a bonafide record of the original research work done by Mr. C.N. Krishnankutty under my guidance and supervision. The thesis has not been previously formed the basis for the award of any other degree, diploma, fellowship or any other similar title.

Thrissur  
17<sup>th</sup> November, 1997

  
K.R. Lakshmi Devi  
Research Guide




## DECLARATION

I declare that the thesis entitled "Demand, Supply and Price of Teakwood in Kerala" submitted by me is a bonafide record of the original research work done by me and that it has not been previously formed the basis for the award of any other degree, diploma, fellowship or any other similar title.

Thrissur

17<sup>th</sup> November, 1997



C.N. Krishnankutty

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## CONTENTS

	Page
<b>LIST OF TABLES</b>	viii
<b>LIST OF FIGURES</b>	xiii
<b>CHAPTER 1. INTRODUCTION</b>	1
1.1. Objectives	3
1.2. Relevance and Scope of the Study	3
1.3. Organisation of the Thesis	9
<b>CHAPTER 2. LITERATURE REVIEW,     DATABASE AND METHODOLOGY</b>	10
2.1. Review of Literature	10
2.2. Database	19
2.3. Demand and Supply : Concepts and Method of Estimation	21
2.4. Methodology of Price Analysis	23
<b>CHAPTER 3. DEMAND FOR TEAKWOOD IN KERALA</b>	39
3.1. Methodology	39
3.2. Demand in the Household Sector	47
3.3. Demand in the Industries Sector	48
3.4. Demand in Other Constructions Sector	49
3.5. Demand for Export	50
3.6. Demand for Teakwood: An Overview	51
<b>CHAPTER 4. SUPPLY OF TEAKWOOD IN KERALA</b>	53
4.1. Methodology	53
4.2. Supply through Import	58
4.3. Supply from Estates	59
4.4. Supply from Forests	59

4.5. Supply from Home-Gardens	60
4.6. Supply of Teakwood: An Overview	63
4.7. Share of Teakwood in the Total Supply	64
<b>CHAPTER 5. PRICE OF TEAKWOOD IN KERALA</b>	66
5.1. Market Structure	66
5.2. Sale of Timber in Government Depots	68
5.3. Price at the Depots	69
5.4. Price-size Relationship	74
5.5. Price-quality Relationship	78
5.6. Spatial Variation in Prices	80
<b>CHAPTER 6. PRICE TRENDS OF TEAKWOOD IN KERALA</b>	82
6.1. General Trends in Real Prices	82
6.2. Selection of Trend Models	87
6.3. Price Behaviour in Different Periods	87
6.4. Comparison with Selected Timbers	95
<b>CHAPTER 7. TEAKWOOD PRICES :</b>	
<b>SOME FURTHER ANALYSIS</b>	109
7.1. Autoregressive Relationship of Prices	109
7.2. Inter-class Price Relationship	111
7.3. Inter-species Price Relationship	114
7.4. Price-quantity Relationship	116
7.5. Price-production Relationship	116
7.6. Price in Relation to Changes in Internal Demand	118
7.7. Price in Relation to Changes in External Demand	123
<b>CHAPTER 8. FORECASTING OF TEAKWOOD PRICES     USING ARIMA MODELS</b>	127
8.1. ARIMA Models	127

8.2. ARIMA Modelling in Teakwood Prices	131
8.3. Price Forecasts	135
<b>CHAPTER 9. FUTURE DEMAND, SUPPLY AND PRICE OF TEAKWOOD IN KERALA : A DISCUSSION</b>	142
9.1. Demand and Supply in Kerala during 1987-88	142
9.2. Future Demand, Supply and Price of Teakwood	143
<b>CHAPTER 10. SUMMARY AND CONCLUSION</b>	157
<b>REFERENCES</b>	162
<b>LIST OF APPENDICES</b>	171
<b>APPENDICES</b>	175-206

## LIST OF TABLES

No.	Title	Page
1.1	Area under forest plantations in different years in Kerala	6
1.2	Production of teakwood and other timbers from the forests of Kerala	8
3.1	Demand for teakwood and other timbers in the household sector of Kerala during 1987-88	47
3.2	Industrial demand for teakwood and other timbers in Kerala during 1987-88	49
3.3	Export of teakwood and other timbers from Kerala during 1987-88	50
3.4	Demand for teakwood and other timbers in Kerala during 1987-88	51
4.1	Import of teakwood and other timbers to kerala during 1987-88	58
4.2	Supply of teakwood and other timbers from forests of Kerala during 1987-88	60
4.3	Production of teakwood and other (notified) timbers from home-gardens in Kerala during 1991-92 and 1992-93 as per cutting passes issued by the Kerala Forest Department	61
4.4	Commercial volume of teak and other trees in the growing stock in home-gardens of Kerala during 1988-89	62
4.5	Supply of teakwood and other timbers in Kerala during 1987-88	63

No.	Title	Page
4.6	Share of teakwood in the total supply of all timbers in Kerala during 1987-88	64
5.1	Price relation with mean girth of logs in teakwood lots of same girth-class within quality class <i>B</i>	75
5.2	Price relation with mean girth of logs in teakwood lots of different girth-classes within quality-class <i>B</i>	76
5.3	Price relation with mean girth of logs in teakwood lots of different girth-classes within quality-class <i>C</i>	77
5.4	Average current prices of teakwood in different girth and quality classes in Kerala	79
5.5	Average real price of teak logs in different girth and quality classes over the period from 1975-76 to 1993-94 in Kerala	79
6.1	Summary statistics of different trend models fitted to the real prices of teak logs in girth-class <i>E</i>	88
6.2	Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 1	89
6.3	Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 2	90
6.4	Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 3	91

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No.	Title	Page
6.5	Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 4	92
6.6	Regression coefficients of linear spline model of real prices of teak logs in different girth-classes along with adjusted $R^2$ and Durbin-Watson $d$ -statistic	93
6.7	Rates of change of real prices of teak logs in different girth-classes during different periods	94
6.8	Summary statistics of different trend models fitted to the real prices of teakwood (girth-classes combined)	97
6.9	Summary statistics of different trend models fitted to the real prices of <i>anjily</i>	98
6.10	Summary statistics of different trend models fitted to the real prices of <i>irul</i>	99
6.11	Summary statistics of different trend models fitted to the real prices of <i>maruthu</i>	100
6.12	Summary statistics of different trend models fitted to the real prices of jackwood	101
6.13	Summary statistics of different trend models fitted to the real prices of <i>thembavu</i>	102
6.14	Summary statistics of different trend models fitted to the real prices of <i>venga</i>	103
6.15	Summary statistics of different trend models fitted to the real prices of <i>venteak</i>	104

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No.	Title	Page
6.16	Regression coefficients of linear spline model of real prices of teakwood (girth-classes combined) and selected timbers along with adjusted $R^2$ and Durbin-Watson $d$ -statistic	105
6.17	Rates of change of real prices of teakwood (girth-classes combined) and selected timbers during different periods	106
7.1.	Coefficients of correlation ( $R$ ) between differenced series of real prices of teak logs in different girth-classes	112
7.2	Coefficients of correlation ( $R$ ) of differenced series of real prices of teakwood with that of <i>anjily</i> , <i>irul</i> , <i>maruthu</i> , jackwood, <i>thembavu</i> , <i>venga</i> and <i>venteak</i>	115
7.3	Annual growth rate of buildings in selected Panchayats in Thrissur District	119
7.4	Pattern of timber-use in the rural household sector of Kerala during the year 1987-88	122
7.5	Contribution of home gardens to rural household timber supply in Kerala during 1987-88	123
7.6	Production of teakwood and other timbers from Kerala forests and trade	124
8.1	Summary statistics of ARIMA models fitted to current prices of teakwood in girth-class 1	132

No.	Title	Page
8.2	Summary statistics of ARIMA models fitted to current prices of teakwood in girth-class 2	133
8.3	Summary statistics of ARIMA models fitted to current prices of teakwood in girth-class 3	134
8.4	Price forecasts for teakwood in girth-class 1 in Kerala	136
8.5	Price forecasts for teakwood in girth-class 2 in Kerala	137
8.6	Price forecasts for teakwood in girth-class 3 in Kerala	138
9.1	Supply-demand balance of teakwood and other timbers in Kerala during 1987-88	142
9.2	Number of teak and other trees in the growing stock in home-gardens of Kerala during 1988-89	151
9.3	Commercial volume of teak and other trees in the growing stock in home-gardens of Kerala during 1988-89	152
9.4	Pattern of growing stock distribution of teak and other high value timber trees in home-gardens of Kerala during 1988-89	153

## LIST OF FIGURES

No.	Title	Page
5.1	Structure of timber market in Kerala	67
6.1	Current prices of teak logs in different girth-classes in Kerala	83
6.2	Real prices of teak logs in different girth-classes in Kerala	83
6.3	Moving averages of real prices of teak logs in different girth-classes in Kerala	84
6.4	Current prices of teakwood and selected timbers in Kerala	85
6.5	Real prices of teakwood and selected timbers in Kerala	85
6.6	Moving averages of real prices of teakwood and selected timbers in Kerala.	86
8.1	Price forecasts for teakwood in girth-class 1 in Kerala	139
8.2	Price forecasts for teakwood in girth-class 2 in Kerala	139
8.3	Price forecasts for teakwood in girth-class 3 in Kerala	140

**DEMAND, SUPPLY AND PRICE OF  
TEAKWOOD IN KERALA**

## CHAPTER 1

### INTRODUCTION

During the last few decades, the extent of natural forests registered a drastic decline in the tropics. Consequently, there is a growing imbalance between supply of and demand for forest products especially wood. In India, the projected demand for wood is 64 million m<sup>3</sup> in 2000 AD<sup>1</sup> and unless afforestation activity is speeded up, the shortfall in wood supply will widen considerably. One of the important consequences of timber scarcity is price escalation. Analysis of timber prices gives valuable information for formulating policies on forest resource management. It is a starting point for several studies such as predicting future prices through projections<sup>2</sup> and ascertaining the long-term trend in the availability of natural resources<sup>3</sup>.

Long-term trend in timber prices gives a clear indication of scarcity or abundance of timber resources. Timber being bulky, the markets are often segregated and an understanding of the spatial variation in prices is useful to plan the location of distribution outlets and appropriate sale strategies. Although it is generally

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<sup>1</sup> Government of India (1976). *Report of the National Commission on Agriculture, Part IX, Forestry*. Ministry of Agriculture and Irrigation, New Delhi.

<sup>2</sup> Nomura, I. and Yukutake, K. (1981). *Timber price movement in Japan since World War II and its theoretical causes*. North American Conference on National Forest Sector Models of IIASA, Williamsburg, USA, Nov.30-Dec.4.

<sup>3</sup> Barnet, H. J. and Morse, C. (1963). *Scarcity and growth, the economics of natural resource availability*. John Hopkins Press, Baltimore, USA.

believed that timber, whatever be the quantity produced, is bound to be absorbed in the market, for long-term planning broad magnitudes of supply and demand are also necessary. Hitherto, no comprehensive study has been undertaken in India on the demand, supply and price behaviour of timber.

Plantation forestry is the prime sector in the forest economy of Kerala and forms one of the important economic activities in the state. Extensive areas under forest plantations have been established in Kerala by investing funds from the state and central governments to produce timber and industrial wood. Most of the long-term investments in timber production had been concentrated on teak plantations. At the end of 1992, the area under teak including teak mixed with softwood species accounted for about 67 per cent of the total area under forest plantations in the state<sup>4</sup>.

Stoppage of clearfelling of natural forests in 1984 and selective felling in 1989 has resulted in the reduction in the supply of different timbers which were obtained from natural forests. At present, teakwood is the main timber from the forest plantations of Kerala, although timbers of other species are also available from forests in smaller quantities. Teakwood is, thus, the principal timber from the forests of Kerala and has a prominent position among different timbers. This study is an attempt to examine the demand, supply and price aspects of teakwood in Kerala.

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<sup>4</sup> Kerala Forest Department (1992-93). *Administration report for the year 1992-93*. Government of Kerala, Thiruvananthapuram.

## 1.1 Objectives

The objectives of this study are

- i) to estimate the sector-wise demand for teakwood, source-wise supply and to assess the share of teakwood in the total supply of all timbers in Kerala for the reference year 1987-88;
- ii) to analyse the price of teakwood sold in auction in government depots;
- iii) to analyse the price trends of teakwood in comparison with those of selected timbers in Kerala;
- iv) to examine autoregressive relationship of teakwood prices and to study the influence of change in teakwood production from forests on price and
- v) to forecast future prices of teakwood in different girth-classes using autoregressive integrated moving average models.

## 1.2 Relevance and Scope of the Study

Teak (*Tectona grandis* Linn.f.) is distributed mostly in the moist deciduous forests and is raised extensively in the forest plantations in Kerala<sup>5</sup>. It also grows in homesteads and farm lands, particularly in dry areas it grows even in the form of pure plantation. Its wood is moderately hard as well as heavy and can be worked well with hand tools and machines<sup>6</sup>. Teakwood, a highly durable timber, is used for a wide range of purposes such as making beams, windows, doors, shutters, furniture, fixtures, implements

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<sup>5</sup> Nazma., Ganapathy, P. M., Sasidharan, N., Bhat, K. M. and Gnanaharan, R. (1981). *A handbook of Kerala timbers*. Research Report No.9, Kerala Forest Research Institute, Peechi.

<sup>6</sup> *Ibid.*

and manufacturing veneers, plywoods, cabinets, textile-mill accessories, engineering and drawing instruments. Teakwood is a high quality multiple-use forest produce<sup>7</sup>.

Forests in Kerala were originally in the possession of Kings. Trees such as teak, rosewood, ebony and sandal whose wood had a considerable export demand were proclaimed as 'royal trees<sup>8</sup>' and restrictions regarding their felling were in force. Wood other than those of the royal trees could be freely removed by people. The list of royal trees was expanded to include other valuable species also. Later, forest reserves were established and felling was regulated by the Forest Department.

The Kingdoms of Kerala coast were engaged in export trade, especially with Arabs who imported teakwood from Kerala for ship building. Superiority of teakwood for ship building enhanced its importance in export trade. During the last century, a substantial quantity of teakwood was extracted from the forests, not only for ship building but also for railways and military purposes. The demand for teakwood was increasing at a rapid rate and considerable quantities of teakwood were transported from Kerala to other states in India and exported to other countries<sup>9</sup>. All the requirements were met by exploiting the natural forests, resulting in the reduction in the supply of teakwood and further the depletion of forests<sup>10</sup>.

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<sup>7</sup> Tewari, D. N. (1992). *A monograph on teak (Tectona grandis Linn. f.)*. International Book Distributers, Dehra Dun.

<sup>8</sup> F A O (1984). *Intensive multiple-use forest management in Kerala*. F A O Forestry Paper No. 53, Rome.

<sup>9</sup> Mammen Chundamannil (1993). *History of forest management in Kerala*. KFRI Research Report No. 89, Kerala Forest Research Institute, Peechi.

<sup>10</sup> F A O (1984). *op.cit.*

Teak plantations were started in Nilambur in Kerala for the first time in India in the year 1842<sup>11</sup>. Since then, raising of teak plantations was carried out on a small scale till the end of the 19th century. The total area under forest plantations at the end of the year 1900 in Kerala<sup>12</sup> was 551 ha of which an area of 546 ha was under teak<sup>13</sup>. The mean annual area of forest plantations added during the period from 1900 to 1955 was 537 ha of which 85 per cent was under teak. Table 1.1 gives the area under forest plantations of different species during the period from 1956-57 to 1992-93 in Kerala. As can be seen in the Table, teak has been the principal species in the plantation forestry of the state. Familiarity with the species and assured success under varying conditions have been responsible for this preference<sup>14</sup>. Since the year 1960, the area under eucalypt plantations increased rapidly due to the growing demand for pulpwood. The area under teak has also expanded during this period. Nevertheless, further growth of forest plantations is likely to be marginal in the further, since most of the forest plantations were established after clearfelling of natural forests, which was stopped in the year 1984. The area under teak and teak mixed with softwood species accounted for the major share in the total area under forest plantations (Table 1.1). It indicates that most of the public investments in forest plantations in

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<sup>11</sup> *Ibid.*

<sup>12</sup> It refers to those regions of erstwhile Malabar District of Madras Presidency, Travancore and Cochin States which constituted Kerala State in the year 1956.

<sup>13</sup> Chandrasekharan, C. (1973). *Forest resources of Kerala: A quantitative assessment*. Kerala Forest Department, Thiruvananthapuram.

<sup>14</sup> F A O (1984). *op. cit.*

Table 1.1 Area under forest plantations in different years in Kerala\*  
(Area in ha)

Year	Teak	Teak and Softwood species mixed	Eucalypts	Cashew	Others**	Total
1956-57	26,452 (80.9)#	3,475 (10.6)	108 (0.3)	1,401 (4.3)	1,265 (3.9)	32,701 (100.0)
1960-61	33,107 (69.4)	7,306 (15.3)	317 (0.7)	5,043 (10.6)	1,913 (4.0)	47,686 (100.0)
1965-66	45,050 (61.3)	13,249 (18.0)	8,527 (11.6)	4,093 (5.6)	2,605 (3.5)	73,524 (100.0)
1970-71	53,483 (52.5)	18,418 (18.1)	23,232 (22.8)	3,226 (3.2)	3,460 (3.4)	1,01,819 (100.0)
1975-76	63,824 (50.3)	21,115 (16.6)	32,645 (25.7)	2,995 (2.4)	6,314 (5.0)	1,26,893 (100.0)
1980-81	75,038 (49.8)	24,066 (16.0)	40,018 (26.6)	4,955 (3.3)	6,432 (4.3)	1,50,509 (100.0)
1985-86	79,596 (48.1)	27,665 (16.7)	43,479 (26.2)	4,658 (2.8)	10,316 (6.2)	1,65,714 (100.0)
1990-91	76,202 (46.8)	32,621 (20.0)	38,141 (23.4)	3,784 (2.3)	12,142 (7.5)	1,62,890 (100.0)
1991-92	75,355 (46.1)	34,018 (20.8)	37,372 (22.9)	4,558 (2.8)	12,109 (7.4)	1,63,412 (100.0)
1992-93	74,914 (45.5)	35,130 (21.3)	37,429 (22.7)	4,570 (2.8)	12,610 (7.7)	1,64,653 (100.0)

\* Plantations of eucalypts and other softwood species under the management of Kerala Forest Development Corporation were also included.

\*\*Others include balsa, wattle, acacia, jack, *anjily*, rosewood, hopea, *murikku*, *matty*, silveroak, rubber, albezia, etc.

# The figure in parenthesis is percentage to total.

Source: Compiled from the Administration Reports of various years of the Kerala Forest Department.

Kerala were concentrated in establishing teak plantations in the state.<sup>15</sup>

At the end of the year 1992, the area under plantations of teak and eucalypts was about 1475 km<sup>2</sup> accounting for about 90 per cent of the total area under forest plantations<sup>16</sup>. The area under teak<sup>17</sup> was about 1100 km<sup>2</sup>. Eucalypt wood is exclusively reserved for pulp and paper industries in the state. The only timber, which can be used for constructions, general uses and for manufacturing furniture, veneers, etc., available from Kerala forest plantations is teakwood<sup>18</sup>. The contribution of teak to the total timber production from the forests of Kerala including forest plantations, was about 11 per cent over the period from 1956-57 to 1992-93. This rose to 57 per cent during 1990-93 period (Table 1. 2). The average price of teakwood during the period from 1980-81 to 1984-85 in real terms (at 1970-71 prices)<sup>19</sup> was Rs. 1,430 per m<sup>3</sup> whereas the prices of seven other important timbers ranged from Rs.532 per m<sup>3</sup> for *chadachy* to Rs. 874 per m<sup>3</sup> for *venga*<sup>20</sup>. Thus, teakwood is the traditional high quality, high value timber and has a significant position in the timber economy of Kerala.

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<sup>15</sup> Mammen Chundamannil (1986). *Pattern of investments in forestry and its implications on sustained yield management in Kerala*. M.Phil. Dissertation. Centre for Development Studies, Thiruvananthapuram.

<sup>16</sup> Kerala Forest Department (1992-93). *op.cit.*

<sup>17</sup> It includes 351 km<sup>2</sup> of area under teak mixed with softwood species.

<sup>18</sup> There are some other timber species like *anjily*, jack, rosewood, etc., but the area under these plantations is very marginal.

<sup>19</sup> Krishnankutty, C. N. (1989). Long-term price trend of timber in Kerala. *Indian J. of For.*, 12(1), 7-12.

<sup>20</sup> The other timbers considered were *anjily*, *irul*, *maruthu*, *thembavu* and *venteak*.

Table 1.2 Production of teakwood and other timbers from the forests of Kerala\*

Period	(Volume in m <sup>3</sup> )			
	Production/year			
	Teakwood	Other timbers	Total	% of teakwood to total
1956-57 to 1959-60	27172	75599	102771	26.4
1960-61 to 1964-65	32445	228588	261033	12.4
1965-66 to 1969-70	41651	457260	498911	8.3
1970-71 to 1974-75	44160	454898	499058	8.8
1975-76 to 1979-80	40799	472711	513510	8.0
1980-81 to 1984-85	24077	255891	279968	8.6
1985-86 to 1989-90	16494	39334	55828	29.5
1990-91 to 1992-93	22568	17096	39664	56.9
1956-57 to 1992-93	31744	267489	299233	10.6

\* Production of timber consists of timbers of as many as 60 species including teak. It excludes eucalypt wood from plantations, and poles obtained through thinning of teak plantations.

Source: Compiled from Administration Reports of various years of the Kerala Forest Department.

Studies on the pattern of demand for teakwood in Kerala, contribution of different sources of supply and price behaviour have not been attempted so far. Information on these aspects is extremely important for planning and monitoring the development of the timber economy in the state. In this context, the present study on 'Demand, supply and price of teakwood in Kerala' is of great relevance in planning timber resource development in the state.

### **1.3 Organisation of the Thesis**

The thesis is organised in ten chapters including 'introduction'. The methodology and database of the present study and the review of literature in this area are given in chapter 2. The demand for teakwood in Kerala for the reference year 1987-88 is presented sector-wise in chapter 3. The supply of teakwood from different sources in Kerala for the year 1987-88 is estimated in chapter 4. The share of teakwood in the total supply of all timbers in Kerala is also assessed in this chapter. The structure of the timber market in Kerala is described and the relationship of price with size and quality of teak logs sold in auction in the government depots is analysed in chapter 5. Variation in teakwood prices in different regions in Kerala is also examined in the fifth chapter. Price trends of teakwood in comparison with those of selected timbers are presented in chapter 6. Autoregressive relationship of teakwood prices and relationship of price with quantity of teakwood sold, production of teakwood from forests, teakwood export, etc. are analysed in chapter 7. Forecasting of future prices of teakwood in different girth-classes using autoregressive integrated moving average models is attempted in chapter 8. A discussion on the future demand, supply and price of teakwood in Kerala is presented in chapter 9 and the conclusions emanating from the study are summarised in the last chapter.

## CHAPTER 2

### LITERATURE REVIEW, DATABASE AND METHODOLOGY

A review on the related studies on demand, supply and price of timber is done in this chapter. The methodology adopted in the present study and the sources of data are also described here.

#### 2.1 Review of Literature

This section consists of a review on the studies in India and other countries.

##### 2.1.1 Studies in India

Studies on demand, supply and price aspects of timber are very few in India. An assessment of the growing stock of wood in the forests of Kerala and annual availability was made for the year 1970 by Chandrasekharan<sup>1</sup>. A rough estimate of the demand for pulpwood in Kerala and supply from forests for the year 1982 was made by Karunakaran<sup>2</sup>. The pioneering work on the wood economy of Kerala covering sector-wise demand for timber and fuelwood and supply from forests as well as non-forest sources has been carried out for the reference year 1987-88 by the author<sup>3</sup> and published as 'demand and supply of wood in Kerala and their future trends'. In the above

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<sup>1</sup> Chandrasekharan, C. (1973). *op.cit.*

<sup>2</sup> Karunakaran, C. K. (1982). *Demand versus supply of important raw materials from forests in Kerala State (Draft)*. Kerala Forest Department, Thiruvananthapuram.

<sup>3</sup> Krishnankutty, C. N. (1990). *Demand and supply of wood in Kerala and their future trends*. KFRI Research Report 67, Kerala Forest Research Institute, Peechi.

study, the demand for construction timber, industrial wood and fuel by different sectors in Kerala was estimated and the various sources of supply were identified. There are also some studies which had been done during the last few years in Kerala. Examples are, availability of plywood logs from forests<sup>4</sup>, household fuelwood consumption and its variation among villages located in different geographical regions<sup>5</sup>, rural energy and use-pattern in Southern Kerala<sup>6</sup> and demand and supply of rubberwood in India<sup>7</sup>. Studies on demand and supply of wood in other states in India reported in the literature are very few. The wood-balance study conducted by the conducted by the West Bengal Forest Department<sup>8</sup> is one among them. Most of these studies dealt with demand and supply of wood, which include industrial wood and fuel, in a particular year.

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<sup>4</sup> i) Kerala Forest Research Institute (1977). *Availability of wood raw material for plywood industry (Kerala - Karnataka Region)*. KFRI Research Report 2(1), Peechi.

ii) Kerala Forest Research Institute (1978). *Availability of wood raw material for plywood industry (North-Eastern Region)*. KFRI Research Report 2(2), Peechi.

<sup>5</sup> Thampi, K. B. (1983). *Pattern of domestic energy consumption in rural Kerala : A study of selected villages*. M.Phil. Dissertation. Centre for Development Studies, Thiruvananthapuram.

<sup>6</sup> State Planning Board (1986). *Rural energy generation and use-pattern: Southern Kerala*. Government of Kerala, Thiruvananthapuram.

<sup>7</sup> Haridasan, V. and Sreenivasan, K. G. (1985). Rubberwood: A study of supply and demand in India. *Rubber Board Bulletin*, 20(4), 19-21.

<sup>8</sup> West Bengal Forest Department (1987). *Wood balance study : West Bengal*. Office of the Chief Conservator of Forests, Calcutta.

There are some studies on timber prices. In a study by Krishnankutty<sup>9</sup> *et al.*, timber prices up to the year 1981-82 were analysed for certain timbers in Kerala. Timber price movements in different periods in Kerala were examined in another study by Krishnankutty<sup>10</sup> after updating the data till 1984-85. There are some studies on timber prices in other states in India. They primarily dealt with price variation between different size classes<sup>11</sup> or short-term fluctuation of firewood prices<sup>12</sup>. Another study by Sagar and Mahendra<sup>13</sup> examined the inter-market price variation of *sal* timber in Orissa and projected the prices using regression model based on 10 years annual data.

### 2.1.2 Studies in other countries

Most of the studies in this area have been done abroad. The relevant studies are grouped into studies on (i) timber demand, supply and market and (ii) timber price and forecasting, and reviewed in the following two sub-sections.

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<sup>9</sup> Krishnankutty, C. N., Rugmini, P. and Rajan, A. R. (1985). *Analysis of factors influencing timber prices in Kerala*. KFRI Research Report No. 34. Kerala Forest Research Institute, Peechi.

<sup>10</sup> Krishnankutty, C. N. (1989). Long-term price trends of timber in Kerala. *Indian J. of For.*, 12(1), 7-12.

<sup>11</sup> i) Suri, S. K. (1973). Comprehensive price trend studies of five commercially important timber species logs - Narainpur Depot (Madhya Pradesh) *Indian For.*, 99(8) : 510-515.

ii) Suri, S. K. (1974). Price trend studies on teak logs - Taku Depot (Madhya Pradesh). *Indian For.*, 100(4) : 235-245.

<sup>12</sup> Mathur, R. S., Sagar, S. R. and Mahendra, A. K. (1984). Price trends of firewood in Haryana. *Indian For.*, 110(10) : 973-981.

<sup>13</sup> Sagar, S. R. and Mahendra, A. K. (1986). Price trends of *sal* timber in Orissa. *Indian For.*, 112(12), 1080-1087.

## **Studies on timber demand, supply and market**

A large number of studies have been done abroad on this topic. McKillop *et al.*,<sup>14</sup> estimated demand function for plywood, taking quantity of plywood demanded as regressand and number of housing started, industrial production index, hourly wage rate of carpenters, plywood and building board prices lagged by one year as regressors in United States. In an econometric study for US hardwood timber, Luppold<sup>15</sup> estimated the model taking the quantity demanded as a function of the lagged rates of interest, a time trend, lagged prices of hardwood timber, wooden furniture and hardboard and lagged wage rates in the furniture industry, using data for the period from 1960 to 1979. Adams and Blackwell<sup>16</sup> estimated US timber and plywood demand taking the quantity demanded in construction as a function of total US housing started and the ratio of past plywood prices to past timber prices, using data for the period from 1949 to 1969.

A long-term domestic demand function for Bangladesh was estimated by McKillop and Sarkar<sup>17</sup> with quantity of timber demanded as a function of real price of timber, population and a time trend, using annual data from 1960 to 1982 and predicted the demand for timber to the year 2025.

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<sup>14</sup> McKillop, W. L. M., Stuart, T. W. and Geissles, P. J. (1980). Competition between wood products and substitute structural products: An econometric analysis. *For. Sci.*, 26(1): 134-148.

<sup>15</sup> Luppold, W. (1984). An econometric study of the U.S. hardwood timber market. *For. Sci.*, 30(4): 1027-1038.

<sup>16</sup> Adams, F. G. and Blackwell, J. (1973). An econometric model of the US forest products industry. *For. Sci.*, 19(1): 82-96.

<sup>17</sup> McKillop, W. and Sarkar, A. (1992). Normative supply modelling and forest policy analysis in a developing economy. *J. of world forest resource management*, 6(1): 85-98.

In a global study, Buongiorno *et al.*,<sup>18</sup> estimated income and price elasticities of demand for sawnwood and wood-based panels, using data from 1963 to 1973 from 43 countries in a combined cross-section/time series analysis. McKillop<sup>19</sup> estimated Japanese demand for US and Canadian timber using quarterly data for the period from 1950 to 1970.

Greber<sup>20</sup> estimated an econometric model to analyse timber supply in Virginia using inventory data from the U.S. Forest Service. The long-term supply response of the regulated forest developed by Clawson was applied by Hyde<sup>21</sup> to the Pacific Northwest region of the United States. Hyde estimated long-run supply curves based upon the selection of a management regime that maximised the present net worth of stumpage returns. Greber and Wisdom<sup>22</sup> developed a timber market model. They estimated product demand functions for pulpwood, hardwood saw - logs and softwood saw - logs, using market data for the period from 1960

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<sup>18</sup> Buongiorno, J., Chou, J. H, and Stone, R. S. (1979). A monthly model of the United States demand for softwood timber imports. *For. Sci.*, 25(4): 641-655.

<sup>19</sup> McKillop, W. (1973). Structural analysis of Japanese-North American trade in forest products. *For. Sci.*, 19(1): 63-74.

<sup>20</sup> Greber, B. J. (1983). *Development of a joint product timber supply model*. Ph.D. Thesis, Va Polytech Inst. and State Univ., Blacksburg.

<sup>21</sup> Hyde, W. F. (1980). *Timber supply, land allocation and economic efficiency*. John Hopkins Univ. Press, Baltimore.

<sup>22</sup> Greber, B. J and Wisdom, H. W. (1985). A timber market model for analysing roundwood product interdependencies. *For. Sci.*, 31(1): 164-179.

to 1979. Hultkrantz and Aronsson<sup>23</sup> made an econometric study on the supply of roundwood from private forest lands in Sweden, using data from 1961 to 1984.

Mori<sup>24</sup> investigated the supply and demand relationship, using time series data relating to the Japanese timber market for the period from 1960 to 1979. Chou and Buongiorno<sup>25</sup> estimated own-price and cross-price elasticities of US demand for imported plywood, using monthly imports for the period from 1974 to 1979. Brannlund<sup>26</sup> *et al.* presented an econometric analysis of the sawn timber and pulpwood market in Sweden based on time-series data, covering the period from 1953 to 1981.

Robinson<sup>27</sup> estimated an econometric model for stumpage market, using data for the period from 1947 to 1967. The demand was expressed as a function of the real price of timber, freight rates, the real value of residential construction per dwelling unit and the number of dwelling units. In Adams and Haynes' US

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<sup>23</sup> Hultkrantz, L. and Aronsson, T. (1989). Factors affecting the supply and demand of timber from private non-industrial lands in Sweden: An econometric study. *For. Sci.*, 35(4): 946-961.

<sup>24</sup> Mori, Y. (1981). *An econometric model of the Japanese timber market*. XVII IUFRO World Congress, Kyoto, Japan.

<sup>25</sup> Chou, J. and Buongiorno, J. (1983). United States demand for hardwood plywood imports by country of origin. *For. Sci.*, 29(2): 225-237.

<sup>26</sup> Brannlund, R., Johnson, P. O. and Lofgren, K. G. (1985). An econometric analysis of aggregate sawn timber and pulpwood supply in Sweden. *For. Sci.*, 31(3): 595-606.

<sup>27</sup> Robinson, V. L. (1974). An econometric model of softwood timber and stumpage markets: 1946-1967. *For. Sci.*, 20(1): 171-179.

timber assessment market model<sup>28</sup>, the volume of available timber was explicitly taken into account in the equations for regional stumpage supply from private lands. This model was used to make projections for the U.S. stumpage demand and supply.

### **Studies on timber price and forecasting**

Huang and Buongiorno<sup>29</sup> developed a model of market value for tracts of timber sold at auction for a minimum appraised value when a substantial number of the tracts offered did not receive a bid. In a study by Frazier<sup>30</sup> for the Californian pine region, the bid price was estimated as a function of the number of bidders competing for each sale and the appraised price. Adams and Haynes<sup>31</sup> presented an aggregate regional model of the national forest timber supply in the determination of regional stumpage price and harvest volume in the Western United States. Components of the model described the distribution of volume sold and bid price.

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<sup>28</sup> Adams, D. M. and Haynes, R. W. (1980). The 1980 softwood timber assessment market model: Structure, projections and policy simulations. *For. Sci. Monograph*, 22:64p.

<sup>29</sup> Huang, F. M. and Buongiorno, J. (1986). Market value of timber when some offerings are not sold: Implications for appraisal and demand analysis. *For. Sci.*, 32(4):845-854.

<sup>30</sup> Frazier, G. D. (1967). *The relationship between Forest Service timber sales behavior and the structure of the Californian pine timber industry*. Ph.D. Thesis, Yale Univ., New Haven, Conn.

<sup>31</sup> Adams, D. M. and Haynes, R. W. (1989). A model of national forest timber supply and stumpage markets in the Western United States. *For. Sci.*, 35(2): 401-424.

Studies in USA<sup>32</sup> and Japan<sup>33</sup> analysed the timber price movement and their causative factors. Brazee and Mendelsohn<sup>34</sup> developed optimal reservation prices by age treating prices as exogenous. In order to calculate the size of historic price fluctuations, they used stumpage prices of douglas-fir for the period from 1975 to 1984 and loblolly pine for the period from 1970 to 1979. These nominal prices were deflated using the GNP deflator to 1986 constant dollars. In the model of Hardie *et al.*<sup>35</sup>, prices were made as a function of calendar time and optimum rotation lengths. Chang<sup>36</sup> treated timber prices and production costs as fixed parameters which did not vary with either harvest age or calendar time. Clements *et al.*<sup>37</sup> described a roundwood supply and price assessment model for regional forest products markets. Holland<sup>38</sup> tried to show how timber price had risen while total timber consumption expanded only moderately during the period from 1920 to 1955. He further predicted the price index for timber for the year 2010.

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<sup>32</sup> Barnett, H. J. and Morse, C. (1963). *op. cit.*

<sup>33</sup> Nomura, I. and Yikutake, K. (1981). *op. cit.*

<sup>34</sup> Brazee, R. and Mendelsohn, R. (1988). Timber harvesting with fluctuating prices. *For. Sci.*, 34(2): 359-372.

<sup>35</sup> Hardie, L. W., Daberkow, J. N. and McConnell, K. E. (1984). A timber harvesting model with variable rotation lengths. *For. Sci.*, 30(2): 511-523.

<sup>36</sup> Chang, S. J. (1981). Determination of the optimal growing stock and cutting cycle for an uneven-aged stand. *For. Sci.*, 27(4): 739-744.

<sup>37</sup> Clements, S. E., Leuschner, W. A., Hoganson, H. and Wisdom, H. W. (1988). A local roundwood supply and price assessment model. *Can.J.For.Res.*, 18:1563-1569.

<sup>38</sup> Holland, I. I. (1960). An explanation of changing timber consumption and prices. *For. Sci.*, 6(1): 171-192.

The Box-Jenkins time series approach<sup>39</sup> has been used quite extensively to predict the price in many other cases, but rarely in timber price. Cheng and Jen<sup>40</sup> tested the Box-Jenkins models to predict timber prices of selected species of Taiwan. Oliveira *et al.*,<sup>41</sup> investigated the potentiality of the Box-Jenkins autoregressive integrated moving average (ARIMA) model for forecasting various timber prices (timber cash prices and their basis series). The sample period for the weekly price series was from January 1973 to December 1974, resulting in 103 observations. By using weekly observations, relatively accurate forecasts could be obtained for timber prices with ARIMA models. The results indicated that forecasting cash price had more merit than forecasting the basis price.

The studies, which have been reviewed, focused on estimation of demand or supply or market models. Some studies dealt with prices alone. All these studies done abroad had access to time series data. A few studies done in India have projected the demand and supply of certain industrial wood using data for a single year and based on certain assumptions. Hitherto, no comprehensive study on demand, supply and price behaviour of timber has been done in India. The present study on 'demand, supply and price of teakwood in Kerala' is an attempt on a regional basis in this direction.

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<sup>39</sup> Box, G. E. P. and Jenkins, G. M. (1976). *Time Series Analysis, Forecasting and Control*. (2nd ed.) San Francisco: Holden-Day.

<sup>40</sup> Cheng, C. C. and Jen, J. A. (1980). *Studies on the fluctuation and prediction of timber prices in Taiwan*. Taiwan Forestry Research Institute Bulletin 338. Taipei, Taiwan.

<sup>41</sup> Oliveira, R. A., Buongiorno, J. and Kmiotek, A. M. (1977). Time series forecasting models of timber cash, futures and basis prices. *For. Sci.*, 23(2): 268-280.

## 2.2 Database

This study focuses on sector-wise demand for teakwood and source-wise supply, prices of teakwood in the government timber depots, regional variations in prices, long-term trends in prices and forecasting. For estimating the share of teakwood in the total timber supply, an assessment of the demand and supply of all timbers in Kerala was necessary. For comparing the price trends of teakwood with those of other timbers, it was necessary to consider the prices of certain important timbers also.

The database of demand and supply of teakwood is the data collected in an earlier study, by the author<sup>42</sup>, funded by the World Bank aided Kerala Social Forestry Project. In the above study, both timber and fuelwood were considered. But the emphasis in the study was to obtain aggregate estimates for all timbers together and fuelwood. The study did not aim at estimating the sector-wise demand for teakwood or any other individual timber. The raw data on teakwood collected in the course of the above study have been used in the present study. The sector-wise demand and source-wise supply of teakwood were estimated from these data. The concepts and method of estimation of demand and supply in this study are described in the next section.

The database of prices is mainly the monthly auction files and registers maintained in the government timber depots. The Kerala Government set up timber depots for sale of timber obtained from

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<sup>42</sup> Krishnankutty, C. N. (1990). *op. cit.*

teak plantations and forests<sup>43</sup>. The depots are managed by the Kerala Forest Department. Teakwood and other timbers obtained from forests and plantations are transported to the timber depots. At the depots, the logs are classified according to species, quality and dimension<sup>44</sup>. The classified logs are then grouped into lots which are then put up for auction, usually every month. Auctions are conducted for each lot and price is realised for each lot in the monthly auction.

Price data available in the monthly auction files for the period from 1975-76 to 1993-94 were collected from 23 depots out of 26 depots currently functioning<sup>45</sup>. Appendix 2 gives the list of the government depots from which data were collected. Since the data prior to 1975-76 were not available in most of the depots, the average annual prices given in various Divisional Forest Working Plans<sup>46</sup> were compiled for the period from 1956-57 to 1974-75.

Data on total quantity of teakwood sold through all the government depots together and production from Kerala forests during the period from 1956-57 to 1992-93 were compiled from the Administration Reports of various years of the Kerala Forest

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<sup>43</sup> There are different sources of timber supply in Kerala. However, an organised market exists only for timber supplied from government forests. Therefore, the study on prices has been confined to the timber supplied from Kerala forests.

<sup>44</sup> For criteria for classification of logs, see Appendix 1.

<sup>45</sup> Clearfelling was discontinued in Kerala since 1984, and consequently the supply of timber declined drastically. This has led to the closure of some of the depots recently.

<sup>46</sup> Twenty two Divisional Forest Working Plans for different periods have been referred. For a complete list, see References.

Department<sup>47</sup>. Quantity of timber imported to Kerala from other states as well as from other countries and the quantity of timber moved out of Kerala to other states and other countries in different years were worked out from data available in registers maintained at ports, border forest check-posts, etc.

Other secondary sources including publications, files and registers of the Kerala Forest Department, Department of Economics and Statistics, Department of Factories and Boilers, Small Industries Service Institute, Panchayat Offices, etc. were also relied upon for data required for the present study.

### **2.3 Demand and Supply : Concepts and Method of Estimation**

In this study, 'timber' refers to teakwood and all other timbers. It includes wood used in solid form for purposes as in construction, furniture, fixtures, veneers, tools, boats, transport bodies, etc. as well as industrial wood and poles. Timbers of teak, *anjily*, jack, *maruthu*, *irul*, *chadachy*, *thembavu*, *venga*, *venteak*, mango, coconut, rubber, eucalypt, etc. come under the definition of 'timber' in this study. Among teak poles, some quantity was utilised in construction and furniture making. This was included under teakwood in this study, while teak poles used for other purposes have been clubbed under 'other timbers' which consist of all timbers except teakwood.

The relationship between consumption, production and trade during a period can be shown as Consumption = Production + Import - Export. In this study, Consumption + Export is taken as the effective

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<sup>47</sup> Kerala Forest Department (1956-57 to 1992-93). *Administration Reports of various years*. Government of Kerala, Thiruvananthapuram.

demand and Production + Import as the supply. Demand for timber in a year is defined, in this study, as the effective demand which is taken as identical with the supply in the same year, ignoring the inventory of timber which is considered to be in dynamic equilibrium over time<sup>48</sup>. As this study is confined to Kerala State, import and export refer to trade with other countries as well as with other states in India.

In the earlier study on demand and supply of timber in Kerala by the author<sup>49</sup>, the estimates were prepared for the reference year 1987-88. It showed the sector-wise demand and source-wise supply of all timbers together. For the above study, different sample surveys such as timber-use in the rural household and other construction sectors of Kerala, timber-use by industries in the unorganised sector in Kerala, growing stock of trees in and timber production from home-gardens, timber availability from the estate sector were carried out. Apart from these surveys, import-export data were collected from fifteen inter-state border forest check-posts, two ports and railways. Timber used in industries in the organised sector was compiled from the survey schedules of the Annual Survey of Industries of the National Sample Survey Organisation. Along with data collection for all timbers during the course of the above study, an effort was made to collect data on

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<sup>48</sup> In any particular year, a portion of the accumulated inventory of timber enters the market as supply while at the same time part of the current production will be added to the inventory. Inventory behaviour is assumed constant and therefore not included in the analysis.

<sup>49</sup> Krishnankutty, C. N. (1990). *op. cit.*

teakwood production from different sources, teakwood used in different sectors and import-export statistics of teakwood separately. But the data on teakwood were not used in the earlier study by the author. The estimates of sector-wise demand and source-wise supply of teakwood have been worked out from the data available in the survey schedules, data sheets and other materials of the earlier study by the author<sup>50</sup> to get estimates of teakwood separately for the present study. The estimates of the demand and supply of teakwood and other timbers dealt in this study, therefore, pertain to the reference year 1987-88.

The demand for teakwood and other timbers was estimated under four components: (i) households, (ii) industries (iii) other constructions sectors and (iv) export. Similarly the supply of teakwood and other timbers was estimated under three components: (i) forests (ii) non-forest sources and (iii) import. The methodology adopted for each of the above components is described in the appropriate places in the third and fourth chapters on 'demand for teakwood in Kerala' and 'supply of teakwood in Kerala' respectively.

## **2.4 Methodology of Price Analysis**

The methodology of price analysis is explained under four main heads: (i) analysis of price at the depots, (ii) trend analysis, (iii) price relationships and (iv) price forecasting. In the analysis of price at the depots, the methodology adopted for examining price-size relationship and spatial variation in prices is explained. In the trend analysis, different trend models fitted and selection criteria are described. Methodology used for analysing price relationships

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<sup>50</sup> *Ibid.*

such as autoregressive relationship of real prices, inter-class and inter-species price relationships and price-production relationship are explained. For price forecasting, the Box-Jenkins procedure used for analysing time series is described.

#### **2.4.1 Analysis of price at the depots**

For the analysis of prices at the government depots, the procedure followed for timber auction in the depots has been studied. Discussions were held with several government depot officers regarding the factors that affect the prices at the depots. The timber users do not usually participate in the auctions as the quantity of teakwood put up in each lot is around 2 to 4 m<sup>3</sup>. The bidders are timber traders and saw-mill owners who retail timber. From the lists of bidders collected from different depots, selected timber traders and saw-mill owners at Perumbavoor, Chalakkudy, Thrissur, Palakkad and Kozhikode were visited and interviewed to obtain information on the factors that influence the prices at auction. On the basis of the observations during several auctions and interviews with depot officers and bidders, the factors affecting monthly price are discussed.

##### **Price-size relationship**

Relationship of price with size of logs in teakwood-lots has been examined using the data collected from auction registers maintained at two selected government depots at Veettoor and Mudical. To identify the determinants of price in relation to number of logs, mean girth, mean length and mean volume of logs in lots, multiple linear regression model given by Model 2.1 has been estimated.

$$P_j = \alpha_0 + \alpha_1 N_j + \alpha_2 G_j + \alpha_3 V_j + \alpha_4 L_j + \varepsilon_j \quad \dots\dots\dots(2.1)$$

where  $P_j$  : Price (Rs. per m<sup>3</sup>) realized for  $j^{\text{th}}$  lot in a depot during a particular month  $t$ ,  $N$  : number of logs in the  $j^{\text{th}}$  lot,  $\bar{G}$  : average girth of a log in the  $j^{\text{th}}$  lot,  $\bar{V}$  : average volume per log in the  $j^{\text{th}}$  lot,  $\bar{L}$  : average length of a log in the  $j^{\text{th}}$  lot, and  $\alpha_i$ ,  $i = 0, 1, 2, 3, 4$ , are the parameters and  $\varepsilon_j$ , the random disturbance term.

### **Spatial variation in prices**

The study on spatial variation in prices was confined to the variation in prices among the three Forest Circles<sup>51</sup> - Southern, Central and Northern Circles - which approximately conform to the broad classification of the state as southern, central and northern regions of Kerala. Based on the prices realised and quantity of teakwood sold during monthly auctions in the selected timber depots, weighted average prices in each year for the Southern, Central and Northern Circles were worked out for the period from 1975-76 to 1993-94. The price variation among regions was statistically examined based on  $t$ -test using the prices for the three regions.

#### **2.4.2 Trend Analysis**

The analysis of price trends<sup>52</sup> was based on average annual prices for the period 1956-57 to 1993-94. In order to study the

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<sup>51</sup> Here, the Forest Circle was defined to include those government timber depots which come under the jurisdiction of the respective Forest Circle of the Kerala Forest Department. The High Range Circle was included in the Central Circle (Appendix 2).

<sup>52</sup> The analysis should be based on data related to a sufficiently long period so that it is possible to separate the short-term fluctuations from long-term changes. Kerala State was formed in 1956 and the study is, therefore, confined to the period from 1956-57 to 1993-94. It would have been ideal if the prices up to 1996-97 could be used in the analysis. It was not done because prices since 1993-94 could not be obtained from all the depots.

price behaviour of teakwood, it was necessary to examine the price behaviour of certain important timbers also. Owing to this reason, seven other important timbers, (i) *anjily* (*Artocarpus hirsutus*), (ii) *irul* (*Xylia xylocarpa*), (iii) *maruthu* (*Terminalia paniculata*), (iv) jackwood (*Artocarpus heterophyllus*), (v) *thembavu* (*Terminalia crenulata*), (vi) *venga* (*Pterocarpus marsupium*), and (vii) *venteak* (*Lagerstroemia microcarpa*) were also selected for the study. The selected timbers including teak accounted for about 48 per cent of the total quantity of timber sold during the period 1956-57 to 1992-93 from all the government depots. The quantum of disposal of each timber as well as the importance of the timbers for construction and other common purposes were taken into account in the choice of the above seven timbers.

Based on the sale value realised and quantity sold during monthly auctions, weighted average prices of teak logs in different girth-classes<sup>53</sup> in each year for the state were worked out for the period from 1975-76 to 1993-94. Girth-classes are based on the mid-girth of the logs. The different girth-classes are *E* (logs with mid-girth 185 cm and above), 1 (150 to 184 cm), 2 (100 to 149 cm), 3 (75 to 99 cm) and 4 (60 to 74 cm). Since the data prior to 1975-76 were not available in most of the depots, the average prices of teak logs in different girth-classes given in various Divisional Forest Working Plans were used to fill up the gap in data. Using the prices and quantity of teak logs sold in different

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<sup>53</sup> Despite the guidelines for classification of logs (see Appendix 1), often inter-depot variation is noticed. Further within a class, variation in quality such as soundness, straightness, etc., are also observed. Since the objective of the study is to examine the trend in price, quality differences were ignored.

girth-classes, weighted average prices of teakwood (girth-classes combined) in each year for the period from 1956-57 to 1993-94 were worked out. In a similar manner, average annual prices of other selected timbers for the period from 1956-57 to 1993-94 were also worked out.

### **Conversion of current prices to real prices**

Changes in the current prices are due to (i) changes in real prices and (ii) inflation. For eliminating the effect of price change due to inflation, the current prices are to be deflated with some price indices<sup>54</sup>. In this study, the current prices in respect of various years were deflated with the All India Wholesale Price Indices of all commodities<sup>55</sup> with base year, 1981-82 = 100. This gave the real prices and this alone reflected the actual change in prices. The average annual real prices (ie. timber prices at 1981-82 constant prices) of teakwood in different girth-classes for the period from 1956-57 to 1993-94 were used for analysing the price trends. The average annual real prices computed for teakwood (girth-classes combined) and those of selected timbers for the period from 1956-57 to 1993-94 were used to examine the price trends of teakwood in comparison with those of selected timbers in Kerala.

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<sup>54</sup> Croxton, F. E., Cowden, D. J. and Klein, S. (1973). *Applied General Statistics*. Parentice-Hall, Inc., Englewood Cliffs, N. J., U.S.A.

<sup>55</sup> Government of India (1994). *Index number of wholesale prices in India - Monthly Bulletin for August 1994*. Office of the Economic Advisor, Ministry of Industry, New Delhi.

## Trend models and selection criteria

To identify the general trends in prices, moving averages of average annual real prices were found so as to smoothen out the effect of year to year fluctuations in prices. Here, 3, 5, and 7 year moving averages were adopted to explain the general trends.

The price trends have been studied in detail by fitting different trend equations<sup>56</sup> to the real price series. The following models were tried, where  $P_t$  stands for the price at time  $t$ ,  $\ln$  for natural logarithm and  $t$  takes values from 1 to 38 for the years from 1956-57 to 1993-94.

$$P_t = \beta_0 + \beta_1 t + \varepsilon_t \quad \dots\dots\dots(2.2)$$

$$P_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \varepsilon_t \quad \dots\dots\dots(2.3)$$

$$P_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + \varepsilon_t \quad \dots\dots\dots(2.4)$$

$$P_t = \beta_0 + \beta_1 \ln t + \varepsilon_t \quad \dots\dots\dots(2.5)$$

$$P_t = \beta_0 + \beta_1 /t + \varepsilon_t \quad \dots\dots\dots(2.6)$$

$$\ln P_t = \ln \beta_0 + \ln \beta_1 t + \varepsilon_t \quad \dots\dots\dots(2.7)$$

$$\ln P_t = \ln \beta_0 + \beta_1 \ln t + \varepsilon_t \quad \dots\dots\dots(2.8)$$

$$\ln P_t = \beta_0 + \beta_1 /t + \varepsilon_t \quad \dots\dots\dots(2.9)$$

$$\ln P_t = \beta_0 + \beta_1 t + \varepsilon_t \quad \dots\dots\dots(2.10)$$

$$\ln P_t = \ln \beta_0 + \beta_1 t + \varepsilon_t \quad \dots\dots\dots(2.11)$$

$$\ln (1/P_t - 1/u) = \ln \beta_0 + \ln \beta_1 t + \varepsilon_t \quad \dots\dots\dots(2.12)$$

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<sup>56</sup> Different trend equations tried are linear (2.2), quadratic (2.3), cubic (2.4), logarithmic (2.5), inverse(2.6), compound (2.7), power (2.8), S-curve (2.9), growth (2.10), exponential (2.11) and logistic (2.12).

Apart from the above models, linear and quadratic spline<sup>57</sup> models were also fitted. From the real prices plotted, different periods could be identified during which the prices were observed to follow more or less a linear pattern with slope change or a quadratic pattern. In such cases, piece-wise regression models can be fitted<sup>58</sup> so as to compare the price movements between periods. Here, linear and quadratic spline models with two and three knots each were fitted. The knots identified graphically were  $k_1 = 13$  (for the year 1968-69),  $k_2 = 21$  (for the year 1976-77) and  $k_3 = 28$  (for the year 1983-84). The linear spline model continuous at two knots ( $k_1$  and  $k_2$ ) and that at three knots ( $k_1$ ,  $k_2$ , and  $k_3$ ) are given by Models 2.13 and 2.14 respectively. The quadratic spline model with two knots and that with three knots are given by Models 2.15 and 2.16 respectively. They are

$$P_t = \beta_{00} + \beta_{01}t + \beta_1(t-k_1)_+ + \beta_2(t-k_2)_+ + \varepsilon_t \quad \dots\dots\dots(2.13)$$

$$P_t = \beta_{00} + \beta_{01}t + \beta_1(t-k_1)_+ + \beta_2(t-k_2)_+ + \beta_3(t-k_3)_+ + \varepsilon_t \quad \dots\dots\dots(2.14)$$

$$P_t = \beta_{00} + \beta_{01}t + \beta_{02}t^2 + \beta_1(t-k_1)_+^2 + \beta_2(t-k_2)_+^2 + \varepsilon_t \quad \dots\dots\dots(2.15)$$

$$P_t = \beta_{00} + \beta_{01}t + \beta_{02}t^2 + \beta_1(t-k_1)_+^2 + \beta_2(t-k_2)_+^2 + \beta_3(t-k_3)_+^2 + \varepsilon_t \quad \dots\dots\dots(2.16)$$

where  $t = 1, 2, \dots\dots 38,$

$$(t-k_i)_+^j = (t-k_i)^j \quad \text{if } t > k_i \\ = 0 \quad \text{if } t \leq k_i,$$

$i = 1, 2, 3$  and  $j = 1, 2.$

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<sup>57</sup> Splines are piecewise polynomials of order  $k$ . The joint points of the pieces are usually called 'knots'.

<sup>58</sup> Montgomery, D. C. and Peck, E. A. (1982). *Introduction to Linear Regression Analysis*. John Wiley and Sons. New York.

The resulting models for different periods with respect to the linear spline model are

$$\begin{aligned}
 P_t &= \beta_{00} + \beta_{01} t + \varepsilon_t & , \text{ if } t \leq k_1 \\
 P_t &= (\beta_{00} - k_1 \beta_1) + (\beta_{01} + \beta_1) t + \varepsilon_t & , \text{ if } k_1 < t \leq k_2 \\
 P_t &= (\beta_{00} - k_1 \beta_1 - k_2 \beta_2) + (\beta_{01} + \beta_1 + \beta_2) t + \varepsilon_t & , \text{ if } t > k_2 \text{ for 2 knots and} \\
 & & \text{if } k_2 < t \leq k_3 \text{ for 3 knots} \\
 P_t &= (\beta_{00} - k_1 \beta_1 - k_2 \beta_2 - k_3 \beta_3) + (\beta_{01} + \beta_1 + \beta_2 + \beta_3) t + \varepsilon_t & \text{ if } t > k_3.
 \end{aligned}$$

The parameters in the Models 2.2 to 2.16 were estimated by the method of least squares. The best fitting model was selected based on (i) statistical non-significance of the Durbin-Watson  $d$ -statistic<sup>59</sup> used for testing the autocorrelation of residual terms in the model, (ii) highest adjusted  $R^2$  value and (iii) the least mean square error value.

### 2.4.3 Price relationships

The relationships of price of teakwood in a particular girth-class with lagged prices and with those of other girth-classes have been analysed. Further, the relationships of teakwood price with prices of other timbers, with quantity of teakwood sold and with teakwood production from forests have been examined. Price changes in relation to internal and external demand have also been discussed. The methodology adopted for each analysis is described below.

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<sup>59</sup> Johnston, J. (1972). *Econometric Methods*. McGraw-Hill Book Company, New York.

### **Autoregressive relationship of real prices**

For examining the relationship of real price with lagged prices, autoregressive model given by Model 2.17 have been estimated.

$$P_t = \gamma_0 + \gamma_1 P_{t-1} + \gamma_2 P_{t-2} + \varepsilon_t \dots\dots\dots (2.17)$$

where,  $P_t$ ,  $P_{t-1}$  and  $P_{t-2}$  denote the real prices in the current year  $t$ , lagged by one and two years respectively and  $\varepsilon_t$  stands for the random disturbance term.

For each series of real prices of teak logs in girth-classes  $E$ , 1, 2, 3 and 4, real prices lagged by one and two years were generated. Step-wise regression analysis has been carried out for prices of each girth-class, taking current year's real price ( $P_t$ ) as regressand and real prices lagged by one year ( $P_{t-1}$ ) and two years ( $P_{t-2}$ ) as regressors. In the autoregressive models, the Durbin-Watson  $d$ -test is invalid for testing autocorrelation of errors in the estimated model. So the Durbin  $h$ -statistic has been computed for each model and tested for autocorrelation<sup>60</sup>.

### **Inter-class price relationship**

The relationship of price of teakwood in a particular girth-class with those of other girth-classes is defined in this study as the inter-class price relationship. The inter-relationships have been analysed using the data for the period from 1970-71 to 1993-94. The apparent autocorrelation problem was eliminated<sup>61</sup> by employing first-order differencing to the real prices of teak logs in

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<sup>60</sup> *Ibid.*

<sup>61</sup> Montgomery, D. C. and Peck, E. A. (1982). *op.cit.*

different girth-classes in Kerala. A correlation analysis has, then, been done for the *differenced* series to examine the inter-class price correlations. The inter-class price relationships of the form given by Model 2.18 have also been estimated by carrying out a step-wise regression analysis through origin<sup>62</sup>, taking each differenced real price as regressand and all other differenced real prices as regressors.

$$(DP E)_t = \delta_1(DP 1)_t + \delta_2(DP 2)_t + \delta_3(DP 3)_t + \delta_4(DP 4)_t + \varepsilon_t \dots\dots\dots (2.18)$$

where  $(DP E)_t$ ,  $(DP 1)_t$ ,  $(DP 2)_t$ ,  $(DP 3)_t$  and  $(DP 4)_t$  denote respectively the *differenced* real prices of teakwood in girth-classes  $E$ , 1, 2, 3 and 4 during the year  $t$ ; and  $\varepsilon_t$  stands for the random disturbance term.

### **Inter-species price relationship**

The relationship of teakwood price with prices of other timbers is defined in this study as the inter-species price relationship. To examine the inter-species price relationship, first-order differencing was employed to the real prices of teakwood (girth-classes combined) and those of selected timbers during the period 1956-57 to 1993-94 for eliminating the problem of autocorrelation. Then, a correlation analysis has been done to the *differenced* real price series in order to examine the inter-species price correlations. Another analysis was also done to estimate the functional relationship of the form given by Model 2.19 of real prices of teakwood with those of selected timbers. A step-wise regression analysis through origin has been carried out, taking the *differenced* real price of teakwood as regressand

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<sup>62</sup> *Ibid.*

and the *differenced* real prices of selected timbers as regressors.

$$(DP TE)_t = \eta_1(DP AN)_t + \eta_2 (DP IR)_t + \eta_3(DP JA)_t + \eta_4(DP MA)_t + \eta_5 (DP TH)_t + \eta_6(DP VG)_t + \eta_7(DP VT)_t + \varepsilon_t \dots\dots\dots (2.19)$$

where  $(DP TE)_t$ ,  $(DP AN)_t$ ,  $(DP IR)_t$ ,  $(DP JA)_t$ ,  $(DP MA)_t$ ,  $(DP TH)_t$ ,  $(DP VG)_t$  and  $(DP VT)_t$  denote the *differenced* real prices of *teak*, *anjily*, *irul*, *jack*, *maruthu*, *thembavu*, *venga* and *venteak* respectively; and  $\varepsilon_t$  stands for the random disturbance term.

**Price-quantity relationship**

For examining the relationship between the real price and total quantity of teakwood sold, data on total quantity of teakwood sold in all the government depots together were compiled from the Administration Reports<sup>63</sup> of the Kerala Forest Department for the period<sup>64</sup> from 1956-57 to 1992-93. Autoregressive model of the form given by Model 2.20 has been estimated, taking real price of teakwood in the current year ( $P_t$ ) as regressand and real price lagged by one year ( $P_{t-1}$ ) and quantity of teakwood sold in the current year ( $Q_t$ ) as regressors.

$$P_t = \lambda_0 + \lambda_1 P_{t-1} + \lambda_2 Q_t + \varepsilon_t \dots\dots\dots (2.20)$$

**Price-production relationship**

Data on total volume of teakwood produced from forests were compiled from the Administration Reports of the Kerala Forest Department for the period from 1956-57 to 1992-93. For examining

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<sup>63</sup> Kerala Forest Department (1956-57 to 1992-93). *Administration Reports*. Government of Kerala, Thiruvananthapuram.

<sup>64</sup> Data for the year 1993-94 was not available.

the influence of total teakwood production<sup>65</sup> from forests on prices, autoregressive relationship given by Model 2.21 has been estimated, taking real price of teakwood in the current year ( $P_t$ ) as regressand and real price lagged by one year ( $P_{t-1}$ ), production of teakwood from forests in the current year ( $F_t$ ) and lagged by one year ( $F_{t-1}$ ) and two years ( $F_{t-2}$ ) as regressors.

$$P_t = \pi_0 + \pi_1 P_{t-1} + \pi_2 F_t + \pi_3 F_{t-1} + \pi_4 F_{t-2} + \varepsilon_t \dots \dots \dots (2.21)$$

### **Changes in internal demand**

Apart from the fluctuations in timber supply, change in demand is an important factor that influences the prices. Demand for timber can be categorised into internal and external demand. Most of the internal demand for timber is in the construction sector, particularly in residential buildings and hence the trend in housing and the pattern of use in the household sector are important factors influencing demand and consequently the prices. Of the total demand for timber in Kerala during the year 1987-88, rural household sector accounted for the major share<sup>66</sup>. Therefore, it was required to examine the pattern of timber-use in the rural household sector. The pattern of timber-use in rural households of Kerala has been examined based on the

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<sup>65</sup>The different sources of teakwood supply in Kerala are home gardens, Kerala forests and import from other states in India and other countries. The timber obtained from home-gardens seldom reaches the organised markets and a major part of it is utilised within the area. Through interview with timber traders, it has been found that a major part of the imported timber directly goes to industries and the supply through import is dependent on prices prevailing in the retail market rather than prices being determined by the supply. Therefore, in the present study, only the changes in supply (production) of teakwood from forests including teak plantations alone have been examined.

<sup>66</sup> Krishnankutty, C. N. (1990). *op.cit.*

data available in the survey schedules of the earlier study by the author. Different species of timbers including teakwood used in house construction, modification of house by way of addition or repair and for making furniture, fixtures and implements were included in the total quantity of timber used in the rural household sector. The volume of teakwood and other timbers utilised for various uses in the rural households have been estimated. To get a general picture of the trend in constructions, over time data on number of residential and non-residential buildings for the years 1973,1978, 1983, 1988 and 1993 were collected<sup>67</sup> from sample panchayats and analysed.

### **Changes in external demand**

Substantial quantities of teakwood and other timbers, both in round and sawn, are exported to other states, particularly to the wood-deficit state of Tamil Nadu<sup>68</sup>. A large number of traders from Tamil Nadu also participate in timber auction in the Kerala government depots. Obviously, auction prices in Kerala are a reflection of the situation that exists in Tamil Nadu. The quantity of teakwood exported to other states through the major inter-state forest check-posts at Kotekar, Vazhikadavu, Walayar, Vaniyampara and Arienkavu were collected from the registers maintained at the check-posts during the period from 1980-81 to 1993-94. First-order differencing was employed to the series of real prices of teakwood and quantities of teakwood exported for eliminating the problem of autocorrelation. An attempt has been made to estimate the relationship of the

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<sup>67</sup> The sample Panchayats were Koorkanchery, Vadanappally, Adat and Orumanayur in Thrissur District.

<sup>68</sup> For quite some time, Kerala was net exporter of other timbers. With the decline in the supply of ordinary construction timbers from Kerala forests, the trend has reversed. Presently, a large quantity of other timbers such as salwood is imported to Kerala.

form given by Model 2.22 for examining the influence of teakwood-export on price of teakwood in Kerala.

$$(DP)_t = \kappa_1(DEX)_t + \varepsilon_t \dots\dots\dots (2.22)$$

where  $(DP)_t$  denotes the *differenced* real price of teakwood (girth-classes combined) and  $(DEX)_t$ , the *differenced* quantity of teakwood exported.

#### 2.4.4 Price Forecasting

For forecasting future prices of teakwood, autoregressive integrated moving average (ARIMA) model, has been used.<sup>69</sup> The general form of the ARIMA model of order  $(p, d, q)$  for a time series  $Z_t$  is written as

$$\phi(B) (1-B)^d Z_t = \theta(B)a_t \dots\dots\dots (2.23)$$

where  $\phi(B) = (1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p)$ ,

$\theta(B) = (1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q)$ ,

$B^j Z_t = Z_{t-j}$ , where  $B$  is the backward shift operator,

$a_t$  : the random shock which is distributed  $N(0, \sigma_a^2)$ ,

$d$  : the degree of differencing.

$\phi(B)$  and  $\theta(B)$  are called autoregressive operator of order  $p$  and moving average operator of order  $q$  respectively.  $\phi_1, \phi_2, \dots, \phi_p$ , known as autoregressive parameters, and  $\theta_1, \theta_2, \dots, \theta_q$  known as moving average parameters, and  $\sigma_a$  are to be estimated from the data. When the degree of differencing,  $d$ , is zero,  $Z_t$  is replaced by  $\bar{Z}_t = Z_t - \mu$ , where  $\mu$  is the mean of the series  $Z_t$ . Model 2.23 can be used for describing stationary and non-stationary time series.

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<sup>69</sup> Box, G. E. P. and Jenkins, G. M. (1976). *op.cit.*

The method developed by Box and Jenkins<sup>70</sup> for analysing time series has four stages -i) identification ii) estimation iii) diagnostic check and iv) forecasting which are described below.

Identification of the time series model is the determination of the model. Before establishing a model for a given time series, whether the given series is stationary or non-stationary has to be understood. If the frequency of occurrence of autocorrelation of various lags is very high, it indicates the existence of clear autocorrelation and the given series is non-stationary. Then, the non-stationary series should be undergone differencing till the stationarity state appears and the number of times differencing sought is the value of  $d$ .

The value of  $p$  and  $q$  are determined as follows. When the autocorrelation function of the time series is cut off at lag  $k$  (where  $k > q$ ) and the partial autocorrelation function shows a gradually declining trend, then the suggested model is MA ( $q$ ). When the autocorrelation function shows a gradually declining trend and the partial autocorrelation function is cut off at  $p$  (where  $k > p$ ), then the suggested model is AR( $p$ ). When both the autocorrelation and partial autocorrelation functions show a gradual decline, then ARMA ( $p, q$ ) model is suggested. If both of them is cut off at  $q$  and  $p$ , then it is difficult to determine the model. In this case, three kinds of models - MA( $q$ ), AR( $p$ ) and ARMA( $p, q$ ) - can be fitted and later by diagnostic check, the actual model can be determined.

After identifying the model, the parameters in the model are to be estimated using the maximum likelihood method. After having estimated the model, the diagnostic check is to be performed. If

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<sup>70</sup> *Ibid.*

there exists autocorrelation between the residual terms, the model is not suitable, otherwise, the model can be accepted. The autocorrelation of residuals can be tested with Box-Ljung statistic. If it is non-significant, there is no autocorrelation. After checking the model for Box-Ljung statistic, the best model among the different models identified can be selected based on (i) the least values of Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC), (ii) relatively small residual standard error, (iii) low mean absolute prediction error and (iv) comparatively small number of parameters.

The method developed by Box and Jenkins described above has been adopted for analysing the time series of teakwood prices. The average annual current prices of teakwood in girth-classes 1, 2 and 3 for the 53 year period from 1941-42 to 1993-94 in Kerala<sup>71</sup> were used for ARIMA modelling and thereby forecasting future prices.

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<sup>71</sup>The data for the period from 1941-42 to 1955-56 was compiled from various Divisional Forest Working Plans in Travancore and Cochin States and Malabar District (Madras Presidency) which constitute the present Kerala State.

## CHAPTER 3

### DEMAND FOR TEAKWOOD IN KERALA

The methodology adopted for the estimation of demand for teakwood in the households, industries and other constructions sectors in Kerala and for export during the reference year 1987-88 and the results are presented in this chapter.

#### 3.1 Methodology

Demand for timber<sup>1</sup> is segregated into the demand in the households, industries, other constructions sectors and for export. The database and the method of estimation adopted in this study for various sectors are explained below.

Teakwood and other timbers are used in households for house construction, repair or alterations and making furniture, fixtures, implements, etc<sup>2</sup>. The demand for timber in households in rural and urban areas constitute the total demand in the household sector of Kerala.

As part of the study on 'demand and supply of wood in Kerala and their future trends' by the author<sup>3</sup>, a sample survey was conducted to estimate the demand for timber in households in the rural areas of Kerala. From the survey schedules, the quantities of

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<sup>1</sup> 'Timber' includes teakwood and timbers of all tree species including coconutwood and palmyrawood.

<sup>2</sup> Use of timber for construction, furniture-making, etc. in households is considered. Finished wood-products such as furniture, fixtures, etc. purchased by households are excluded as they are accounted in the industries sector. Houses include residential and other buildings for household uses.

<sup>3</sup> Krishnankutty, C. N. (1990). *op.cit.*

teakwood used in households were taken for estimating the demand for teakwood in the present study. The methodology adopted for the survey was as follows.

A stratified three-stage sampling procedure was adopted for the selection of sample households. For each revenue village in Kerala, the percentage of dryland (garden land) area under agricultural use to the total area under agricultural use<sup>4</sup> was calculated from the unpublished data available in the State Land Use Board. For each village, the population density was also computed using data available in the 1981 Census Report<sup>5</sup>. By forming 5 classes for the percentage area and 3 classes for the population density, 15 strata were formed and the villages were classified into different strata accordingly<sup>6</sup>. Revenue villages in each stratum were treated as first-stage units of sampling. Out of the total number of villages in Kerala according to 1981 Census, 2.5 per cent of the number were distributed in different strata approximately in

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<sup>4</sup> In the study, the total area under agricultural use was defined to include land under miscellaneous tree crops, cultivable waste, current and other fallows and net area sown. The dryland area under agricultural use equals the total area under agricultural use less the area under wet land (paddy fields). For each village, the data was available in the files of State Land Use Board, Thiruvananthapuram.

<sup>5</sup> Government of India (1984). *Census of India 1981*. Directorate of Census Operations, Kerala.

<sup>6</sup> Two way stratification was adopted since the timber availability depends on the extent of drylands where trees are maintained and the timber consumption depends on population density. Different classes of percentage of dryland area under agricultural use to total area under agricultural use were: 0-50, 50-70, 70-80, 80-90 and 90-100 and various classes of population density were: below 500, 500-1000 and above 1,000 persons per km<sup>2</sup>.

proportion to the dryland area under agricultural use in each stratum ensuring at least one village from each stratum. The villages in each stratum were chosen at random and in all the strata, 30 villages were selected (Appendix 3).

Census villages or desoms were taken as second stage units of sampling, since several desoms form a revenue village. The third-stage units of sampling were the households where timber was utilised during the year 1987-88. One desom each was randomly selected from the chosen revenue villages. For preparing the sampling frame, all the households in the selected desom were visited to collect information such as year of house construction, whether timber was utilised during the reference year 1987-88 for (i) house construction, (ii) repair or alterations and (iii) making furniture, fixture, implements, etc.

The households were classified into three categories as mentioned above. In a selected desom, 10 households each were randomly and independently chosen from the list of households of the above three categories. Actual measurements, on teakwood and other timbers used for specific purposes, were made in each selected household. The quantities of teakwood and other timbers used for (i) new house construction, (ii) repair or alterations and (iii) making furniture, fixtures and implements were separately estimated for the rural household sector. The three quantities were added together to give the total quantity of teakwood and other timbers used in the rural households sector of Kerala.

For estimating the quantity of timber used in households in urban areas of Kerala, the total number and plinth area of residential houses constructed in urban areas of Kerala for the years 1981 to 1985 were compiled from the Brochure on housing statistics<sup>7</sup>.

The total number and plinth area per year was worked out and assumed as that of 1987-88. Based on these figures, the average plinth area per residential house was estimated. Using the average plinth area per residential house and the average timber requirement in m<sup>3</sup> per residential house calculated by Central Building Research Institute<sup>8</sup> as  $0.23 + 0.0232A$  (where A is the plinth area of a house in m<sup>2</sup>), the mean quantity of timber used per house was computed. The quantity of all timbers used in residential house construction in the urban areas of the state<sup>9</sup> was computed by multiplying the mean quantity of timber used per house with the number of new houses estimated for the year 1987-88. Based on the proportion of teakwood in the total timber used in new houses in semi-urban villages among the 30 villages surveyed (see 3.1.), the quantity of teakwood used in the urban household sector was estimated.

Industries sector consists of industries which use teakwood and other timbers as raw material<sup>10</sup>. Industries use teakwood and other timbers as raw material for furniture, veneers, boat making,

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<sup>7</sup> Department of Economics and Statistics (1988). *Brochure on housing statistics 1987*. Government of Kerala, Thiruvananthapuram.

<sup>8</sup> Central Building Research Institute (1985). *Manpower and material requirements in residential buildings*, Buildings research note 31, Roorkee.

<sup>9</sup> The quantity of timber used for making furniture, fixtures and implements in urban areas was assumed to be negligible since most of them were purchased by the households.

<sup>10</sup> In this study, timber processed in saw-mills has been accounted in their finished state in building construction, furniture, fixtures, etc. Therefore, in order to avoid double counting, timber used by saw-milling industry has not been separately shown.

handicrafts, etc. Industries sector is comprised of two broad groups: organised and unorganised sectors. All industrial units registered under Sections 2(m) and 85 of the Factories Act are included in the organised sector<sup>11</sup>. The unorganised sector consists of units registered as small-scale and other unregistered industrial units.

Annual Survey of Industries (ASI) of the National Sample Survey Organisation (NSSO), Government of India, provides valuable information on consumption of raw materials including timber. The factories registered under Section 2(m) are sub-classified in the ASI into census and non-census sectors<sup>12</sup>. The NSSO surveys all units in the census sector every year through the ASI. Half of the units in each industry in the non-census sector is surveyed by the NSSO in each year by rotation so as to cover all units within a period of two years. The ASI data of Kerala State pertaining to the years from 1979-80 to 1985-86 except for 1982-83 were collected from the survey schedules available at the Department of Economics and Statistics, Thiruvananthapuram<sup>13</sup>. Based on the number of units and the quantity consumed in each

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<sup>11</sup> Factories which are using power and employing 10 or more workers and those which are not using power and employing 20 or more workers on any day during the accounting year come under Section 2(m). Factories employing less than 10 workers and working with the aid of power and those employing less than 20 workers and working without the aid of power on any day during the year come under Section 85.

<sup>12</sup> The units employing 50 or more workers working with the aid of power and those employing 100 or more workers without using power come under census sector. The non-census sector includes the remaining factories coming under section 2(m).

<sup>13</sup> The data for the year 1982-83 were not available.

year, weighted average consumption of timber by different industries in the census and non-census sectors in each district was worked out. The mean consumption of timber by industries coming under Section 85 was taken to be the same as that for industries in the non-census sector<sup>14</sup>. An attempt was also made to collect data on consumption of teakwood and other timbers by different industries through a survey for the year 1987-88. These data were used to cross-check with the norms of consumption derived from the ASI data and it was found that in many cases, they were in broad agreement. It was, therefore, decided to use the ASI data in view of wider coverage. The number of factories functioned during 1987-88 in respect of census, non-census sectors and Section 85 in each district were compiled from the publications of the Department of Factories and Boilers<sup>15</sup> and from registers maintained by that Department. The quantity of teakwood and other timbers used by different industries in Kerala during 1987-88 was estimated on the basis of the number of units and average consumption per unit in each district.

Data on the number of various small-scale timber using units were collected from the Small Industries Service Institute, Thrissur. Sample units were approached to estimate the average consumption.

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<sup>14</sup> Since the technology used and the number of employees including temporary workers in both the groups of timber-based industries are the same, it was assumed that there was not much difference in the consumption of timber.

<sup>15</sup> i) Department of Factories and Boilers (1984). *List of factories as on 31st December 1982*. Government of Kerala, Thiruvananthapuram.

ii) ——— (1987). *Division-wise list of registered (2m) factories in Kerala*. Government of Kerala, Govt. Press Ernakulam.

The quantity of teakwood and other timbers used by small-scale industries was arrived at based on the number of units in each category and the average consumption per unit. The volume of teakwood and other timbers used by industrial units including household enterprises which are not registered anywhere was estimated based on the data on the number of such units and average consumption of timber per unit in the selected villages of the sample survey.

Other constructions sector is defined to include all timber-using activities such as construction of non-residential buildings like business establishment, schools, hostels, hospitals, etc. and use of timber in government departments, railways, etc. Timber consumption in this sector is mostly in the form of construction timber. From the data compiled from the Brochure on housing statistics<sup>16</sup> on number and plinth area of non-residential buildings constructed in the private and public sectors in the urban areas for the period 1981 to 1985 according to type of buildings, the total number and plinth area per year were worked out and assumed as the total number and plinth area of non-residential buildings constructed during 1987-88 in the urban areas. Based on the total number and plinth area, the average plinth area per non-residential building was estimated. The quantity of timber used was worked out on the basis of the estimated total number, average plinth area per non-residential building and the average timber requirement per house provided by the Central Building Research Institute<sup>17</sup>. The quantity of teakwood and other timbers used in the rural areas was

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<sup>16</sup> Department of Economics and Statistics (1988). *op.cit.*

<sup>17</sup> Central Building Research Institute (1985). *op.cit.*

estimated based on the number of newly built non-residential buildings during the year 1987-88 in the desoms of the selected villages of the sample survey (meant for the estimation of timber-use for house construction and other purposes by households in the rural areas) and the average quantity of timber used. The actual quantity of teakwood and other timbers utilised for non-residential buildings constructed by the Central Public Works Department was added to give the total quantity of timber used in the non-residential construction sector. Volume of teakwood and other timbers used in government departments as well as institutions and as railway sleepers was estimated from data available in the administration report and files of the Kerala Forest Department.

Considering the fact that teakwood and other timbers move out of Kerala, an attempt was made to estimate the quantum of out-flow. The quantity of timber moved out of Kerala by road was compiled from registers maintained at fifteen forest check-posts (Appendix 4)<sup>18</sup>. Besides, data from records available at railway stations as well as Cochin and Calicut Chambers of Commerce and Industry for Ports<sup>19</sup> were taken to estimate the total export demand (Appendix 4).

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<sup>18</sup> There are a few more border exit points. The data pertaining to these were not collected due to non-availability of registers in some check-posts and non-existence of check-posts.

<sup>19</sup> i) Cochin Chamber of Commerce and Industry (1989). *131<sup>st</sup> Annual Report 1987-88*. Cochin.

ii) Calicut Chamber of Commerce and Industry (1989). *Annual Report 1987-88*. Calicut.

### 3.2. Demand in the Household Sector

The demand for teakwood and other timbers in the rural and urban households of Kerala is given in Table 3.1. The estimated total quantity of all timbers<sup>20</sup> including teakwood (sawn timber) used for house construction, repair, alterations and making furniture, fixtures, implements, etc. in the household sector of Kerala is 5,58,000 m<sup>3</sup>. Teakwood accounted for 21,186m<sup>3</sup> which comes about 3.8 per cent of the total. In roundwood equivalent<sup>21</sup>, the

Table 3.1 Demand for teakwood and other timbers in the household sector of Kerala during 1987-88

Households	(volume of sawn timber in m <sup>3</sup> )		
	Teakwood	Other timbers	Total
Rural	19,419 (22,847) <sup>#</sup>	4,97,347 (9,73,181)	5,16,766 (9,96,028)
Urban	1,767 (2,079)	39,467 (1,34,893)	41,234 (1,36,972)
Total	21,186 (24,926)	5,36,814 (11,08,074)	5,58,000 (11,33,000)

<sup>#</sup> The figure in parenthesis is the roundwood equivalent (m<sup>3</sup>).

Source: Re-worked from Krishnankutty, C. N. (1990). *op.cit.*

<sup>20</sup> Krishnankutty, C. N. (1990). *op. cit.*

<sup>21</sup> The sawn wood recovery of 1 m<sup>3</sup> of round log of coconutwood is 0.255 m<sup>3</sup>. [Gnanaharan, R. and Dhamodaran, T. K. (1988). *Comparison of wilt diseased and non-diseased (over aged) coconut stem wood with respect to their utilisation potential*. Kerala Forest Research Institute, Peechi]. For teakwood, it is 0.85 m<sup>3</sup>. For other timbers, it was taken as 0.75 m<sup>3</sup>. [See also Forestry Commission (1965). *Conversion tables for research workers in forestry and agriculture*. Booklet No. 5. London].

total quantity of all timbers is worked out to be 11,33,000 m<sup>3</sup> of which teakwood accounted for 24,926 m<sup>3</sup> (2.2 per cent). Teakwood was used in the household sector mainly for furniture, door and window shutters whereas coconutwood, jack and *anjily* were the most common timbers used in house construction (see also Appendix 7).

### 3.3. Demand in the Industries Sector

Saw-milling is the most important timber-using industry in Kerala. Quantity of teakwood and other timbers processed in sawmills during 1987-88 was estimated as 15,72,000 m<sup>3</sup>, of which 7,50,000 m<sup>3</sup> represented custom sawing of all timbers brought by users directly<sup>22</sup>. Quantity of sawn timber of teakwood and other timber from sawmills used in the households, industries and other constructions sectors and for export has been accounted in the total demand for teakwood and that of other timbers. Therefore to avoid double counting, quantities of teakwood and other timbers processed in saw-milling industry are not shown separately.

Table 3.2 gives the industrial demand for timber in Kerala. The estimated total quantity of all timbers including teakwood used in the industries sector is 10,61,000 m<sup>3</sup> roundwood of which teakwood accounted for about 15,000 m<sup>3</sup> (1.4%). Of the total industrial demand for teakwood, furniture industry accounted for the major share (82.0 per cent) and use of teakwood in other industries was marginal. The highest demand for other timbers was in the packing case industry, match industry ranked next, followed by furniture industry.

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<sup>22</sup> Krishnankutty, C. N. (1990). *op.cit.*

Table 3.2 Industrial demand for teakwood and other timbers in Kerala during 1987-88

(round logs in m<sup>3</sup>)

Industry	Teakwood		Other timbers		All timber	
	Qty.	%	Qty.	%	Qty.	%
Packing case	0	0.0	3,19,224	30.5	3,19,224	30.1
Match splint and veneer	0	0.0	2,83,346	27.1	2,83,346	26.7
Furniture	12,195	82.0	1,40,242	13.4	1,52,437	14.4
Plywood and veneer	1,430	9.6	1,30,568	12.5	1,31,998	12.4
Pulp and Paper <sup>23</sup>	0	0.0	1,11,374	10.6	1,11,374	10.5
Others <sup>24</sup>	1,251	8.4	61,311	5.9	62,562	5.9
Total	14,876	100.0	10,46,065	100.0	10,60,941	100.0
	(1.4)		(98.6)		(100.0)	

Source: Re-worked from Krishnankutty, C. N. (1990). *op.cit.*

### 3.4 Demand in Other Constructions Sector

The estimated quantity of all timbers including teakwood (sawn timber) used in the other constructions sector is 1,16,000 m<sup>3</sup> of which teakwood accounted for 3.7 percent. The round wood equivalent of the total quantity of all timbers is 2,24,000 m<sup>3</sup>. The quantity of teakwood used was 4928 m<sup>3</sup> which forms 2.2 percent of the total demand for all timbers in this sector.

<sup>23</sup> Two pulp-based units were lying closed during the reporting year.

<sup>24</sup> Others include industries producing hand tools, agricultural implements, wooden structural goods, pencil, photo frames, wooden toys, wooden boats, transport equipment, etc.

### 3.5 Demand for Export

Teakwood and other timbers (sawn size and round logs) and poles are being sold from Kerala to other states in India and sawn timber to other countries (Appendices 5 and 6). Table 3.3 provides

Table 3.3 Export<sup>25</sup> of teakwood and other timbers from Kerala during 1987-88.

Products	Unit	Quantity	% to total
Teakwood (round logs <sup>26</sup> )	m <sup>3</sup>	19,288	25.6
Rosewood (round logs <sup>26</sup> )	"	125	0.2
Timbers of other kinds (round logs <sup>26</sup> )	"	25,131	33.4
Poles <sup>27</sup>	'000 nos.	340	31.9
"	m <sup>3</sup>	6,670	8.9
Total (round wood equivalent)	m <sup>3</sup>	75,328	100.0

Source: Krishnankutty, C. N. (1990). *op.cit.*

the data on export of teakwood and other timbers from Kerala. A quantity of 75,000 m<sup>3</sup> roundwood equivalent of timbers and poles had moved out of Kerala during 1987-88. The quantity of teakwood exported was 19,000 m<sup>3</sup> which did not include the quantity of teak poles since poles were excluded from the definition of teakwood in the present study. Teakwood accounted for 25.6 per cent of the total export demand of all timbers.

<sup>25</sup> Does not include timber-products like packing cases, veneers, plywood, etc.

<sup>26</sup> Includes sawn timber which was converted into round wood equivalent using the conversion factor 1 m<sup>3</sup> of sawn timber equals 1.33 m<sup>3</sup> of roundwood.

<sup>27</sup> The conversion factor used in the total was 14.1 number of medium-size poles equals 1 m<sup>3</sup> roundwood (KFRI, 1979).

### 3.6. Demand for Teakwood: An Overview

Table 3.4 shows the demand for teakwood and other timbers in Kerala during the year 1987-88. The estimated demand for

Table 3.4 Demand for teakwood and other timbers in Kerala during 1987-88

(in '000' m<sup>3</sup> roundwood equivalent)

Sectors	Teakwood		Other timbers		All timber Quantity
	Quantity	(%)	Quantity	(%)	
Households	25 (1.0)#	39.1	1108 (44.4)	45.6	1133 (45.4)
Industries	15 (0.6)	23.4	1046 (42.0)	43.1	1061 (42.6)
Other constructions	5 (0.2)	7.8	219 (8.8)	9.0	224 (9.0)
Export	19 (0.8)	29.7	56 (2.2)	2.3	75 (3.0)
<b>Total demand</b>	<b>64 (2.6)</b>	<b>100.0</b>	<b>2429 (97.4)</b>	<b>100.0</b>	<b>2493 (100.0)</b>

# The figure in parenthesis is percentage to the total demand all timbers.

Source: Re-worked from Krishnankutty, C. N. (1990) *op.cit.*

teakwood and that of other timbers are 64,000 m<sup>3</sup> and 24,29,000 m<sup>3</sup> round wood equivalent respectively. Household sector accounted for 39.1 per cent of the total demand for teakwood, industries sector for 23.4 per cent, other constructions sector for 7.8 per cent and export for 29.7 per cent.

Of the total demand for all timbers, household sector accounted for 45.4 per cent, industries sector for 42.6 per cent, other constructions sector for 9.0 per cent and export for only

3.0 per cent. Teakwood contributed only 2.6 per cent of the total demand for all timbers in Kerala.

In this chapter, the estimates of demand for teakwood as well as other timbers in Kerala for the reference year 1987-88 have been presented. The study revealed that the household sector, followed by export, accounted for the major share of the demand for teakwood. Demand for teakwood for furniture making in the industries sector was also substantial.

## CHAPTER 4

### SUPPLY OF TEAKWOOD IN KERALA

The methodology followed for the estimation of supply of teakwood through import and from different internal sources in Kerala during the reference year 1987-88 and the results are presented here. The share of teakwood in the total supply of all timbers in Kerala is also assessed in this chapter.

#### 4.1 Methodology

Supply of timber in Kerala comprises of import and production from estates, forests and home gardens. Production of timber from the non-forest sources refers to the quantity of timber extracted and used or brought to the market in the reference year 1987-88.

Quantity of teakwood and other timbers imported to Kerala from outside the state and from other countries was arrived at by perusing the records available at fifteen border forest check-posts, railway stations as well as Cochin and Calicut Chambers of Commerce and Industry for port<sup>1</sup> (Appendix 4).

For estimating the supply of timber from the estate sector, which include plantations of rubber, cardamom, coffee and tea, the method adopted was as follows. It was reported by the officials of the different Commodity Boards that teak (a dry deciduous species) trees are not retained or planted in plantations for shade. Therefore, teakwood production in estates was considered as negligible. The supply of rubberwood from rubber plantations was arrived at based

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<sup>1</sup> i) Cochin Chamber of Commerce and Industry (1989). *op.cit.*

ii) Calicut Chamber of Commerce and Industry (1989). *op.cit.*

on the area re-planted per annum and the yield of wood per ha. It was estimated by the officials of the Rubber Board that about 5,000 ha were re-planted annually and the yield of rubberwood was 199.76 m<sup>3</sup> per ha. The distribution of stem wood (commercial timber) and branch wood (fuelwood) has been reported as 60 and 40 per cent respectively<sup>2</sup>. The estimated commercial timber is thus 119.856 m<sup>3</sup> per ha. The Rubber Board permits a maximum of 20 trees per hectare other than rubber to be retained in rubber plantations. Valuable trees of medium growth such as *anjily* and jack are usually retained by farmers at the time of planting rubber. From field surveys, it was assessed that at least two trees of diameter at breast height (dbh) above 65 cm were felled per hectare during felling of rubber plantations for re-planting and the estimated volume of commercial timber from such trees is 3.641 m<sup>3</sup>. The supply of timber such as *anjily* and jack from rubber plantations was arrived at based on the area re-planted per annum and timber production per hectare. As regards coffee, tea and cardamom plantations, it was also assessed that at least one tree above 45 cm dbh was felled per hectare per annum producing 0.971 m<sup>3</sup> of commercial timber and the supply was estimated based on the timber production per hectare and the area of plantations.

For estimating the recorded production of teakwood and other timbers from forests, data available in the Administration Report of the Kerala Forest Department was taken. However, unrecorded production of timber has been estimated as 10 per cent of the recorded production<sup>3</sup>.

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<sup>2</sup> Haridasan, V. and Sreenivasan, K. G. (1985). *op.cit.*

<sup>3</sup> Department of Economics and Statistics (1986). *State income and related aggregates of Kerala, 1983-84*. Government of Kerala, Thiruvananthapuram.

As part of the earlier study by the author<sup>4</sup>, a survey on teak and other trees felled in home-gardens was attempted to quantify the production of teakwood and other timbers from home-gardens. Home-gardens include homesteads and farm lands. Dry land area under agricultural use (foot-note 4 of chapter 3 for definition) less area under estates is defined as the area under home-gardens. There was lack of information regarding the restrictions imposed by the government on felling of certain trees in home-gardens. The households were found to conceal actual tree-felling due to fear of bureaucratic harassment later. Also the recall method adopted for the survey had several defects, the most important being the non-availability of exact dimensions of the already felled trees. Due to unreliability in the data taken from the survey schedules, it was not used for further analysis.

The teakwood production from home-gardens has been therefore, taken as the difference between the estimated demand for teakwood and the sum of import of teakwood and production of teakwood from forests. The absence of a specific estimate of timber production from home gardens is a limitation. However, as all other components of demand and supply have been accounted and quantified reliably, it was justifiably assumed that the residual quantity was contributed by the home-gardens.

As part of the earlier study by the author, another sample survey was conducted during 1988-89 to estimate the volume of growing stock of trees in home gardens, the tree-mix and the preference for particular species. The methodology adopted for the survey was as follows. In the stratified three-stage sampling procedure,

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<sup>4</sup> Krishnankutty, C. N. (1990). *op.cit.*

the strata, first-stage and the second stage units of sampling were the same as that of the sample survey used for estimating the timber-use in households (see also section 3.1.). The households in the selected desom (second-stage unit) were classified<sup>5</sup> on the basis of size of dryland holding<sup>6</sup>. The households with dryland holding formed the third-stage units of sampling. 25 households were allocated proportional to the number of households in each class and households in each class were randomly and independently selected. All dryland belonging to the sample households in the desom were surveyed. In the home-gardens of the selected households, teak and other trees of different species coming under different diameter classes (dbh)<sup>7</sup> were enumerated and the growing stock in number in the state during the year 1988-89 was estimated. Trees in plantations of rubber, cardamom, coffee and tea and all palms except coconut were excluded from the definition of trees in this study.

The growing stock of trees in terms of commercial volume was also worked out. Commercial volume refers to the volume of wood

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<sup>5</sup> Tree cropping intensity partly depends on the size of dryland holding. It is, therefore, reasonable to classify the households on the basis of size of dryland holding. The different size classes are: below 0.09 acre, 0.1-0.24, 0.25-0.49, 0.50-0.99, 2.0-2.99, 3.0-4.99 and above 5 acres.

<sup>6</sup> Nair, C. T. S. and Krishnankutty, C. N. (1987). Socio-economic factors influencing farm forestry: A case study of tree cropping in the homesteads in Kerala, India. In Rao, Y. R., Vergara, N. T. and Lovelace, G. W. (Ed). *Community forestry: socio-economic aspects*. F.A.O. and East-West Center, Bangkok, 115-130.

<sup>7</sup> Diameter at breast height (dbh) is measured at 1.37 m from the ground. The different classes are: below 10 cm, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90 cm and above.

underbark of logs above 60 cm girth overbark. Commercial timber can also be used as fuelwood and vice versa. Tables for commercial volume of different species are available from 20 to 30 cm dbh class upwards for the forest trees of Kerala<sup>8</sup>. Species for which separate volume tables were not available had been divided into evergreen and deciduous and the volumes were estimated using the volume tables for 'miscellaneous evergreen' and 'miscellaneous deciduous' species<sup>9</sup>. The growing stock of trees in terms of commercial volume was computed by multiplying the number of trees by species and diameter classes with the corresponding commercial volume given in the volume tables. The growing stock of coconut palms in terms of commercial volume<sup>10</sup> has been estimated by multiplying the number of coconut palms with 0.072 m<sup>3</sup>. Trees of different species were classified into two groups, trees with multiple-use value and trees with only timber value. They were further sub-classified<sup>11</sup> by suffixing 1, 2, 3 and 4 ranked according to durability<sup>12</sup> and commercial timber value. They were high value, medium value, low value and very low value respectively. The first group - CO, M2, M3 and M4 - consisted of coconut (CO)

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<sup>8</sup> Nair, N. R. (1971). *Commercial volume tables for the forest trees of Kerala*. Kerala Forest Department, Thiruvananthapuram.

<sup>9</sup> *Ibid.*

<sup>10</sup> Gnanaharan, R. and Dhamodaran, T. K. (1988). *op.cit.*

<sup>11</sup> Durability<sup>12</sup> (life span in years obtained in graveyard test) below two years: perishable; 2-5 years: non-perishable; 5-7 years: moderately durable; 7-10 years: durable; and above 10 years: very durable. Trees with durability of timber above 5 years: medium value, 2-5 years: low value and below 2 years: very low value.

<sup>12</sup> Nazma, *et.al.*, (1981). *op.cit.*

and other multiple use trees<sup>13</sup>. The second group - T1, T2, T3, and T4 consisted of trees with only wood value.

## 4.2 Supply through Import

A substantial quantity of timber of all kinds is being imported to Kerala (Appendix 8). Table 4.1 presents the details regarding the

Table 4.1 Import<sup>14</sup> of teakwood and other timbers to Kerala during 1987-88

Timber (round logs)	Unit	Quantity	%
Teakwood	m <sup>3</sup>	1,553	0.8
Rosewood	"	2,023	1.1
Eucalypt wood	tonnes	4,678	3.3
Other kinds <sup>15</sup>	m <sup>3</sup>	1,74,091	91.8
Poles	'000 nos.	81	3.0
Total (roundwood equivalent) <sup>16</sup>	m <sup>3</sup>	1,89,733	100.0

Source. Krishnankutty, C.N. (1990). *op.cit.*

import of teakwood and other timbers to Kerala from other states in India and abroad during 1987-88. The quantity of teakwood imported

<sup>13</sup> Multiple use trees are those which provide a combination of uses such as timber, fruit, green manure, fodder, etc.

<sup>14</sup> Timber logs of 898 m<sup>3</sup> imported by rail was also included. Wood-pulp of 5259 tonnes imported from New Zealand, Norway, USA, etc. was excluded.

<sup>15</sup> Of the total quantity of timber other kinds, 60 per cent was imported from Malaysia.

<sup>16</sup> The roundwood equivalent had been worked out using conversion factors 1 m<sup>3</sup> equals 0.740 tonnes for *Eucalyptus grandis* wood, 0.980 for *E. tereticornis* wood and 0.945 tonnes for sandalwood<sup>17</sup>.

<sup>17</sup> Nazma, *et al.*, (1981). *op.cit.*

was 1,553 m<sup>3</sup>. The total quantity of all timbers imported was 1,90,000 m<sup>3</sup> of which teakwood accounted for only 0.8 per cent. Timber imported from Malaysia was about 1,04,000 m<sup>3</sup> which accounted for about 55 per cent of the total timber imported.

#### **4.3 Supply from Estates**

Production of teakwood from plantations of rubber, coffee, tea and cardamom was negligible, considering the fact that teak trees are not retained or planted for shade in estates. The estimated quantity of timber production from rubber plantations including small holdings during 1987-88 was 5,99,000 m<sup>3</sup>. In addition to rubberwood, timber of *anjily*, jack, etc. was also obtained during felling of rubber plantations. The quantity of such timber has been estimated to range from 18,000 to 36,000 m<sup>3</sup>. The supply of timber from plantations of tea, coffee and cardamom has been worked out to range from 1,58,000 to 3,16,000 m<sup>3</sup>. The total supply of other timbers from all estates has been thus arrived at ranging from 7,75,000 to 9,51,000 m<sup>3</sup> roundwood.

#### **4.4 Supply from Forests**

Supply of teakwood and other timbers from the natural forests and plantations of Kerala during 1987-88 is presented in Table 4.2. The supply of teakwood from forests has been estimated to range from 21,000 m<sup>3</sup> to 23,000 m<sup>3</sup>. The production of all timbers has been worked out to range from 2,71,000 m<sup>3</sup> to 2,95,000 m<sup>3</sup>. Eucalypt wood contributed the major share (51.6 per cent) of the recorded production whereas teakwood only 7.8 per cent. Of the total supply of all timbers from the forests of Kerala, teakwood contributed to range from 6.5 to 7.1 per cent.

Table 4.2 Supply of teakwood and other timbers from forests of Kerala during 1987-88

Timber (round logs)	Unit	Recorded production	Unrecorded production (in range)	Total production (in range)
Teakwood	m <sup>3</sup>	19,222	1,922 - 3,844	21,144 - 23,066
Other timbers	m <sup>3</sup>	31,929	3,193 - 6,386	35,122 - 38,315
Eucalyptwood	tonnes	97,815	9,782 - 19,564	1,07,597 - 1,17,379
Poles	'000 nos.	957	96 - 192	1,053 - 1,149
Total (in round timber equivalent)	m <sup>3</sup>	2,46,033	24,603 - 49,206	2,70,636 - 295,239

Source. Re-worked from Krishnankutty, C.N. (1990). *op.cit.*

#### 4.5. Supply from Home-Gardens

The total production of timber including coconut wood from home-gardens during 1987-88 has been worked out to range from 10,57,000 to 12,57,000 m<sup>3</sup>. Production of teakwood from home-gardens has been estimated to range from 39,000 to 41,000 m<sup>3</sup>. Contribution of teakwood ranges from 3.3 to 3.7 per cent of the total supply of all timbers from home-gardens.

Table 4.3 gives the production of teakwood, rosewood and other certain timbers from the home-gardens of Kerala during the year 1991-92 and 1992-93 as per cutting passes issued by the Kerala Forest Department<sup>18</sup>. Sandal, teak, rosewood, *irul*, *thembavu*, *kambakam*, *chembakam*, *chadachi*, *chandनावemбу* and *cheeni* are the timber species for which cutting permission is

<sup>18</sup> Published data for previous years are not available.

Table 4.3 Production of teakwood and other (notified) timbers from home-gardens in Kerala during 1991-92 and 1992-93 as per cutting passes issued by the Kerala Forest Department.  
(volume in m<sup>3</sup>)

Year	Teakwood	Rosewood	Other certain timbers	Total
1991-92	14,113 (24.6)*	2,693 (4.7)	40,671 (70.7)	57,477 (100.0)
1992-93	9,797 (13.6)	2,918 (4.1)	59,295 (82.3)	72,010 (100.0)

\* Figures in parenthesis are percentages to total.

Source: 1. Kerala Forest Department (1991-92). *Administration report for the year 1991-92*. Govt. of Kerala, Thiruvananthapuram.

2. — (1992-93). *Administration report for the year 1992-93*. Govt. of Kerala, Thiruvananthapuram.

required. Cutting permission is usually taken only when the trees are cut for sale or transportation from places to distant places. Without taking cutting permission, even if it is required, considerable number of teak, rosewood and certain other trees mentioned above are being cut.

The production of teakwood of 14,113 m<sup>3</sup> in 1991-92 and 9,797 m<sup>3</sup> in 1992-93 from home-gardens was the recorded production, which is far below the actual production. However, the figures give some indication regarding the level of teakwood production from home-gardens. The commercial volume of teak and other trees in the growing stock in home-gardens during the year 1988-89 is also estimated (Table 4.4). The percentages of the estimate of production of teakwood and other timbers from home-gardens to the corresponding commercial volume in the growing stock are 6.8 and 4.1% respectively which are modest. Considering the

above facts, the estimates of teakwood and other timber production during 1987-88 from home-gardens seem to be very reasonable.

Table 4.4 Commercial volume of teak and other trees in the growing stock in home-gardens of Kerala during 1988-89

Trees	Growing stock	
	Number in '000	Commercial volume in '000 m <sup>3</sup> underbark
Teak	18160 (4.1)*	583 (2.0)
Other trees	424005 (95.9)	27943 (98.0)
Total	442165 (100.0)	28526 (100.0)

\* The figure in parenthesis is percentage to total.

Source: Re-worked from Krishnankutty, C.N. (1990). *op.cit.*

The upper limit of 12,57,000 m<sup>3</sup> of production of all timbers including coconutwood (41,000 m<sup>3</sup> of teakwood) from home-gardens represents 0.852 m<sup>3</sup> of all timbers including coconutwood (0.028 m<sup>3</sup> of teakwood) per ha of home-gardens used exclusively for agriculture or 0.718 m<sup>3</sup> of all timbers including coconutwood (0.023 m<sup>3</sup> of teakwood) per ha of home-gardens plus area under non-agricultural uses within home gardens. The definition of timber used in this study is different from the conventional definition where, usually, only timber above 60 cm girth underbark is considered. Our definition of timber includes timber and poles. Therefore 0.718 m<sup>3</sup> of all timbers including coconutwood (0.023 m<sup>3</sup> of teakwood) per ha per annum cannot be considered to be a very high figure. No attempt has been made to assess the sustainability of production of teakwood and other timbers from home-gardens considering the above level of production.

## 4.6 Supply of Teakwood: An Overview

The supply of teakwood and other timbers in Kerala from different sources is shown in Table 4.5. Of the total supply of all

Table 4.5 Supply of teakwood and other timbers in Kerala during 1987-88

Source	(range in '000 m <sup>3</sup> roundwood equivalent)				Total
	Teakwood		Other timbers		
	Qty	%	Qty	%	
Home gardens	41 - 39 (1.7 - 1.6) <sup>#</sup>	64.1 - 60.9	1216 - 1018 (48.7 - 40.8)	50.1 - 41.9	1257 - 1057 (50.4 - 42.4)
Estates	0	0.0	775 - 951 (31.1 - 37.1)	31.9 - 39.2	775 - 951 (31.1 - 38.1)
Forests	21 - 23 (0.8 - 0.9)	32.8 - 36.0	250 - 272 (10.0 - 10.9)	10.3 - 11.2	271 - 295 (10.8 - 11.8)
Imports	2 (0.1)	3.1	188 (7.6)	7.7	190 (7.7)
Total supply	64 (2.6)	100.0	2429 (97.4)	100.0	2493 (100.0)

<sup>#</sup> The figures in parentheses are percentages to total supply of timber.

Source: Re-worked from Krishnankutty, C.N. (1990). *op.cit.*

timbers, the contribution of teakwood was 2.6 per cent. Of the total supply of teakwood from all sources, home-gardens contributed 60.9 to 64.1 per cent and then the forests 32.8 to 36.0 per cent. Import of teakwood was very marginal (3.1 per cent).

Home-gardens contributed 42.4 to 50.4 per cent of the total timber supply and estates 31.1 to 38.1 per cent. Forests provided only 10.8 to 11.8 per cent of the total supply although the recorded production was only 9.9 percent. Timber imported from other states and countries was 7.7 per cent. The importance of home-gardens in

the production of teakwood and other timbers in the timber economy of Kerala is thus very obvious.

#### 4.7 Share of Teakwood in the Total Supply

Table 4.6 shows the share of teakwood in the total supply of all timbers in Kerala during 1987-88. The share of teakwood was only 2.6% when timbers of all conventional tree species, coconutwood, palmyrawood, rubberwood and eucalyptwood are included in the total supply. When timbers of only conventional tree species are included in the total supply of timber excluding wood from coconut as well as palmyra palms, rubber and eucalypts, the share of teakwood comes to 6%, while the corresponding share of jackwood and *anjily* used in the rural household sector alone comes to 25% and 7% respectively. Nevertheless, the value of teakwood used in all the sectors is higher than any of the other timbers except jackwood.

Table 4.6 Share of teakwood in the total supply of all timbers in Kerala during 1987-88

Timber supply	Quantity (in '000 m <sup>3</sup> )	Share of teakwood (%)
All timbers together	2493	2.6
All timbers excluding wood of rubber and eucalypts	1757	3.6
All timbers excluding wood of coconut, palmyra, rubber and eucalypts	1064	6.0

Source: Re-worked from Krishnankutty, C. N. (1990). *op.cit.*

In this chapter, the supply of teakwood in Kerala during the reference year 1987-88 has been estimated and the share of teakwood in the total supply has been assessed. The results showed that supply of teakwood from the home-gardens was about double of that from forests. The share of teakwood among all timbers was 2.6 per cent. This rises to 6 per cent when wood of coconut, rubber and eucalypts are excluded.

## CHAPTER 5

### PRICE OF TEAKWOOD IN KERALA

The structure of the timber market in Kerala and the auction procedure in the government timber depots are described in this chapter. Price of teakwood sold in monthly auction in the depots and the relationship of price with size and quality of teak logs are analysed. Variation in prices among different regions in Kerala is also examined in this chapter.

#### 5.1 Market Structure

A highly simplified structure of the timber market in Kerala is given in Fig. 5.1.a. The different sources of timber supply in Kerala are forests, estates, home-gardens and import<sup>1</sup>. The major part of the teakwood and other timbers obtained from home-gardens is utilised within the rural household sector and seldom reaches any organised market. The timber extracted from estates goes to saw-mills and other wood-based industries either directly or through traders. Import of teakwood and other timbers is directly done by saw-mills and wood-based industries. Only the timber extracted from the forests including teak plantations reaches in an organised market.

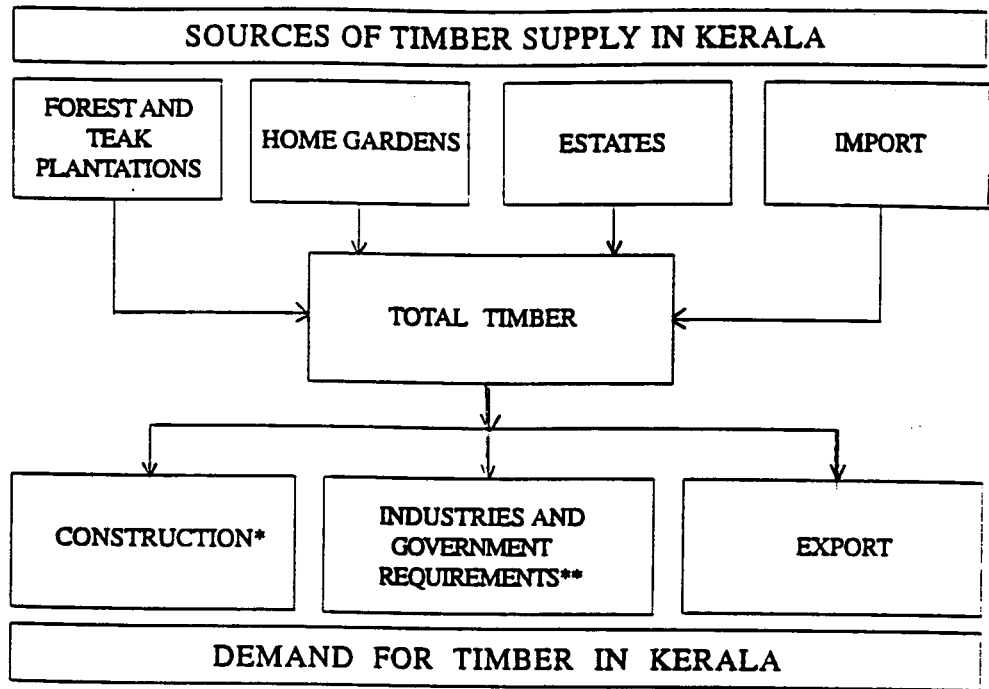
The flow of timber from Kerala forests to final users is shown in Fig. 5.1.b. Timber from Kerala forests was extracted either under selective felling or clearfelling systems. The former was resorted to the evergreen forests and a major proportion of timber was supplied

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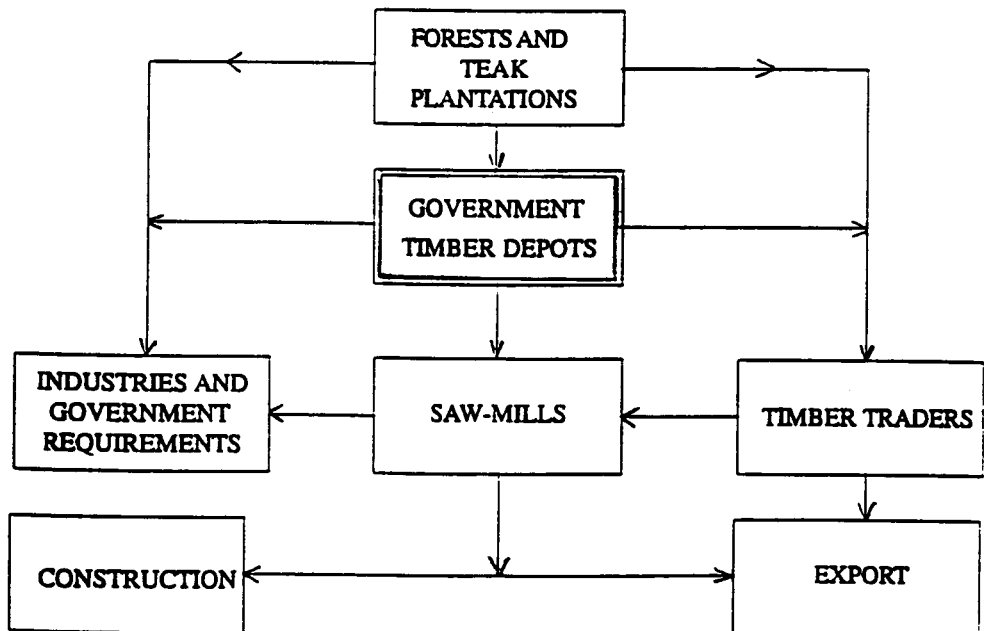
<sup>1</sup> A substantial quantity of timber is imported from countries like Malaysia and Myanmar and superior timbers such as rosewood and teakwood in converted form are exported to Japan, erstwhile USSR, etc.

**Fig. 5.1. STRUCTURE OF THE TIMBER MARKET IN KERALA**

**a. Source and Distribution of Timber**



**b. Flow of teakwood and other timbers from Kerala Forests**



\* Includes demand for timber both from households and other construction sectors in Kerala

\*\* Includes supply to government departments such as Railways, Defence, Telecommunications, Electricity, etc.

directly to wood-based industries. Clearfelling was followed in areas for re-forestation or non-forestry purposes and was undertaken in two stages. In the first stage, all teak trees (irrespective of girth) and other important trees (above 100 cm girth at breast height) were marked and worked down to government timber depots by contractors. In the second stage of clearfelling, the residual trees and material that remained in the area after the initial felling was also sold in auction<sup>2</sup>. The timber from such areas was purchased by timber traders. Clearfelling of natural forests was stopped in the year 1984 and selective felling in the year 1989. However, teakwood and other timbers are worked down to government depots from forests under schemes such as salvage felling in 'non-revertible forests' and as 'dead and windfallen' trees. Apart from the supply of teakwood and other timbers from natural forests, timber is obtained from teak plantations. At present, the major forest-source of timber supply in the state is teak plantations.

## **5.2 Sale of Timber in Government Depots**

Teakwood and other timbers are transported to the government timber depots where they are sold in monthly auctions. The government depots are managed by the Kerala Forest Department<sup>3</sup>. Before the timber from government depots reaches the final consumer, it moves through one or more stages (Fig. 5.1.b). At each stage there also exists a market and price is established in each market. Since the demand for timber in the government depots is a derived

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<sup>2</sup> Rosewood trees are protected and retained in the area.

<sup>3</sup> The list of government timber depots managed by Kerala Forest Department is given in Appendix 2.

demand, the structure of the markets at the subsequent levels has implications on the marketing and pricing process in the depots. Analysis of prices in the government depots in relation to those in the subsequent markets is important as a basic theoretical framework, in which the market and price structure are the focus of attention. This study provides a starting point for the theoretical treatment of the price formation in the monthly timber auction in the government depots.

### **5.3 Price at the Depots**

At the government depots, logs are classified according to species, quality and dimensions<sup>4</sup>. The classified logs are then grouped into lots. Logs of the same species, size and quality-class are alone grouped in one such lot, which contains one or more number of logs depending upon the volume of each log in the lot<sup>5</sup>. Several such lots of teakwood and other timbers are then put up for auction, generally, every month. Auctions are given wide publicity and attract a large number of participants. Most of the bidders in the auctions are timber traders<sup>6</sup>. The auction is conducted for each lot<sup>7</sup> and commences at the upset prices. The upset price of a particular species of timber belonging to a specific size-class and quality is

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<sup>4</sup> The criteria of classification of teakwood and other timbers adopted by the Kerala Forest Department are given in Appendix 1.

<sup>5</sup> Such lots do not exceed 4m<sup>3</sup> in the case of teak and rosewood other than export-size logs and 8 m<sup>3</sup> for other hardwood timbers. Export-size teak and rosewood logs are sold as individual log.

<sup>6</sup> The earnest money deposit for participating in the auction is Rs. 20,000.

<sup>7</sup> Occasionally, more than one lot of inferior quality timbers are grouped together and auction is conducted.

the average of prices obtained during the last three auctions in the depot for the same species, size-class and quality. The bidders may raise the price and the auction for that lot is finalised when there is no further increase in the amount. If the upset price is not agreed upon by the bidders participating, it is reduced slightly and at the reduced price, auction re-begins. If the final bid amount exceeds 90% of the upset price, the auction of that particular lot is confirmed immediately. If not, it is to be confirmed by the higher auctioning authority and some delay is expected for getting the confirmation order. Usually, the traders try to raise the amount till it exceeds 90% of the upset price for getting the auction confirmed immediately.

The amount finally bid (Rs. per m<sup>3</sup>) during monthly auction and confirmed by the appropriate auctioning authority represents the auction price of that timber-lot in the depot. Since auction is conducted for each lot of the same species, quality and size classes, different auction prices are realized for different lots. In this study, price of timber refers to the price of timber sold in auction in government timber depots. The monthly price (Rs. per m<sup>3</sup>) of a particular timber of specific size and quality is the weighted average price based on the prices realized (Rs. per m<sup>3</sup>) and quantities sold (m<sup>3</sup>) of different lots of the same timber of specific size and quality sold in auction in the same month in the depot. Since the auction starts at the upset price, generally the auction price will be higher than that existed during the last month. The current month's price is, therefore, related to the previous month's price. A successive dependence on previous month's price can be expected.

The successful bidder should pay one-third of the total sale value bid by him immediately after auction<sup>8</sup>. The minimum one-third of the amount to be remitted immediately is Rs. 10,000 and maximum Rs. 20,000. The earnest money deposit of the successful bidder is accounted in the one-third of the bid amount<sup>9</sup>. The balance amount should be remitted by the bidder within 60 days from the date of issue of confirmation order<sup>10</sup>. According to this procedure, the bidder is required to invest a maximum of Rs. 20,000 to get as much timber as possible. But the timber can be removed only after paying the total sale value. Often, the bidder gets more than two months from the date of auction to remove the timber from the depot without any interest or ground rent. During this two-month period, two more auctions will be held. If the same bidder participates in these two auctions, he will try to increase the price so that the timber already bid by him and kept in the depot with an investment of Rs.20,000 can be sold at the current month's auction price. The current auction price will probably be much greater than that in the preceding auctions. At this stage, after

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<sup>8</sup> If the bid amount is below Rs, 10,000, the full bid amount should be remitted on the spot immediately after the auction.

<sup>9</sup> Failure to remit the one third amount as above will entail cancellation of sale, forfeiture of the earnest money deposit and resale of the log. The earnest money deposits of the unsuccessful bidders are returned to them at the conclusion of the auction sale.

<sup>10</sup> If the balance amount is not remitted within the period of 60 days, a further period of 30 days with a penal interest of 18% per annum will be allowed. If the balance amount is not remitted even within the extended period of 30 days, a further period of 30 days will be allowed with interest of 24% and 2.5% surcharge. When interest is calculated for the balance amount as above, even for one day the interest is taken for one month. In addition to the interest paid, a ground rent of Rs. 2 per cubic meter and its fraction per month is charged.

remitting the remaining amount, the timber can be taken from the depot and sold at the current auction rate so that the profit can be increased<sup>11</sup>.

The prices are influenced by the competition between traders. Accumulated stock of timber with the traders has a direct impact on competition during auction. Stock of timber includes timber purchased from the government depots, private lands and through import. Usually when a huge stock has accumulated, competition during auction is adversely affected, consequently reducing the prices and vice versa.

Traders having high economic power participate in all the auctions in the depots. They try to increase the price in auction and get as much timber as possible. As they know that timber prices are increasing, they stock timber in their yards or saw-mills and afterwards they sell it at the current month's auction price in the government depots to get maximum profit. Therefore, requirement of timber of the traders may influence the price in the auction.

Most often, timber loading labourers working in interior depots are not well-organised as compared to those in the depots located at urban centres. So it is quite likely that loading wages in depots in urban areas will be higher than that in interior depots. In the case of timber depots in interior areas, often transport will be an important bottleneck and cost of transportation will be higher. For transporting the timber from the depots to the destination, a permit from the Forest Department is essential. Informal charges have also

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<sup>11</sup> (See foot-note 12). If he fails to remit the balance amount within the additional thirty days, re-auction will be conducted within the next thirty days cancelling the earlier auction.

to be paid for getting the permit. This informal expense varies between depots. So, informal expense, cost of loading and transportation are also factors which affect the auction price.

Prices during auction are determined by the current supply, existing demand as well as expectations on future prices. To some extent, current supply can be treated as given and not dependent on price or demand. This is because of the fact that timber is supplied from the forests and plantations<sup>12</sup> and the annual area to be felled is most often determined independently of the demand. There is usually a time-lag between auction and removal of timber from depots and its ultimate sale to actual users. Therefore the future prices, that is, the prices which are expected in the future, when timber is sold to final users is an important factor influencing price during auction.

Expected supply of timber is also an important factor in determining competition during auctions and consequently prices. Since preliminary work for timber extraction commences about a year before the timber finally reaches the depot for auction, the quantity that is expected to be available for the next one year can be estimated. When a huge quantity is expected to arrive in the market, auction prices tend to be low, while a high price can be expected when the expected supply is low. In practical situation, the expected supply has only a limited role in the formation of price. However, the traders take into account the accumulated stock of timber in the depot at the time of auction in a particular month.

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<sup>12</sup> Cost of production is generally an important factor influencing auction prices. However, production cost component in timber prices is negligible when the timber is obtained from natural forests. Even for timber obtained from teak plantations, cost of production has only an unimportant role in the formation of auction price.

The prices are also influenced by the number of traders participating in the auction. However, in some cases participation in depot auction is restricted to a few established timber merchants and the timber price in the auction is controlled by the stock position of timber in the yard of these merchants. Manipulation of price through ring formation is also a common phenomenon. In theory, except when there is ring formation, timber auction represents a near perfect competitive market situation.

Many of the general factors discussed above are not amenable to rigorous quantification and analysis. However, the relationship of price with size is more objective. Using the data from two government depots, the price-size relationship has been analysed and presented in the following section.

#### **5.4 Price-size Relationship**

Usually, there are a number of lots having logs of the same quality and size - classes. The price of lots differs between even lots of same species, quality and size - class within a depot. Among lots of the same group put up for auction, the price is expected to vary with size and quality of logs between lots. It is expected that the price per  $m^3$  will be more for a lot with a given volume if the lot is composed of larger logs in volume and girth and fewer number of logs. Here, the determinants of price with respect to size of logs are analysed first.

The Model 2.1 given in chapter 2 has been estimated by employing step-wise regression procedure using data on number of logs ( $N$ ), average girth<sup>13</sup> of logs ( $\bar{G}$ ), average volume per log ( $\bar{V}$ )

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<sup>13</sup> The girth of log refers to the girth measured at the middle of the log and called as mid-girth.

and average length of logs ( $\bar{L}$ ) in the lot and price realised ( $P$ ) pertaining to different lots of same quality and size - classes for four months<sup>14</sup>. The four set of data used were 18 lots of girth - class 2B, 15 lots of 3B, 10 lots of 3B and 12 lots of 4B.

Table 5.1. Price relation with mean girth of logs in teakwood lots of same girth-class within quality class B

Depot	Auction month	Classes Girth	Quality	Estimated regression equation	Adj. $R^2$	No. of lots
Mudical	1/1993	2	B	$\hat{P} = 6899.76 + 108.88^{**} \bar{G}$ (4909.2) <sup>#</sup> (40.9)	0.26 <sup>**</sup>	18
Veetoor	6/1993	3	B	$\hat{P} = 4456.36 + 115.90^* \bar{G}$ (4781.7) (56.4)	0.18 <sup>*</sup>	15
Veetoor	8/1993	3	B	$\hat{P} = 4798.20 + 118.56^* \bar{G}$ (4357.7) (50.9)	0.33 <sup>*</sup>	10
Veetoor	6/1993	4	B	$\hat{P} = -1609.13 + 167.01^{**} \bar{G}$ (2173.9) (32.9)	0.69 <sup>**</sup>	12

# The figure in parenthesis is standard error of the coefficient.

\* Statistically significant at 5% probability level and \*\* at 1% level.

The results of the step-wise regression analysis are presented in Table 5.1. In the 4 sets of data analysed, among the different variables  $N$ ,  $\bar{G}$ ,  $\bar{V}$  and  $\bar{L}$ , relationship is seen only between price and average mid-girth of the logs. However, adjusted  $R^2$  values are not high enough, although they are significant. The regression coefficients have the right sign, indicating that higher girth brings up the price of that lot.

<sup>14</sup> See Appendix 1 for details regarding size and quality-classes.

Table 5.2 Price relation with mean girth of logs in teakwood lots of different girth-classes within quality-class B

Depot	Month	Estimated regression equation	Adj $R^2$	No. of lots
Mudical	2/1993	$\hat{P} = -2915.46 + 187.77^* \bar{G}$ (1946.0) <sup>#</sup> (20.0)	0.80**	22
“	4/1993	$\hat{P} = 107.66 + 149.29^* \bar{G}$ (1290.9) (12.2)	0.84**	29
“	5/1993	$\hat{P} = -962.41 + 168.64^* \bar{G}$ (2283.9) (24.8)	0.82**	11
Veettoor	6/1993	$\hat{P} = -4467.31^* + 216.63^* \bar{G}$ (716.6) (8.4)	0.96**	31
“	7/1993	$\hat{P} = -1815.51 + 181.72^* \bar{G}$ (1486.1) (13.1)	0.92**	18
“	8/1993	$\hat{P} = -4381.15^* + 228.01^* \bar{G}$ (948.1) (11.0)	0.95**	21
“	9/1993	$\hat{P} = 1100.51 + 167.11^* \bar{G}$ (1747.5) (17.3)	0.82**	21
“	10/1993	$\hat{P} = 2817.89 + 159.33^* \bar{G}$ (1674.4) (16.9)	0.76**	30
“	11/1993	$\hat{P} = 2532.77 + 161.37^* \bar{G}$ (1330.3) (13.9)	0.76**	43
“	12/1993	$\hat{P} = 2393.71 + 161.91^* \bar{G}$ (1054.9) (11.20)	0.84**	41
“	1/1994	$\hat{P} = -1143.55 + 190.93^* \bar{G}$ (1392.2) (13.8)	0.88**	27
“	4/1994	$\hat{P} = -3533.58 + 216.08^* \bar{G}$ (1093.1) (11.9)	0.86**	54

# The figure in parenthesis is standard error of the coefficient.

\* Statistically significant at 5% probability level and \*\* at 1% level.

Source : Results of step-wise regression analysis.

Another analysis has also been done estimating the same model (2.1) for quality classes *B* and *C* separately with different girth-classes together. Using data on *N*,  $\bar{G}$ ,  $\bar{V}$ ,  $\bar{L}$  and *P* in respect of different lots belonging to girth-classes *E*, 1, 2, 3 and 4 of quality - class *B* for 12 months and quality - class *C* for 7 months, model 2.1 has been fitted using step-wise regression procedure. The results are presented in Tables 5.2 and 5.3 respectively.

Table 5.3 Price relation with mean girth of logs in teakwood lots of different girth-classes within quality-class *C*

Depots	Month	Estimated regression equation	Adj. $R^2$	No. of lots
Mudical	1/1993	$\hat{P} = 1021.78 + 122.8^* \bar{G}$ (1251.1) <sup>#</sup> (12.8)	0.79**	25
“	2/1993	$\hat{P} = 2144.41 + 90.35^* \bar{G}$ (1637.1) (18.6)	0.68**	14
“	3/1993	$\hat{P} = -460.70 + 124.60^* \bar{G}$ (2731.0) (30.9)	0.63**	10
“	4/1993	$\hat{P} = 3267.22 + 86.12^* \bar{G}$ (1732.1) (18.4)	0.52**	20
“	8/1993	$\hat{P} = -2275.95 + 172.26^* \bar{G}$ (2495.7) (27.1)	0.80**	11
Veettoor	6/1993	$\hat{P} = -2329.56 + 140.61^* \bar{G}$ (1741.9) (22.1)	0.72**	18
“	4/1994	$\hat{P} = -1858.67 + 143.36^* \bar{G}$ (782.4) (9.2)	0.93**	18

<sup>#</sup> The figure in parenthesis is standard error of the coefficient

\* Statistically significant at 5% probability level and \*\* at 1% level.

Source : Results of step-wise regression analysis.

In all the 19 sets of data analysed, relationship between price and mean mid-girth is established. The adjusted  $R^2$  values are significant at 1% probability level and range from 0.52 to 0.96. This indicates that most of the variation in prices of different lots within a quality class is explained by mean girth. The other variables such as number of logs in a lot, mean volume and length of logs in a lot have no significant effect on the price of individual lots.

Higher girth of logs allows wider planks to be sawn and provides a higher out-turn of timber. That is, the higher is the girth of log, higher the price it commands.

### **5.5 Price-quality Relationship**

After the price-girth relationship, the quality of logs is expected to be the most important determinant of the price of timber. To compare the prices between quality-classes A, B and C, the  $t$ -test has been carried out for each girth-class. The average current prices of teakwood in different girth and quality classes in Kerala is presented in Table 5.4 (Appendices 9 to 13). The results of the  $t$ -tests showed that the prices of teakwood in various quality-classes are significantly different for all girth-classes for both the years at 5% probability level.

Even when the average real prices of teakwood in various quality-classes for all girth-classes from 1975-76 to 1993-94 in Kerala were taken (Table 5.5 and Appendices 9 to 13), the  $t$ -tests showed the same results that the price is strongly related with quality of logs.

Table 5.4 Average current prices of teakwood in different girth and quality classes in Kerala

(Current price Rs. per m<sup>3</sup>)

Year	Quality class	Girth-class				
		<i>E</i>	1	2	3	4
1992-93	<i>A</i>	36737	29651	20826	14233	11149
	<i>B</i>	29194	23041	18648	13671	10193
	<i>C</i>	20113	17745	13032	10028	7799
Weighted mean		23131	21450	17178	12572	9162
1993-94	<i>A</i>	33667	28198	23217	NA	NA
	<i>B</i>	31023	25978	20938	16621	11839
	<i>C</i>	22297	19830	15388	12407	9062
Weighted mean		24034	23516	18986	14784	10375

NA. Not available

Source: Computed from the monthly auction files of government timber depots in Kerala.

Table 5.5 Average real price of teak logs in different girth and quality classes over the period from 1975-76 to 1993-94 in Kerala

(Real price Rs. per m<sup>3</sup> per year)

Quality class	Girth-class				
	<i>E</i>	1	2	3	4
<i>A</i>	8208	7839	6352	4469	3768
<i>B</i>	7416	6720	5661	4564	3541
<i>C</i>	5462	5239	4473	3738	3246

Source: Computed from the average annual real price.

## 5.6 Spatial Variation in Prices

The region-wise current prices of teakwood in different girth-classes for the period from 1975-76 to 1993-94 are given in Appendices 14 to 19. It can be seen that the prices are consistently high in Northern region for most of the years and in Southern region in certain years. The region-wise average real prices of teakwood (girth-classes combined) per annum over the period from 1975-76 to 1993-94 have been computed as Rs. 4332, Rs. 4032 and Rs. 4336 per m<sup>3</sup> in Southern, Central and Northern regions respectively<sup>15</sup>. It can be seen that teak has received relatively higher average real price per annum in Southern and Northern region compared to that received in Central region. However, the *t*-test for comparing the prices in the three regions showed that the differences in prices are statistically non-significant at 5% probability level. The absence of significant regional variation in prices is due to (i) the geographic area of Kerala is very small and the forests are available in the entire stretch and (ii) size as well as quality grading of timber in all the depots in different regions are objective and consistent.

In this chapter, the working of the timber market and the auction procedure in the government timber depots have been described. The factors which influence the price of teakwood sold in monthly auction in the government depots have been discussed. The relationship of price with size and quality of logs in individual teakwood lot within depot has been analysed. Among the variables such as number of logs, mean volume, mean girth and mean length

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<sup>15</sup> Computed from the real prices during the period from 1975-76 to 1993-94 (Appendix 20).

considered, mean girth of logs in individual lot and quality have been found to be important. Other things remaining the same, higher girth of logs allows wider planks to be sawn and provides a higher out-turn of timber. That is, the higher is the girth of log, higher the price it commands. Likewise when the girth-classes are the same, a higher quality class of logs fetches a higher price. The analysis on spatial variation in prices has shown that there is statistically not much difference in prices over time among different regions in Kerala.

## CHAPTER 6

### PRICE TRENDS OF TEAKWOOD IN KERALA

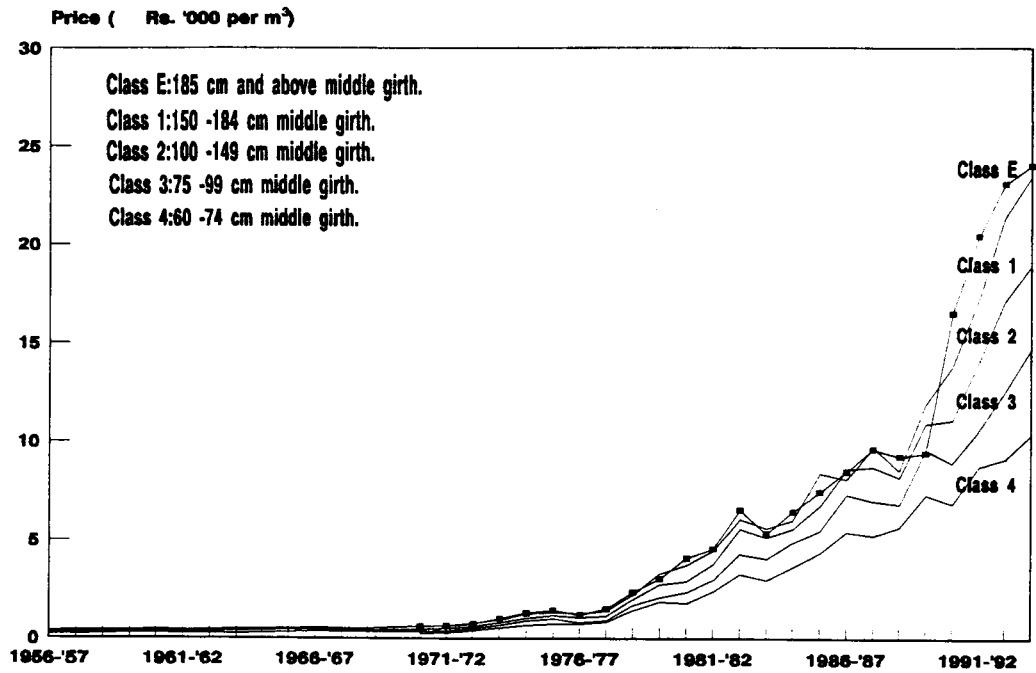
Different trend models have been fitted to the real prices of teakwood in various girth-classes and those of selected timbers in Kerala and the best fitting models are selected. Using the best models, the price trends of teakwood in different girth-classes are examined. The price trend of teakwood (girth-classes combined) and those of selected timbers are also compared in this chapter.

#### 6.1 General Trends in Real Prices

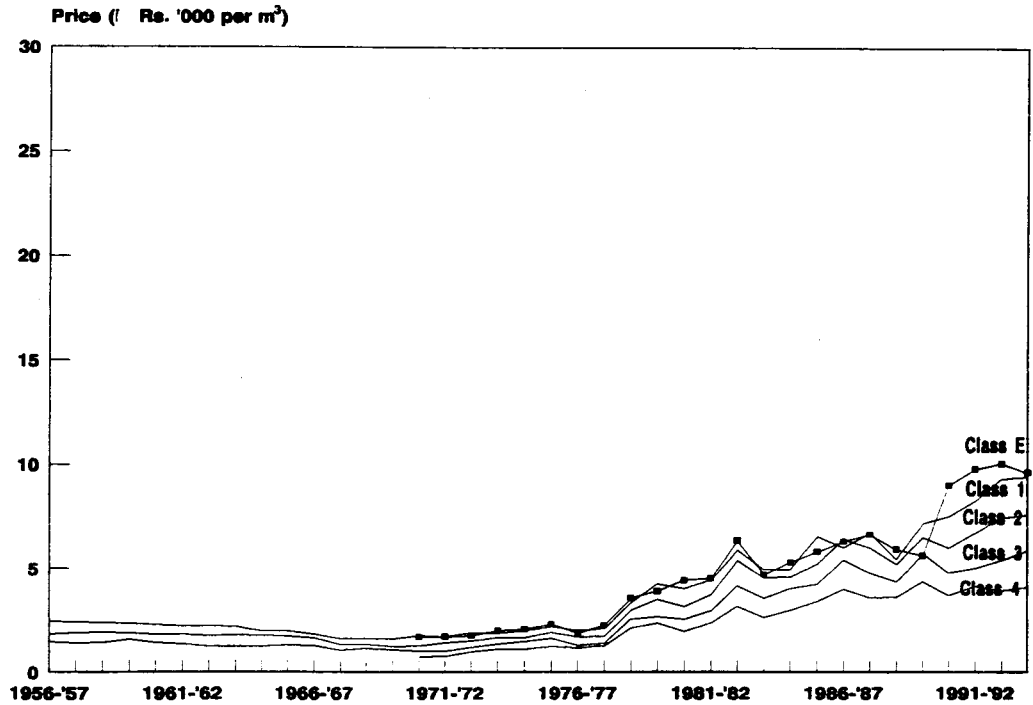
Figure 6.1 shows the current prices of teak logs in girth-classes *E* (logs with mid-girth 185 cm and above, 1(150 to 184 cm), 2(100 to 149 cm), 3(75 to 99 cm) and 4(60 to 74 cm) in Kerala for the period from 1956-57 to 1993-94 (see Appendix 22). For getting a clear understanding of the real change in prices, the real prices of teak logs in different girth-classes were plotted in Figure 6.2 (see Appendix 23). For smoothing out the year-to-year fluctuations, 3, 5 and 7-year moving averages of real prices were depicted in Figure 6.3. From the figures, it can be seen that the trends in prices of teak logs in all girth-classes were more or less the same.

The current prices of teakwood (girth-classes combined) and selected timbers were depicted in Figure 6.4 (see Appendix 24), the real prices in Figure 6.5 (see Appendix 25) and the 3, 5 and 7-year moving averages in Figure 6.6. From the figures, it can be seen that the general trends in prices of teakwood and selected timbers were more or less the same, although teakwood commanded higher prices than the others.

**Fig. 6.1 Current prices of teak logs in different girth-classes in Kerala**

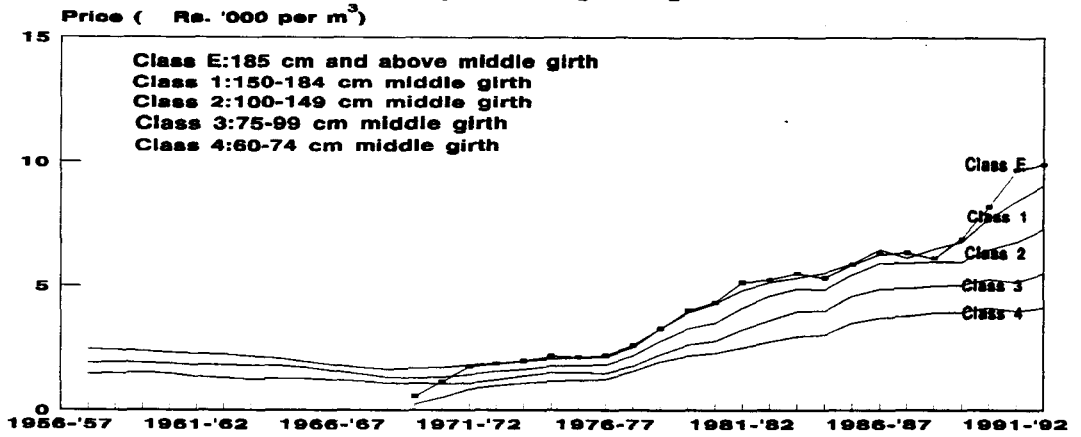


**Fig. 6.2 Real prices of teak logs in different girth-classes in Kerala**

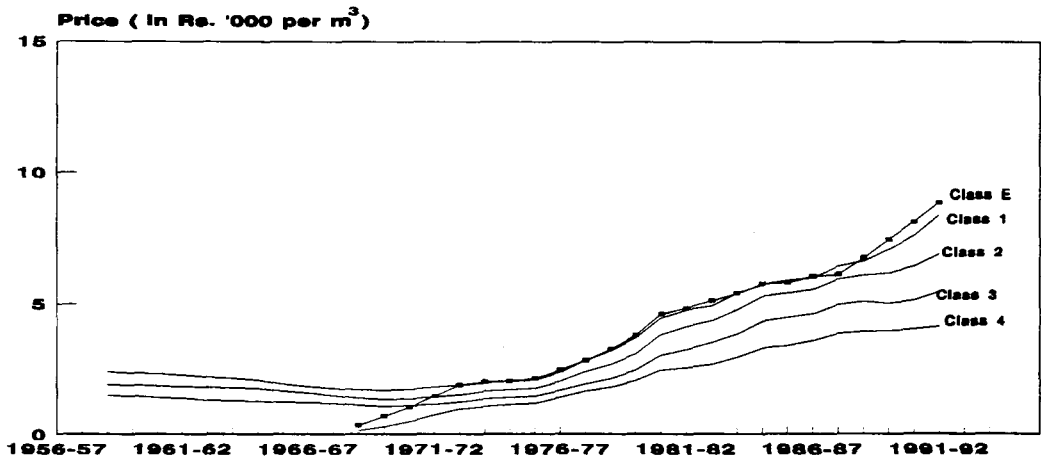


**Fig. 6.3 Moving averages of real prices of teak logs in different girth-classes in Kerala**

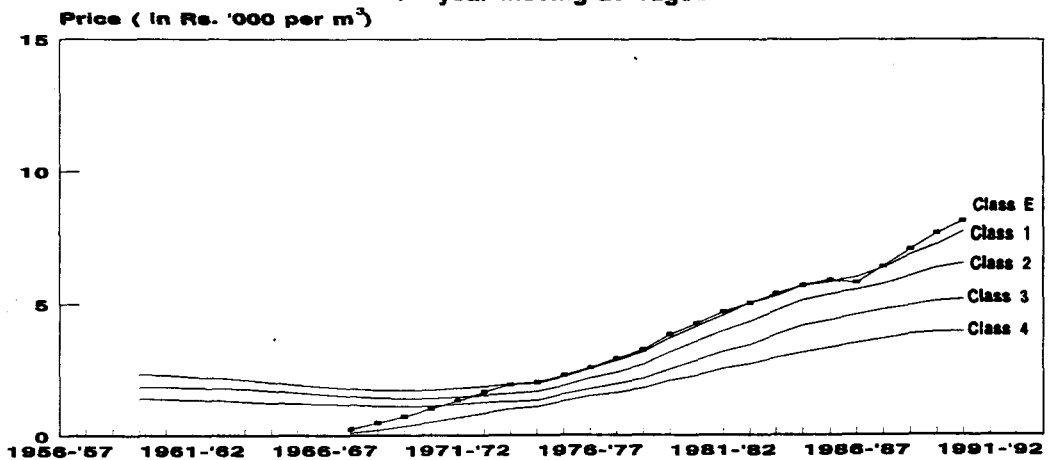
3 - year moving averages



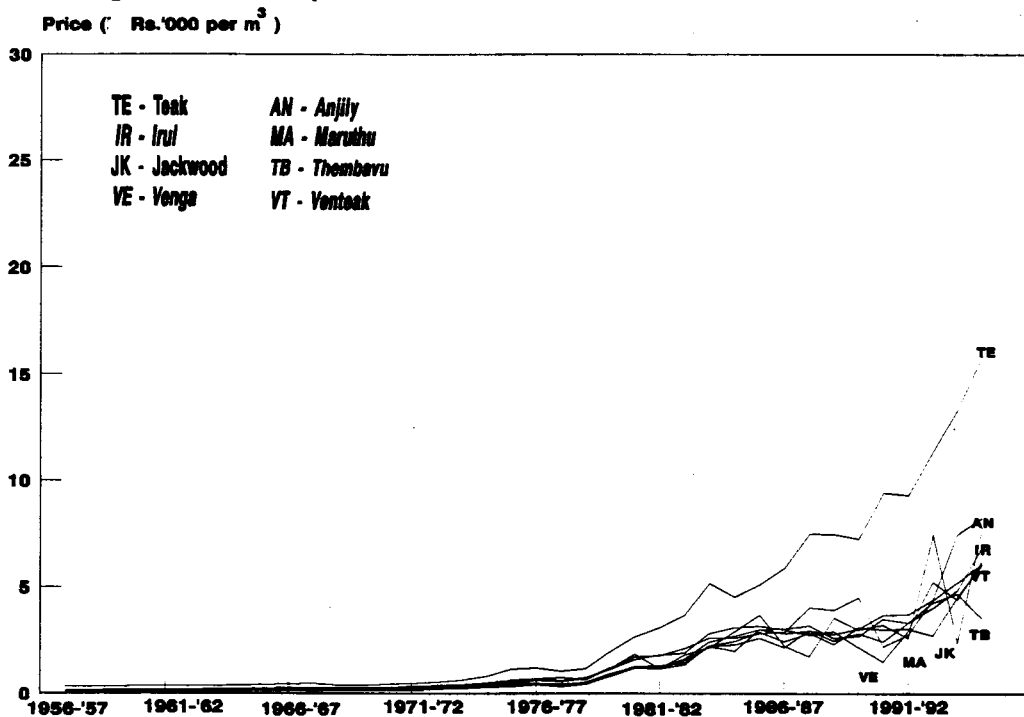
5 - year moving averages



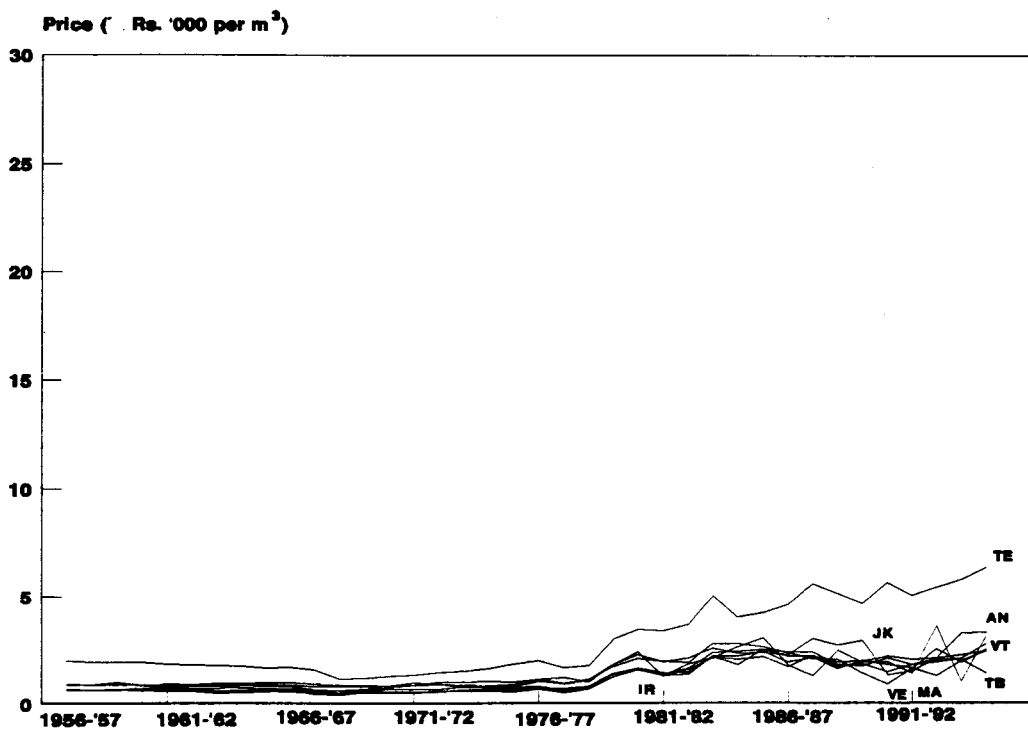
7 - year moving averages



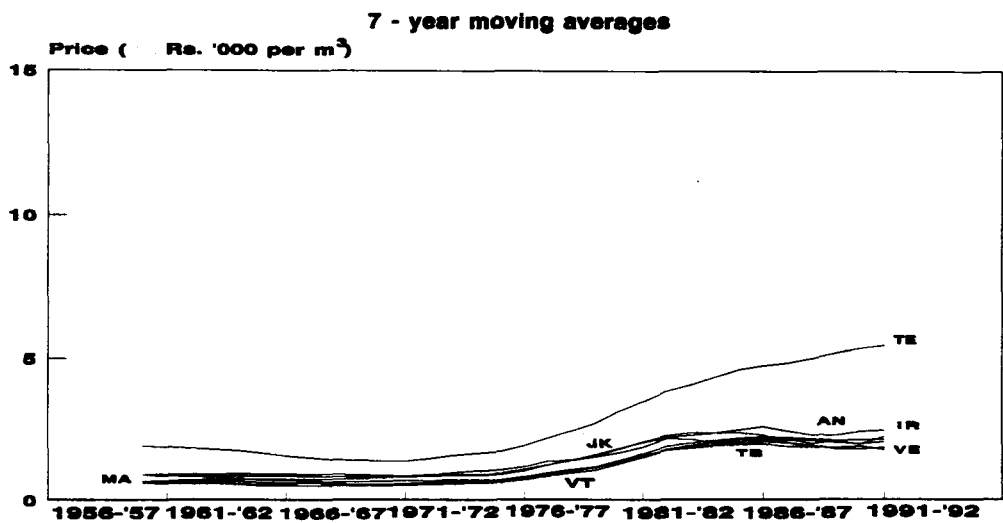
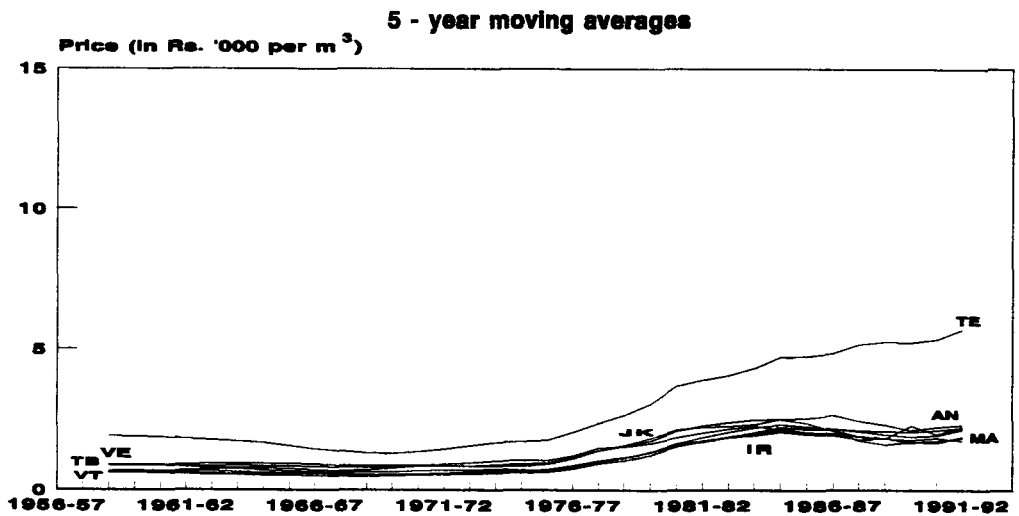
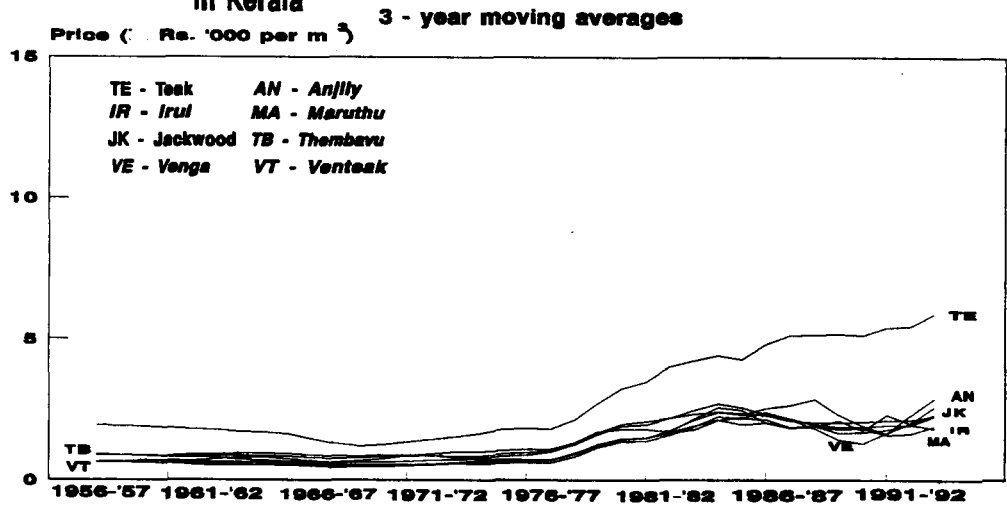
**Fig. 6.4 Current prices of teakwood and selected timbers in Kerala**



**Fig. 6.5 Real prices of teakwood and selected timbers in Kerala**



**Fig. 6.6 Moving averages of real prices of teakwood and selected timbers in Kerala**



## 6.2 Selection of Trend Model

Among the different trend models estimated for real prices of teak logs in different girth-classes, linear spline model with three knots  $k_1$  for the year 1968-69,  $k_2$  for the year 1976-77 and  $k_3$  for the year 1983-84 is found to be the best in most cases except for prices of teak logs in girth-classes  $E$  (see Tables 6.1 to 6.5). For the prices of girth-class  $E$ , quadratic spline model having 3 knots with adjusted  $R^2$  value 0.92 is the best (Table 6.1) since Durbin-Watson  $d$ -statistic is non-significant at 5% level. Whereas for the linear spline model having 3 knots and adjusted  $R^2$  value 0.91, the  $d$ -test is inconclusive. For the prices of teak log in girth-class 1, both the linear spline models having 2 and 3 knots and quadratic spline model with 3 knots are found to be more or less best (see Table 6.2). The preference of linear spline model with 2 knots over the linear spline model with 3 knots is only in the increase of 0.01 in the adjusted  $R^2$  value. For the prices of teak log in girth-class 4, the linear spline model with 3 knots is found to be better than the cubic and quadratic spline models considering the lower value of  $d$  which is non-significant at 5% level (Table 6.5).

## 6.3 Price Behaviour in Different Periods

The least square estimates of the regression coefficients  $\beta_{00}$ ,  $\beta_{01}$ ,  $\beta_1$ ,  $\beta_2$  and  $\beta_3$  in the linear spline model having three knots  $k_1$ ,  $k_2$  and  $k_3$  given by Model 2.14 in chapter 2, along with adjusted  $R^2$  and the Durbin-Watson ' $d$ ' statistic, with respect to teak logs in different girth-classes are presented in Table 6.6. The adjusted  $R^2$  values range from 0.91 to 0.97 and all  $R^2$  are statistically significant at 1% probability level. All the Durbin-

Table 6.1 Summary statistics of different trend models fitted to the real prices of teak logs in girth-class *E*

Sl. no.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson $d$ -statistic
1	Linear	0.90**	7.77x10 <sup>5</sup>	1.13**
2	Quadratic	0.93**	6.24x10 <sup>5</sup>	1.46 <sup>ic</sup>
3	Cubic	0.93**	6.51x10 <sup>5</sup>	1.48 <sup>ic</sup>
4	Logarithmic	0.68**	25.00x10 <sup>5</sup>	0.46**
5	Inverse	0.31**	54.50x10 <sup>5</sup>	0.31**
6	Compound	0.93**	6.64x10 <sup>5</sup>	1.34 <sup>ic</sup>
7	Power	0.82**	15.32x10 <sup>5</sup>	0.60**
8	S-curve	0.43**	51.39x10 <sup>5</sup>	0.21**
9	Growth	0.93**	6.64x10 <sup>5</sup>	1.34 <sup>ic</sup>
10	Exponential	0.93**	6.64x10 <sup>5</sup>	1.34 <sup>ic</sup>
11	Logistic	0.88**	8.04x10 <sup>5</sup>	1.09**
12	Linear spline with 2 knots	0.91**	6.42x10 <sup>5</sup>	1.39 <sup>ic</sup>
13	Linear spline with 3 knots	0.91**	6.67x10 <sup>5</sup>	1.41 <sup>ic</sup>
14	Quadratic spline with 2 knots	0.91**	6.48x10 <sup>5</sup>	1.47 <sup>ic</sup>
15	Quadratic spline with 3 knots	0.92**	5.74x10 <sup>5</sup>	1.76 <sup>ns</sup>

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant at 5% probability level.

<sup>ic</sup> Durbin-Watson  $d$ -test inconclusive at 5% level.

Source : Results of trend analysis.

Table 6.2 Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 1

Sl. no.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson $d$ -statistic
1	Linear	0.72**	16.70x10 <sup>5</sup>	0.23**
2	Quadratic	0.96**	2.55x10 <sup>5</sup>	1.37*
3	Cubic	0.96**	2.61x10 <sup>5</sup>	1.38*
4	Logarithmic	0.37**	36.90x10 <sup>5</sup>	0.13**
5	Inverse	0.08 <sup>ns</sup>	53.90x10 <sup>5</sup>	0.10**
6	Compound	0.70**	11.55x10 <sup>5</sup>	0.31**
7	Power	0.35**	36.25x10 <sup>5</sup>	0.11**
8	S-curve	0.07 <sup>ns</sup>	57.41x10 <sup>5</sup>	0.07**
9	Growth	0.70**	11.57x10 <sup>5</sup>	0.31**
10	Exponential	0.70**	11.57x10 <sup>5</sup>	0.31**
11	Logistic	0.67**	12.85x10 <sup>5</sup>	0.29**
12	Linear spline with 2 knots	0.97**	2.02x10 <sup>5</sup>	1.73 <sup>ns</sup>
13	Linear spline with 3 knots	0.96**	2.05x10 <sup>5</sup>	1.75 <sup>ns</sup>
14	Quadratic spline with 2 knots	0.96**	2.07x10 <sup>5</sup>	1.76 <sup>ns</sup>
15	Quadratic spline with 3 knots	0.96**	1.97x10 <sup>5</sup>	1.90 <sup>ns</sup>

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant at 5% probability level.

Source : Results of trend analysis.

Table 6.3 Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 2

Sl. no.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson $d$ -statistic
1	Linear	0.74**	11.4 x 10 <sup>5</sup>	0.26**
2	Quadratic	0.94**	2.60x10 <sup>5</sup>	1.08**
3	Cubic	0.95**	2.47x10 <sup>5</sup>	1.17**
4	Logarithmic	0.41**	26.4 x 10 <sup>5</sup>	0.14**
5	Inverse	0.10*	39.9 x 10 <sup>5</sup>	0.10**
6	Compound	0.72**	7.77x10 <sup>5</sup>	0.36**
7	Power	0.37**	25.72x10 <sup>5</sup>	0.12**
8	S-curve	0.09 <sup>ns</sup>	42.68x10 <sup>5</sup>	0.07**
9	Growth	0.72**	7.77x10 <sup>5</sup>	0.36**
10	Exponential	0.72**	7.77x10 <sup>5</sup>	0.36**
11	Logistic	0.73**	7.86x10 <sup>5</sup>	0.36**
12	Linear spline with 2 knots	0.96**	1.65x10 <sup>5</sup>	1.68 <sup>ns</sup>
13	Linear spline with 3 knots	0.97**	1.30x10 <sup>5</sup>	2.19 <sup>ns</sup>
14	Quadratic spline with 2 knots	0.96**	1.50x10 <sup>5</sup>	1.92 <sup>ns</sup>
15	Quadratic spline with 3 knots	0.96**	1.54x10 <sup>5</sup>	1.94 <sup>ns</sup>

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant at 5% probability level.

Source : Results of trend analysis.

Table 6.4 Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 3

Sl. no.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson $d$ -statistic
1	Linear	0.76**	7.04x10 <sup>5</sup>	0.33**
2	Quadratic	0.93**	2.05x10 <sup>5</sup>	1.13**
3	Cubic	0.95**	1.78x10 <sup>5</sup>	1.34**
4	Logarithmic	0.42**	16.70x10 <sup>5</sup>	0.17**
5	Inverse	0.11*	25.80x10 <sup>5</sup>	0.12**
6	Compound	0.75**	4.73x10 <sup>5</sup>	0.48**
7	Power	0.41**	16.10x10 <sup>5</sup>	0.15**
8	S-curve	0.09 <sup>ns</sup>	27.68x10 <sup>5</sup>	0.10**
9	Growth	0.75**	4.73x10 <sup>5</sup>	0.48**
10	Exponential	0.75**	4.73x10 <sup>5</sup>	0.48**
11	Logistic	0.75**	6.65x10 <sup>5</sup>	0.49**
12	Linear spline with 2 knots	0.95**	1.35x10 <sup>5</sup>	1.70 <sup>ns</sup>
13	Linear spline with 3 knots	0.97**	0.96x10 <sup>5</sup>	2.46 <sup>ns</sup>
14	Quadratic spline with 2 knots	0.95**	1.18x10 <sup>5</sup>	2.02 <sup>ns</sup>
15	Quadratic spline with 3 knots	0.96**	1.07x10 <sup>5</sup>	2.33 <sup>ns</sup>

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant at 5% probability level.

Source : Results of trend analysis.

Table 6.5 Summary statistics of different trend models fitted to the real prices of teak logs in girth-class 4

Sl. no.		Adj. $R^2$	Mean square error	Durbin-Watson $d$ -statistic
1	Linear	0.94**	1.07x10 <sup>5</sup>	1.63 <sup>ns</sup>
2	Quadratic	0.94**	1.07x10 <sup>5</sup>	1.70 <sup>ns</sup>
3	Cubic	0.96**	0.74x10 <sup>5</sup>	2.53 <sup>ns</sup>
4	Logarithmic	0.80**	3.43x10 <sup>5</sup>	0.66**
5	Inverse	0.41**	10.10x10 <sup>5</sup>	0.36**
6	Compound	0.91**	3.13x10 <sup>5</sup>	0.63**
7	Power	0.89**	1.54x10 <sup>5</sup>	1.15**
8	S-curve	0.54**	8.59x10 <sup>5</sup>	0.24**
9	Growth	0.91**	3.13x10 <sup>5</sup>	0.62**
10	Exponential	0.91**	3.13x10 <sup>5</sup>	0.62**
11	Logistic	0.93**	1.87x10 <sup>5</sup>	0.97**
12	Linear spline with 2 knots	0.93**	1.10x10 <sup>5</sup>	1.65 <sup>ns</sup>
13	Linear spline with 3 knots	0.95**	0.83x10 <sup>5</sup>	2.27 <sup>ns</sup>
14	Quadratic spline with 2 knots	0.95**	0.83x10 <sup>5</sup>	2.26 <sup>ns</sup>
15	Quadratic spline with 3 knots	0.95**	0.77x10 <sup>5</sup>	2.54 <sup>ns</sup>

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant at 5% probability level.

Source : Results of trend analysis.

Table 6.6 Regression coefficients of linear spline model of real prices of teak logs in different girth-classes along with adjusted  $R^2$  and Durbin-Watson  $d$ -statistic.

Girth class \$	Regression coefficients					Adj. $R^2$	Durbin-Watson $d$ -statistic
	$\hat{\beta}_{00}$	$\hat{\beta}_{01}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$		
<i>E</i>	-396.31 (2423.0) <sup>#</sup>	134.37 (129.7)	-	254.38* (198.6)	64.68 (142.6)	0.91**	1.41 <sup>ic</sup>
1	2680.37** (255.2)	-79.82** (29.2)	157.09** (62.5)	350.71** (79.5)	-52.47 (76.6)	0.96**	1.75 <sup>ns</sup>
2	2101.16** (203.2)	-53.97* (23.3)	102.52* (49.8)	397.28** (63.3)	-196.06** (60.9)	0.97**	2.19 <sup>ns</sup>
3	1583.36** (174.7)	-38.09* (20.0)	81.86* (42.8)	331.41** (54.4)	-202.71** (52.4)	0.97**	2.46 <sup>ns</sup>
4	-532.79 (858.5)	87.45* (45.96)	-	175.50* (70.3)	-140.83** (50.5)	0.95**	2.27 <sup>ns</sup>

<sup>\$</sup> For girth-classes, *E* and 4, price data were obtained only from the year 1970-71 onwards.

<sup>#</sup> The figure in parenthesis is the standard error of the coefficient.

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant.

<sup>ic</sup> Durbin-Watson  $d$ -test inconclusive at 5% level, but non-significant at 1% level.

Source: Results of regression analysis.

Table 6.7 Rates of change of real prices of teak logs in different girth-classes during different periods<sup>§</sup>.

Girth class	$t \leq k_1$	$k_1 < t \leq k_2$	$k_2 < t \leq k_3$	$t > k_3$
	(1956-57 to 1968-69)	(1969-70 to 1976-77)	(1977-78 to 1983-84)	(1984-85 to 1993-94)
	$(\hat{\beta}_{01})$	$(\hat{\beta}_{01} + \hat{\beta}_1)$	$(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2)$	$(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3)$
<i>E</i>	-	134.37	388.75	452.83
1	-79.82	77.27	427.98	375.51
2	-53.97	48.55	445.83	249.77
3	-38.09	43.77	375.18	172.47
4	-	87.45	262.95	122.12

<sup>§</sup>  $k_1, k_2$  and  $k_3$  stand for the years 1968-69, 1976-77 and 1983-84 respectively.

Source: Computed from the regression coefficients.

Watson *d*-statistics are non-significant at 5% probability level except for girth-class *E* for which the *d*-test is inconclusive at 5% level, but non-significant at 1% level. All the regression coefficients are statistically significant either at 1% or 5% probability level, except the coefficients of *t* in the trend model for girth-classes *E*, ( $t-k_3$ ) in the trend models for girth-classes *E* and 1 and the intercept of the equations for girth-classes *E* and 4.

The rates of change of real prices with respect to the year *t* during the period  $t \leq k_1$ ,  $k_1 < t \leq k_2$ ,  $k_2 < t \leq k_3$  and  $t > k_3$  are  $\hat{\beta}_{01}$ ,  $(\hat{\beta}_{01} + \hat{\beta}_1)$ ,  $(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2)$  and  $(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3)$  respectively. Table 6.7 gives the annual rate of change of real prices of teakwood in different girth-classes during different periods.

#### Period $t \leq k_1$ (1956-57 to 1968-69)

The real prices of teak logs in girth-classes 1, 2 and 3

registered a decline during this period. The rate varied from Rs. 38 for girth-class 3 to Rs. 80 for girth class 1 per annum.

**Period  $k_1 < t \leq k_2$  (1969-70 to 1976-77)**

During this period, the real prices of teak logs in all girth-classes increased at a moderate rate. The rate varied from Rs. 44 for girth-class 3 to Rs. 134 for girth-class *E* whereas the prices of logs in girth-class 4 increased more than that registered for girth-classes 1, 2 and 3. The rate was Rs. 87 per annum.

**Period  $k_2 < t \leq k_3$  (1977-78 to 1983-84)**

This period is characterised by a rapid increase in real prices for teaklogs in all girth-classes. The rate of increase for girth-class *E* was Rs. 389 per annum which was lower than that for girth-classes 1 and 2. The rate of increase ranged from Rs. 263 for girth-class 4 to Rs. 428 for girth-class 1 per annum.

**Period  $t > k_3$  (1984-85 to 1993-94)**

Although the increasing trend continued for prices of teak logs in all girth-classes during this period, the rate of increase was lower than that existed during the preceding period except for girth-class *E* for which the rate was higher than that of the preceding period.

#### **6.4 Comparison with Selected Timbers**

The linear spline model with 3 knots is found to be the best for the real prices of teakwood (girth-classes combined) among different trend models fitted, as can be seen in Table 6.6. The same model is also found to be the best among different trend models fitted to the real

prices of most of the selected timbers except for *anjily* and *venteak* (see Tables 6.8 to 6.15). Durbin-Watson  $d$ -statistic is significant at 1% level for most of the models of prices of *anjily* except for linear spline model with 3 knots and quadratic spline models with 2 and 3 knots for which it is significant at 5% level (Table 6.8). The highest adjusted  $R^2$  value and least mean square error is for the linear spline model having 3 knots. For the prices of *venteak*, the Durbin-Watson  $d$ -statistic in none of the models is non-significant. However, the linear spline model with 3 knots has highest adjusted  $R^2$  value and the Durbin-Watson  $d$ -test is inconclusive (Table 6.15). Since the selection of the trend model is only for comparing the real change in prices during different periods, the linear spline model with 3 knots has been selected for teakwood and for all the selected timbers.

The regression coefficients of the trend models of teakwood (girth-classes combined) and those of selected timbers are presented in Table 6.16. All  $R^2$  are statistically significant and the adjusted  $R^2$  values range from 0.66 to 0.96. Most of the regression coefficients are significant. Among the significant coefficients, all are significant except three at 1% level. Except for prices of *anjily* and *venteak*, the Durbin-Watson  $d$ -statistics are non-significant either at 5% or 1% level. For the prices of *anjily*, the Durbin-Watson  $d$ -statistic is significant at 5% level showing the presence of positive autocorrelation of errors. In this case, the regression coefficients will be less reliable. For *venteak*, the Durbin-Watson  $d$ -test for autocorrelation is inconclusive. However, since the purpose of this study is to compare the price behaviour of teakwood with selected timbers during different periods, the models for which the test for autocorrelation

Table 6.8 Summary statistics of different trend models fitted to the real prices of teakwood (girth-classes combined)

Sl. no.		Adj. $R^2$	Mean square error	Durbin-Watson $d$ -statistic
1	Linear	0.74**	1.37x10 <sup>5</sup>	1.31**
2	Quadratic	0.92**	2.48x10 <sup>5</sup>	0.89**
3	Cubic	0.94**	1.94x10 <sup>5</sup>	1.17**
4	Logarithmic	0.40**	16.90x10 <sup>5</sup>	0.16**
5	Inverse	0.09 <sup>ns</sup>	25.60x10 <sup>5</sup>	0.12**
6	Compound	0.70**	5.29x10 <sup>5</sup>	0.41**
7	Power	0.36**	16.25x10 <sup>5</sup>	0.15**
8	S-curve	0.07 <sup>ns</sup>	27.19x10 <sup>5</sup>	0.10**
9	Growth	0.70**	5.29x10 <sup>5</sup>	0.41**
10	Exponential	0.70**	5.29x10 <sup>5</sup>	0.41**
11	Logistic	0.72**	5.35x10 <sup>5</sup>	0.41**
12	Linear spline with 2 knots	0.95**	1.51x10 <sup>5</sup>	1.46 <sup>ic</sup>
13	Linear spline with 3 knots	0.96**	1.03x10 <sup>5</sup>	2.17 <sup>ns</sup>
14	Quadratic spline with 2 knots	0.95**	1.19x10 <sup>5</sup>	1.92 <sup>ns</sup>
15	Quadratic spline with 3 knots	0.95**	1.23x10 <sup>5</sup>	1.92 <sup>ns</sup>

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant at 5% probability level.

<sup>ic</sup> Durbin-Watson  $d$ -test inconclusive at 5% level

Source : Results of trend analysis.

Table 6.9 Summary statistics of different trend models fitted to the real prices of *anjily*

Sl. no.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.65**	2.44x10 <sup>5</sup>	0.68**
2	Quadratic	0.71**	2.04x10 <sup>5</sup>	0.82**
3	Cubic	0.74**	1.93x10 <sup>5</sup>	0.92**
4	Logarithmic	0.41**	4.14x10 <sup>5</sup>	0.43**
5	Inverse	0.12*	6.13x10 <sup>5</sup>	0.31**
6	Compound	0.68**	2.25x10 <sup>5</sup>	0.72**
7	Power	0.43**	3.94x10 <sup>5</sup>	0.43**
8	S.curve	0.13**	6.35x10 <sup>5</sup>	0.27**
9	Growth	0.67**	2.25x10 <sup>5</sup>	0.73**
10	Exponential	0.67**	2.25x10 <sup>5</sup>	0.73**
11	Logistic	0.65**	2.20x10 <sup>5</sup>	0.75**
12	Linear spline with 2 knots	0.71**	1.89x10 <sup>5</sup>	0.91**
13	Linear spline with 3 knots	0.77**	1.52x10 <sup>5</sup>	1.16*
14	Quadratic spline with 2 knots	0.75**	1.61x10 <sup>5</sup>	1.11*
15	Quadratic spline with 3 knots	0.77**	1.57x10 <sup>5</sup>	1.15*

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant.

Source : Results of trend analysis in chapter 6.

Table 6.10 Summary statistics of different trend models fitted to the real prices of *irul*

Sl. No.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.73**	1.42x10 <sup>5</sup>	0.51**
2	Quadratic	0.81**	1.01x10 <sup>5</sup>	0.70**
3	Cubic	0.85**	0.8x10 <sup>5</sup>	0.94**
4	Logarithmic	0.43**	2.92x10 <sup>5</sup>	0.27**
5	Inverse	0.12*	4.56x10 <sup>5</sup>	0.20*
6	Compound	0.74**	1.20x10 <sup>5</sup>	0.52**
7	Power	0.44**	2.72x10 <sup>5</sup>	0.27**
8	S.curve	0.12*	4.80x10 <sup>5</sup>	0.16**
9	Growth	0.74**	1.20x10 <sup>5</sup>	0.59**
10	Exponential	0.74**	1.20x10 <sup>5</sup>	0.59**
11	Logistic	0.73**	1.16x10 <sup>5</sup>	0.62**
12	Linear spline with 2 knots	0.83**	0.82x10 <sup>5</sup>	1.31 <sup>ic</sup>
13	Linear spline with 3 knots	0.91**	0.47x10 <sup>5</sup>	1.62 <sup>ic</sup>
14	Quadratic spline with 2 knots	0.88**	0.60x10 <sup>5</sup>	1.31 <sup>ic</sup>
15	Quadratic spline with 3 knots	0.87**	0.61x10 <sup>5</sup>	1.31 <sup>ic</sup>

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant at 5% level.

<sup>ic</sup> Durbin-Watson *d*-test inconclusive.

Source : Results of trend analysis in chapter 6.

Table 6.11 Summary statistics of different trend models fitted to the real prices of *maruthu*

Sl. No.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.67**	1.54x10 <sup>5</sup>	0.50**
2	Quadratic	0.74**	1.26x10 <sup>5</sup>	0.61**
3	Cubic	0.81**	0.93x10 <sup>5</sup>	0.88**
4	Logarithmic	0.40**	2.79x10 <sup>5</sup>	0.30**
5	Inverse	0.10*	4.16x10 <sup>5</sup>	0.22**
6	Compound	0.68**	1.42x10 <sup>5</sup>	0.52**
7	Power	0.39**	2.70x10 <sup>5</sup>	0.28**
8	S.curve	0.09 <sup>ns</sup>	4.42x10 <sup>5</sup>	0.18**
9	Growth	0.68**	1.42x10 <sup>5</sup>	0.52**
10	Exponential	0.68**	1.42x10 <sup>5</sup>	0.52**
11	Logistic	0.67**	1.32x10 <sup>5</sup>	0.57**
12	Linear spline with 2 knots	0.77**	1.03x10 <sup>5</sup>	0.76**
13	Linear spline with 3 knots	0.90**	0.45x10 <sup>5</sup>	1.63 <sup>ic</sup>
14	Quadratic spline with 2 knots	0.84**	0.70x10 <sup>5</sup>	1.18*
15	Quadratic spline with 3 knots	0.84**	0.72x10 <sup>5</sup>	1.18*

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant.

<sup>ic</sup> Durbin-Watson *d*-test inconclusive at 5% level, but non-significant at 1% level.

Source : Results of trend analysis in chapter 6.

Table 6.12 Summary statistics of different trend models fitted to the real prices of jackwood

Sl. No.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.60**	$2.68 \times 10^5$	2.34 <sup>ns</sup>
2	Quadratic	0.61**	$2.66 \times 10^5$	2.41 <sup>ns</sup>
3	Cubic	0.64**	$2.58 \times 10^5$	2.58 <sup>ns</sup>
4	Logarithmic	0.42**	$3.87 \times 10^5$	1.64 <sup>ns</sup>
5	Inverse	0.14*	$5.74 \times 10^5$	1.14**
6	Compound	0.72**	$2.71 \times 10^5$	2.30 <sup>ns</sup>
7	Power	0.50**	$3.61 \times 10^5$	1.74 <sup>ns</sup>
8	S.curve	0.21**	$5.79 \times 10^5$	1.08**
9	Growth	0.72**	$2.71 \times 10^5$	2.30 <sup>ns</sup>
10	Exponential	0.72**	$2.71 \times 10^5$	2.30 <sup>ns</sup>
11	Logistic	0.63**	$2.56 \times 10^5$	2.44 <sup>ns</sup>
12	Linear spline with 2 knots	0.60**	$2.58 \times 10^5$	2.56 <sup>ns</sup>
13	Linear spline with 3 knots	0.63**	$2.43 \times 10^5$	2.70 <sup>ns</sup>
14	Quadratic spline with 2 knots	0.61**	$2.55 \times 10^5$	2.68 <sup>ns</sup>
15	Quadratic spline with 3 knots	0.61**	$2.55 \times 10^5$	2.75 <sup>ns</sup>

\* Statistically significant at 5% probability level and \*\* at 1% level

<sup>ns</sup> Statistically non-significant.

Source : Results of trend analysis in chapter 6.



Table 6.13 Summary statistics of different trend models fitted to the real prices of *thembavu*

Sl. No.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.60**	1.27x10 <sup>5</sup>	0.51**
2	Quadratic	0.67**	1.07x10 <sup>5</sup>	0.64**
3	Cubic	0.80**	0.67x10 <sup>5</sup>	0.99**
4	Logarithmic	0.34**	2.12x10 <sup>5</sup>	0.32**
5	Inverse	0.08 <sup>ns</sup>	2.97x10 <sup>5</sup>	0.24**
6	Compound	0.58**	1.20x10 <sup>5</sup>	0.55**
7	Power	0.30**	2.07x10 <sup>5</sup>	0.32**
8	S.curve	0.06 <sup>ns</sup>	3.10x10 <sup>5</sup>	0.22**
9	Growth	0.58**	1.20x10 <sup>5</sup>	0.55**
10	Exponential	0.58**	1.20x10 <sup>5</sup>	0.55**
11	Logistic	0.59**	1.16x10 <sup>5</sup>	0.56**
12	Linear spline with 2 knots	0.73**	0.84x10 <sup>5</sup>	0.82**
13	Linear spline with 3 knots	0.91**	0.27x10 <sup>5</sup>	2.19 <sup>ns</sup>
14	Quadratic spline with 2 knots	0.86**	0.43x10 <sup>5</sup>	1.48 <sup>ic</sup>
15	Quadratic spline with 3 knots	0.86**	0.44x10 <sup>5</sup>	1.48 <sup>ic</sup>

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant.

<sup>ic</sup> Durbin-Waston *d*-test inconclusive at 5% level.

Source : Results of trend analysis in chapter 6.

Table 6.14 Summary statistics of different trend models fitted to the real prices of *venga*

Sl. No.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.57**	2.12x10 <sup>5</sup>	0.54**
2	Quadratic	0.57**	2.12x10 <sup>5</sup>	0.55**
3	Cubic	0.66**	1.71x10 <sup>5</sup>	0.73**
4	Logarithmic	0.36**	3.04x10 <sup>5</sup>	0.40**
5	Inverse	0.10*	4.31x10 <sup>5</sup>	0.31**
6	Compound	0.60**	2.17x10 <sup>5</sup>	0.52**
7	Power	0.39**	2.93x10 <sup>5</sup>	0.39**
8	S.curve	0.11*	4.43x10 <sup>5</sup>	0.27**
9	Growth	0.60**	2.17x10 <sup>5</sup>	0.53**
10	Exponential	0.60**	2.17x10 <sup>5</sup>	0.53**
11	Logistic	0.55**	2.04x10 <sup>5</sup>	0.56**
12	Linear spline with 2 knots	0.60**	1.87x10 <sup>5</sup>	0.65**
13	Linear spline with 3 knots	0.91**	0.47x10 <sup>5</sup>	1.62 <sup>ic</sup>
14	Quadratic spline with 2 knots	0.69**	1.44x10 <sup>5</sup>	0.88**
15	Quadratic spline with 3 knots	0.72**	1.28x10 <sup>5</sup>	0.96**

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant.

<sup>ic</sup> Durbin-Wastin *d*-test inconclusive at 5% level, but non-significant at 1% level.

Source : Results of trend analysis in chapter 6.

Table 6.15 Summary statistics of different trend models fitted to the real prices of *venteak*

Sl. No.	Trend model	Adj. $R^2$	Mean square error	Durbin-Watson 'd' statistic
1	Linear	0.75**	1.51x10 <sup>5</sup>	0.26**
2	Quadratic	0.82**	1.09x10 <sup>5</sup>	0.36**
3	Cubic	0.88**	0.72x10 <sup>5</sup>	0.57**
4	Logarithmic	0.45**	3.33x10 <sup>5</sup>	0.15**
5	Inverse	0.12*	5.36x10 <sup>5</sup>	0.11**
6	Compound	0.75**	1.30x10 <sup>5</sup>	0.30**
7	Power	0.44**	3.13x10 <sup>5</sup>	0.13**
8	S.curve	0.11*	5.76x10 <sup>5</sup>	0.07**
9	Growth	0.75**	1.30x10 <sup>5</sup>	0.30**
10	Exponential	0.75**	1.30x10 <sup>5</sup>	0.30**
11	Logistic	0.75**	1.16x10 <sup>5</sup>	0.33**
12	Linear spline with 2 knots	0.86**	0.83x10 <sup>5</sup>	0.48**
13	Linear spline with 3 knots	0.96**	0.21x10 <sup>5</sup>	1.51 <sup>ic</sup>
14	Quadratic spline with 2 knots	0.92**	0.44x10 <sup>5</sup>	0.89**
15	Quadratic spline with 3 knots	0.92**	0.46x10 <sup>5</sup>	0.89**

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant.

<sup>ic</sup> Durbin-Watson *d*-test inconclusive at 5% level, but non-significant at 1% level.

Source : Results of trend analysis in chapter 6.

Table 6.16 Regression coefficients of linear spline model of real prices of teakwood (girth-classes combined) and selected timbers along with adjusted  $R^2$  and Durbin-Watson  $d$ -statistic.

Timber	Regression coefficients					Adj. $R^2$	Durbin-Watson $d$ -statistic
	$\hat{\beta}_{00}$	$\hat{\beta}_{01}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$		
Teak-wood	2171.71** (180.8)#	-67.81** (20.7)	144.22** (44.3)	299.19** (56.3)	-232.11** (54.2)	0.96**	2.17 <sup>ns</sup>
Anjily	934.09** (220.3)	-6.50 (25.2)	31.17 (54.0)	182.85** (68.7)	-201.65** (66.1)	0.77**	1.16*
Irul	735.90** (122.4)	-14.88 (14.03)	42.41 (30.0)	165.47** (38.1)	-188.61** (36.7)	0.91**	1.62 <sup>ic</sup>
Maruthu	716.40** (119.9)	-18.51 (13.7)	40.44 (29.4)	187.18** (37.4)	-239.60 (36.0)	0.90**	1.63 <sup>ic</sup>
Jack-wood	657.47* (278.1)	5.43 (31.8)	55.37 (68.2)	83.08 (86.6)	-145.31 (83.5)	0.63**	2.79 <sup>ns</sup>
Them-bavu	953.39** (93.6)	-24.82* (10.7)	40.68 (22.9)	176.27** (29.1)	-235.47** (28.1)	0.91**	2.19 <sup>ns</sup>
Venga	735.90** (122.4)	-14.88 (14.0)	42.41 (30.0)	165.47** (38.1)	-188.61** (36.7)	0.91**	1.62 <sup>ic</sup>
Ven-teak	665.40** (83.30)	-14.97 (9.6)	42.25* (20.4)	202.53** (25.9)	-245.08** (25.0)	0.96**	1.52 <sup>ic</sup>

# The figure in parenthesis is the standard error of the coefficient.

\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant.

<sup>ic</sup> Durbin-Watson  $d$ -test inconclusive at 5% level, but non-significant at 1% level.

Source: Results of regression analysis.

Table 6.17 Rates of change of real prices of teakwood (girth-classes combined) and selected timbers during different periods<sup>\$</sup>.

Timber	$t \leq k_1$	$k_1 < t \leq k_2$	$k_2 < t \leq k_3$	$t > k_3$
	(1956-57 to 1968-69)	(1969-70 to 1976-77)	(1977-78 to 1983-84)	(1984-85 to 1993-94)
	$(\hat{\beta}_{01})$	$(\hat{\beta}_{01} + \hat{\beta}_1)$	$(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2)$	$(\hat{\beta}_{01} + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3)$
Teak wood	-67.81	76.41	375.6	143.49
<i>Anjily</i>	-6.50	24.67	207.52	5.87
<i>Irul</i>	-14.88	27.53	193.00	4.39
<i>Maruthu</i>	-18.51	21.93	209.11	-30.49
Jackwood	5.43	60.8	143.88	-1.43
<i>Thembavu</i>	-24.82	15.86	192.13	-43.34
<i>Venga</i>	-14.88	27.53	193.00	4.39
<i>Venteak</i>	-14.97	27.28	229.81	-15.27

<sup>\$</sup>  $k_1, k_2$  and  $k_3$  stand for the year 1968-69, 1976-77 and 1983-84 respectively.

Source: Computed from the regression coefficients.

significant and inconclusive were also considered. Table 6.17 shows the annual rate of change of real prices of teakwood (girth-classes combined) and those of selected timbers during different periods.

#### Period $t \leq k_1$ (1956-57 to 1968-69)

During this period, real prices of selected timbers registered a decline at a marginal rate except for jackwood for which the real prices increased at a marginal rate (Rs. 5 per annum). When teakwood prices came down at a rate of about Rs. 68 per year, the rate of decline for the remaining timbers varied from Rs. 7 for *anjily* to Rs. 25 for *thembavu*.

**Period  $k_1 < t \leq k_2$  (1969-70 to 1976-77)**

This period is characterised by an increase in price for teakwood and selected timbers. The rate of increase of real price of teakwood was Rs. 76 and that of jackwood was Rs. 61 per annum. The rate of increase in prices for other timbers was more or less the same except for *thembavu* for which it was only Rs. 16 per annum. The rate of other timbers varied from Rs. 22 for *maruthu* to Rs. 28 for *irul* and *venga*.

**Period  $k_2 < t \leq k_3$  (1977-78 to 1983-84)**

This period is marked by a drastic increase in prices for all timbers. The rate varied from Rs. 144 for jackwood to Rs. 230 for *venteak* and the rate of teakwood was Rs. 376 per year.

**Period  $t > k_3$  (1984-85 to 1993-94)**

During this period, teakwood prices showed an increasing trend but the rate of increase was lower than that existed during the proceeding period. The rate of increase of real prices of *anjily* and *irul* was very marginal. The real prices of other timbers declined at a moderate rate except for *anjily* and *venteak* for which prices increased marginally.

In this chapter, the price trends of teakwood and other selected timbers using 3, 5 and 7 year moving averages have been described. The overall trend has been found to be more or less similar for all timbers. Among different trend models tried, the best fitting model identified for real prices of teak logs in different girth-classes is the linear spline model with three knots. The price behaviour of teakwood in each of the four periods has been analysed. In the first

period (1956-57 to 1968-69) the real prices declined for all girth classes. In the other three periods, the prices have increased. Among them, the period from 1977-78 to 1983-84 saw the highest rate of increase. The price behaviour of selected timbers was compared with that of teakwood. The price trend of all timbers showed similar behaviour during the period from 1956-57 to 1983-84. During the period from 1984-85 to 1993-94, while the price of teakwood continued to increase, most of the selected timbers had a decline in price.

## CHAPTER 7

### TEAKWOOD PRICES : SOME FURTHER ANALYSIS

In theory, long-term changes in both demand and supply tend to affect the prices. On account of constraints in availability of time series data, it has not been possible to indicate clearly the contribution of each of the causative factors. Nevertheless, there are some indications to what may be the factors that influence the long-term change in teakwood prices. In this chapter, the results of some further analysis of teakwood prices are presented.

#### 7.1 Autoregressive Relationship of Real Prices

Autoregressive Model 2.17 given in chapter 2 has been estimated, using the step-wise regression procedure taking the current year's real price ( $P_t$ ) as regressand and the real prices lagged by one year ( $P_{t-1}$ ) and two years ( $P_{t-2}$ ) as regressors. The real price lagged by two years was dropped from all the models in the analysis except that of price of girth-class 1. The estimated autoregressive models along with adjusted  $R^2$  values and Durbin  $h$ -statistics are given below. Models 7.1, 7.2, 7.3, 7.4 and 7.5 represent the estimated models of prices of teak logs in girth-classes  $E$ , 1, 2, 3 and 4 respectively.

$$\hat{P}_t = 511.6675 + 0.9692^{**} P_{t-1}, \dots\dots\dots(7.1)$$

(453.16)<sup>#</sup> (0.08)

$$\text{Adj. } R^2 = 0.87^{**}, h = -0.68^{\text{ns}}$$

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\* Statistically significant at 5% probability level and \*\* at 1% level.

<sup>ns</sup> Statistically non-significant at 5% probability level

<sup>#</sup>The figure in parenthesis is the standard error of the coefficient.

$$\hat{P}_t = -97.1410 + 0.6836^{**} P_{t-1} + 0.4179^* P_{t-2}, \dots\dots\dots(7.2)$$

(198.67) (0.16) (0.17)

$$\text{Adj. } R^2 = 0.94^{**}, h = -0.35^{\text{ns}}$$

$$\hat{P}_t = 77.4814 + 1.0260^{**} P_{t-1}, \dots\dots\dots(7.3)$$

(175.85) (0.04)

$$\text{Adj. } R^2 = 0.93^{**}, h = -1.31^{\text{ns}}$$

$$\hat{P}_t = 104.1200 + 1.0087^{**} P_{t-1}, \dots\dots\dots(7.4)$$

(155.97) (0.05)

$$\text{Adj. } R^2 = 0.91^{**}, h = -2.01^{\text{ns}(1\%)}$$

$$\hat{P}_t = 365.6847 + 0.9187^{**} P_{t-1}, \dots\dots\dots(7.5)$$

(216.70) (0.07)

$$\text{Adj. } R^2 = 0.87^{**}, h = -1.80^{\text{ns}}$$

The adjusted  $R^2$  values of the above models range from 0.87 to 0.94 and all  $R^2$  are statistically significant at 1% probability level. All the coefficients of the real price lagged by one year are significant at 1% level. The coefficient of real price lagged by two years in Model 7.2 is significant only at 5% level. The Durbin  $h$ -statistics are all non-significant at 5% level, except that of girth-class 3 for which it is non-significant at 1% level.

The above analysis shows that each year's price is related to the preceding year's price. That is, each year's real price of teak logs in a girth-class is very closely related to that of the previous year's price of the same girth-class. This is in conformity with what is expected. In the monthly auction of teak logs of a particular quality and girth-class in the depot, the auction initially begins at the upset price, which

is the average of prices of teak logs of the same quality and girth-class obtained in the preceding three auctions in the same depot. If the upset price is not agreed upon by the bidders participating in the auction, it is further reduced by the auctioning authority and at the reduced rate, auction re-starts. However, the auction will be confirmed in the spot only if the final bid amount exceeds 90% of the upset price. Usually, the bidders will try to increase the final bid price so as to reach above 90% of the upset price to avoid delay in confirmation. That is, auction price in a particular month is dependent on the preceding months' prices. Therefore, the relationship between current year's real price with that of the preceding year's real price is a reflection of the successive dependence of monthly auction prices.

## 7.2 Inter-class Price Relationship

The inter-relationships between the real prices of teak logs in different girth-classes have been analysed using the data for the period from 1970-71 to 1993-94 (Appendix 23). First-order differencing was employed to all series. The results of the correlation analysis for the *differenced* series of real prices of teak logs in different girth-classes are shown in Table 7.1. The real price of teak logs in girth class *E* is only related to the real price of teak logs in girth class 1. However, only 19% of the variation in the (*differenced*) real prices of teak logs in girth-class *E* is explained by the variation in the (*differenced*) real prices of teak logs in girth-class 1. Strong relationship exists between real prices of teak logs in girth-classes 2 and 3 ( $R^2 = 0.83$ ) and those of girth-classes 3 and 4 ( $R^2 = 0.79$ ).

The inter-class price relationships of the form given by Model 2.18 in chapter 2 have been estimated using the step-wise regression procedure, taking *differenced* real price of teak logs in a girth-class

Table 7.1 Coefficients of correlation ( $R$ ) between differenced series of real prices of teak logs in different girth-classes

Girth class	E	1	2	3	4
$E$ (above 185cm)	1.00	0.43* (0.19)	0.29 (0.09)	0.07 (0.05)	0.07 (0.05)
1 (150-184cm)	0.43* (0.19)#	1.00	0.71** (0.52)	0.50* (0.25)	0.47* (0.23)
2 (100-149cm)	0.29 (0.09)	0.71** (0.52)	1.00	0.90** (0.83)	0.84** (0.72)
3 (75-99cm)	0.07 (0.05)	0.50* (0.25)	0.90** (0.83)	1.00	0.89** (0.79)
4 (60-74cm)	0.07 (0.05)	0.47* (0.23)	0.84** (0.72)	0.89** (0.79)	1.00

\* The figure in parenthesis is  $R^2$  value.

\* Statistically significant at 5% probability level and\*\* at 1% level.

Source. Results of correlation analysis.

as regressand and *differenced* real prices of other girth-classes as regressors. The estimated relationships, along with adjusted  $R^2$  values and Durbin-Watson  $d$ -statistics, are given below.

$$(DP E)_t = 0.6241^* (DP 1)_t, \dots\dots\dots(7.6)$$

(0.25)

Adj.  $R^2 = 0.19$ ,\*  $d = 2.71^{ns}$

$$(DP 1)_t = 1.8800^{**} (DP 2)_t - 1.2192^{**} (DP 3)_t, \dots\dots\dots(7.7)$$

(0.40)                      (0.45)

Adj.  $R^2 = 0.68$ ,\*\*  $d = 2.69^{ns}$

$$(DP 2)_t = 0.3099^{**} (DP 1)_t + 0.8131^{**} (DP 3)_t, \quad \dots\dots\dots(7.8)$$

(0.06)                      (0.08)

Adj.  $R^2 = 0.93$ , \*\*  $d = 1.97^{ns}$

$$(DP 3)_t = 0.112^* (DP E)_t + 0.8127^{**} (DP 2)_t, \quad \dots\dots\dots(7.9)$$

(0.04)                      (0.06)

Adj.  $R^2 = 0.93$ , \*\*  $d = 2.56^{ns}$

$$(DP 4)_t = 0.6280^{**} (DP 3)_t, \quad \dots\dots\dots(7.10)$$

(0.07)

Adj.  $R^2 = 0.79$ , \*\*  $d = 2.59^{ns}$

where  $(DP E)_t$ ,  $(DP 1)_t$ ,  $(DP 2)_t$ ,  $(DP 3)_t$  and  $(DP 4)_t$  represent the *differenced* real price of teak logs in girth-class  $E$ , 1, 2, 3 and 4 during the year  $t$  respectively.

The  $R^2$  values of the first equation is statistically significant at 5% probability level (Model 7.6) and those of the other equations at 1% level (see Model 7.7 to 7.10). All the Durbin-Watson  $d$ -statistics are statistically non-significant at 5% probability level. The above models show strong relationship between real prices of teak logs in proximate girth-classes. For example, the real price of logs in girth class 2 is related to real price of logs in girth-classes 1 and that of 3 (Model 7.8). Similarly, real price of logs in girth-class 3 is related to the real prices of logs in girth-classes 2 and  $E$  (Model 7.9). Other equations show the relationship of real price of logs in girth class 1 with real prices of logs in girth-classes 2 and 3 (Model 7.7), between those in girth classes 4 and 3 (Model 7.10) and between those in girth-classes  $E$  and 1. The analysis shows that the real prices of teak logs in different girth-classes are mutually related.

### 7.3 Inter-species Price Relationship

First-order differencing was employed to the real prices of teakwood (girth-classes) and those of selected timbers during the period from 1956-57 to 1993-94 (Appendix 23 and 25). A correlation analysis has been carried out to the *differenced* real price series. The coefficients of correlation between *differenced* real prices of teakwood and those of selected timbers are given in Table 7.2. It can be seen that teakwood price has weak relation with *irul* and with *venteak*.

The inter-species price relationship of the form 2.19 given in chapter 2 has been estimated using the step-wise regression procedure, taking *differenced* real price of teakwood (girth-classes combined) as regressand and the *differenced* real prices of selected timber as regressors. The estimated relationship, along with adjusted  $R^2$  and Durbin-Waston  $d$ -statistic, is given below.

$$(DP TE)_t = 1.5699^{**}(DP IR)_t - 0.4087^{**} (DP JA)_t + 0.4671^{**}(DP VG)_t, \dots(7.11)$$

(0.15)                      (0.08)                      (0.15)

$$\text{Adj. } R^2 = 0.79^{**}, \quad d = 1.20^{**}$$

where  $(DP TE)_t$ ,  $(DP IR)_t$ ,  $(DP JA)_t$ , and  $(DP VG)_t$  denote respectively the *differenced* real price of teak, *irul*, jack and *venga* during the year  $t$ .

The relation between the real price of teakwood with the price of *irul*, jackwood and *venga* in the same year is seen (Model 7.11). The adjusted  $R^2$  value is 0.79. Although the regression coefficients are significant at 1% probability level, the Durbin-Watson  $d$ -statistic is significant at 1% probability level, as the value of  $d$  was 1.20 (Model 7.11). The absence of autocorrelation of errors in the estimated

functional relationship is not confirmed, even after the first-order differencing.

Table 7.2 Coefficients of correlation ( $R$ ) of differenced real price of teakwood with that of *anjily*, *irul*, *maruthu*, *jackwood*, *thembavu*, *venga* and *venteak*.

	Timber						
	<i>Anjily</i>	<i>Irul</i>	<i>Maaruthu</i>	<i>Jack-wood</i>	<i>Them-bavu</i>	<i>Venga</i>	<i>Venteak</i>
$R$	.22	.75**	.48**	.10	.34*	.24	.66**
$R^2$	0.05	0.56	0.23	0.01	0.12	0.06	0.44

\* Statistically significant at 5% probability level and \*\* at 1% level.

Source: Results of correlation analysis.

Therefore, the relationship between the price of teakwood and other timbers cannot be relied upon in this case. Even otherwise, a relationship of price of teakwood with prices of *irul*, jackwood and *venga* cannot be logically expected. Among the timbers, only jackwood is used as a substitute for teakwood for furniture, door, window shutters, etc. Jackwood has high workability, good colour and smooth texture. The only timber which can be expected to have a price relationship with teakwood is jackwood. However, the production of jackwood<sup>1</sup> from the forests during 1987-88 was only 61 m<sup>3</sup> while the rural household sector alone used 1,98,740 m<sup>3</sup> (sawn timber) of jackwood (Table 7.4). Therefore, the price realised for jackwood at the government depots may not be representative.

<sup>1</sup> Kerala Forest Department (1989). *Administration Report for the year 1987-88*. Govt. of Kerala, Thiruvananthapuram.

#### 7.4 Price-quantity Relationship

Data on quantity of teakwood sold in all the government depots were compiled from the Administration Reports of the Kerala Forest Department for the period for 1956-57 to 1992-93 (Appendix 26). The relationship of real price of teakwood (girth-classes combined) and total quantity of teakwood sold in all the government depots together has been analysed by estimating autoregressive model 2.20 given in chapter 2, taking the current year's real price ( $P_t$ ) as regressand and real price lagged by one year ( $P_{t-1}$ ) and quantity of teakwood sold ( $Q_t$ ) as regressors. The estimated autoregressive model along with adjusted  $R^2$  value and Durbin  $h$ -statistic is given below.

$$\hat{P}_t = 598.9181 + 0.9466^{**} P_{t-1} - 0.0105 Q_t, \dots\dots\dots(7.12)$$

(524.10)      (0.07)                      (0.01)

$$\text{Adj. } R^2 = 0.91^{**}, \quad h = -1.20^{\text{ns}}$$

The  $R^2$  value of the estimated model is statistically significant at 1% level and the Durbin  $h$ -statistic is non-significant at 5% level. When the coefficient of real price lagged by one year is significant at 1% level, the coefficient of quantity sold is not significant, although its sign is negative as expected (Model 7.12). The same analysis has also been done for the log-transformed data. But there is not much improvement in the  $R^2$  value and the coefficient of sale quantity in the log-scale is also found to be non-significant. This shows that the quantity of teakwood sold in Kerala has no influence on its real price.

#### 7.5 Price-production Relationship

Data on total volume of teakwood produced from forests were compiled from the Administration Reports of the Kerala Forest Department for the period from 1956-57 to 1992-93 (Appendix 21).

Autoregressive model of the form 2.21 given in chapter 2 has been estimated using of the step-wise regression procedure, taking real price ( $P_t$ ) of teakwood (girth-classes combined) as regressand and real price lagged by one year ( $P_{t-1}$ ), teakwood production from forests in the current year ( $F_t$ ), lagged by one year ( $F_{t-1}$ ) and lagged by two years ( $F_{t-2}$ ) as regressors. The estimated model along with adjusted  $R^2$  and Durbin  $h$ -statistic is given below.

$$\hat{P}_t = 1158.0683^* + 0.8767^{**} P_{t-1} - 0.0221^* F_{t-1} , \dots\dots\dots(7.13)$$

(523.96)            (0.07)                            (0.01)

Adj.  $R^2 = 0.92^{**}$  ,     $h = -0.13^{ns}$

In the step-wise regression analysis, the production in the current year as well as that lagged by two years have been dropped from the model. The coefficient of real price lagged by one year is significant at 1% level and the others are significant at 5% level. The Durbin  $h$ -statistic is non-significant at 5% level. Although the coefficient of  $F_{t-1}$  is negative as expected, the magnitude is very low (Model 7.13). This shows that teakwood production in the previous year has little influence on current year's real price over the period from 1956-57 to 1993-94.

To examine the above relationship during the period from 1976-77 to 1993-94, the period during which real prices increased drastically, a step-wise regression analysis has also been carried out, taking first-order *differenced* real price,  $(DP)_t$  as regressand and first-order *differenced* production in the current year,  $(DF)_t$ , lagged by one year,  $(DF)_{t-1}$  and two-years,  $(DF)_{t-2}$  as regressors<sup>2</sup>. The estimated

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<sup>2</sup> Autoregressive relationship could not be estimated as the Durbin  $h$ -statistic for testing autocorrelation of errors in the estimated autoregressive model is a large sample test.

regression equation along with adjusted  $R^2$  and Durbin-Waston  $d$ -statistic is given below.

$$(DP)_t = \frac{-0.0827^{**}}{(0.01)}(DF)_{t-1} - \frac{0.0329^{**}}{(0.01)}(DF)_{t-2}, \dots\dots\dots(7.14)$$

$$\text{Adj. } R^2 = 0.74^{**}, \quad d = 2.31^{\text{ns}}$$

In the above analysis also, current year's production of teakwood was dropped from the model by the step-wise regression procedure. But the teakwood price is related not only with one year lagged production, but also with two-year lagged production. The  $R^2$  and the coefficients are statistically significant at 1% probability level and Durbin-Watson  $d$ -statistics is non-significant at 5% level (Model 7.14). During the period from 1976-77 to 1993-94, when the prices increased drastically, 74% of the variation in (*differenced*) prices is explained by the one and two-year lagged (*differenced*) productions of teakwood. An important observation is that the magnitude of the coefficients of the two-year lagged production in the model is very low. This shows that teakwood production two-years back has only very little influence on current year's real price.

For the teakwood from the forests or plantations to be sold in auction in the government depots, there exists a time lag for transporting logs to the depots and for classifying logs according to dimension, grouping into lots as well as auction procedure. This is the reason for the relationship between real price and lagged production of timber.

### **7.6 Price in Relation to Changes in Internal Demand**

The demand for timber is a derived demand and changes in the pattern of demand for timber-based products affect demand for timber.

As timber is used in a large number of end-products, estimating the changes in demand is difficult. However, an attempt has been made here to indicate the broad magnitude of changes.

Construction sector is a major user of timber. The trend in constructions is found to have a significant effect on timber prices. Table 7.3 gives the annual growth rate of residential buildings and all buildings during the periods from 1973-74 to 1992-93. It can be seen that growth rate has registered a significant increase during the period from 1978-79 to 1982-83 and from 1988-89 to 1992-93. Data, based on number of occupied residential houses from population Census<sup>3</sup>,

Table 7.3. Annual growth rate of buildings in selected Panchayats in Thrissur District

Period	Compound rate per annum (%)	
	Residential buildings	All buildings
1973-74 to 1977-78	1.9	1.7
1978-79 to 1982-83	2.3	2.6
1983-84 to 1987-88	1.9	2.4
1988-89 to 1992-93	3.4	3.2

Source: Computed from the data compiled from the registers at four selected Panchayat Offices in Thrissur District.

indicate an annual compound growth rate of 2.0%, 2.3%, and 2.4 % in Kerala for the periods 1961-71, 1971-81 and 1981-91 respectively.

<sup>3</sup> i) Government of India (1982). *op.cit.*

ii) Department of Economics and Statistics (1993). Statistics for planning 1993. Government of Kerala, Thiruvananthapuram.

Households represented the largest timber using sector accounting for 45.4 per cent of the total quantity of timber used ( Table 3.4). These facts indicate that the construction sector has expanded registering a steady increase during the last several years. Factors such as government financed construction programme, liberal credits supplied to the construction sector by various institutions, inflow of foreign remittance from people working abroad, etc. have contributed immensely to enhance the momentum in construction activities in the state. The sudden spurt<sup>4</sup> in the construction activities during the short span of time has resulted in a change in the pattern of timber-use in households. To what extent the expansion in the construction sector has contributed to increase demand for timber is difficult to estimate. The quantity of timber used in different types of constructions varies considerably. In the household sector, use of teakwood is marginal (only 1%) considering all the timbers used (Table 3.4). Even in the teakwood-using households, only some items such as the main door, furniture, frames for window, shutters, etc. are made with teakwood. The source of teakwood also influences the quantity of teakwood used. That is, when teakwood is from own home-gardens, its use may be relatively higher. In the urban households, most teakwood and other timbers are purchased from sawmills who obtain their supply mostly from the government timber depots. However, only less than 5% of teakwood goes to urban households (Table 3.1). Therefore, the teakwood-use in urban households may not influence the teakwood price.

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<sup>4</sup> The construction boom has been particularly attributable to the inflow of remittances from the migrant workers in the Gulf countries.

In the rural households, a definite preference for different species of timber for specific uses can be seen. Table 7.4 gives the pattern of timber-use in the rural household sector of Kerala during the year 1987-88. Just 8 timbers accounted for about 83% of the total quantity of sawn timber used in rural households (Appendix 7). Teakwood accounted for only 3.8% of the total. Among other timbers, jackwood accounted for 38.5% followed by coconutwood 23.2%, *anjily* 11.3% and mangowood 3.6% of the total sawn timber utilised. Jackwood is commonly used for door frame, window, roof and ceiling. The preference for jackwood may be due to availability. Jackwood accounted for 43.3% for roof and ceiling, 35.4% door frame and window and 15.9% for doors and shutters. Coconutwood was mainly used for roof and ceiling. *Anjily* was also largely used for roof and ceiling (52.9%) followed by door frame and windows (32.1%) and doors and shutters (11.1%).

In the pattern of timber-use in the rural households, timbers other than teakwood are dominant. Even inferior timber such as coconutwood is substantially utilised. Partly this is due to greater availability and partly due to the price increase of other timbers. In the rural household sector, home-gardens are the major source of timber used (Table 7.5). Jackwood, coconutwood and *anjily* together accounted for 73% of the total quantity of all timbers used in rural households. These are plentiful in the home-gardens. Therefore, the demand for teakwood in the rural household sector in Kerala also may not influence teakwood price significantly.

Table 7.4 Pattern of timber-use in the rural household sector of Kerala during the year 1987-88

(Volume of sawn timber in m<sup>3</sup>)

Species of timber	Uses				Total
	Door frame and windows	Doors and shutters	Roof and ceiling	Other uses <sup>5</sup>	
Teak	7118 (1.4) <sup>#</sup>	2385 (0.5)	8173 (1.6)	1743 (0.3)	19419 (3.8)
Jack	70392 (13.6)	31603 (6.1)	86102 (16.7)	10643 (2.1)	198740 (38.5)
Coconut	1320 (0.3)	906 (0.2)	115356 (22.3)	2209 (0.4)	119791 (23.2)
<i>Anjily</i>	18715 (3.6)	6432 (1.2)	30772 (6.0)	2281 (0.5)	58200 (11.3)
Mango	3590 (0.7)	9852 (1.9)	3942 (0.8)	1228 (0.2)	18612 (3.6)
<i>Irul</i>	3344 (0.6)	307 (0.1)	2193 (0.4)	18 (0.0)	5862 (1.1)
<i>Palmyra</i>	117 (0.0)	73 (0.0)	5749 (1.1)	0 (0.0)	5939 (1.1)
<i>Maruthu</i>	541 (0.1)	149 (0.0)	2231 (0.4)	73 (0.0)	2994 (0.5)
Others	27447 (5.3)	7316 (1.4)	44701 (8.7)	7745 (1.5)	87209 (16.9)
Total	132584 (25.6)	59023 (11.4)	299219 (58.0)	25940 (5.0)	516766 (100.0)

\* Figure in parenthesis is percentage to total

Source. Estimated from the data collected during the sample survey of Krishnankutty, C. N. 1990. *op.cit.*

<sup>5</sup> Include timber used for making furniture, fixtures, implements, etc.

Table 7.5 Contribution of home-gardens<sup>6</sup> to rural household timber supply in Kerala during 1987-88

(percentage)

Timber	Sources			Total
	Own home-gardens	Other home-gardens	Purchased from saw-mills	
Teakwood	1.7 (42.7)#	0.6 (17.7)	1.5 (39.6)	3.8 (100.0)
Other timbers	49.7 (51.7)	22.1 (22.9)	24.4 (25.4)	96.2 (100.0)
All timbers	51.4	22.7	25.9	100.0

\* The figure in parenthesis is percentage to total of timbers.

Source. Estimated from data collected during the sample survey for Krishnankutty, C. N. (1990). *op cit*.

### 7.7 Price in Relation to Change in External Demand

Substantial quantities of timber are exported from Kerala, particularly to Tamil Nadu, a wood-deficit State (Appendix 5). In addition to purchasing a large quantity of timber from Kerala government timber depots, traders in Tamil Nadu also obtain large quantities of sawn timber through traders in Kerala. This is probably due to the growing shortage of timber<sup>7</sup> within the state of Tamil Nadu<sup>8</sup>. Table 7.6 shows the average annual recorded production of teakwood and other timbers from the forests of Kerala and trade. In the trend analysis (chapter 6) the period during which prices increased rapidly

<sup>6</sup> This does not include the quantity of timber sold from home-gardens.

<sup>7</sup> Out-turn of round logs from the forests of Tamil Nadu declined from 37660 m<sup>3</sup> in 1976-77 to 378 m<sup>3</sup> in 1991-92 (see also Appendix 27)

<sup>8</sup> Government of Tamil Nadu (1972-73 to 1981-82 and 1991-92). *Administration reports of the Forest Department*. Tamil Nadu Forest Department, Madras.

Table 7.6 Production of teakwood and other timbers from Kerala forests and trade

Period	Timber	Production (m <sup>3</sup> )	Real Price (Rs./m <sup>3</sup> )	Import (m <sup>3</sup> )	Export (m <sup>3</sup> )
1980-81 to 1983-84	Teakwood	24615	4032	469*	9187*
	Others	112369	1865	29275*	24779*
1984-85 to 1993-94	Teakwood	19081	5282	1256*	18601*
	Others	38941	1465	68538*	18730*
1987-88	Teakwood	19222	5188	1553	19288
	Others	31929	1882	176114	25256

\* Import and export data for the first two periods were compiled from 5 important forest check-posts in Kerala. For the period 1987-88, the coverage is comprehensive. Source. Krishnankutty, C. N. 1990. *op.cit.* for import-export data up to the year 1987-88. The rest compiled from Administration Reports of the Kerala Forest Department and Registers maintained at border forest check-posts.

was from 1976-77 to 1983-84. Therefore, the data is presented for two periods namely 1980-81 to 1983-84 and after 1983-84. However, only five major check-posts have been covered for import-export data. For the year 1987-88 presented in the last row, the import-export data cover all border check-posts in Kerala. During the period from 1980-81 to 1983-84, the export of teakwood has doubled in quantity as well as in the proportion of teakwood to all timbers. During the same period, the real prices of teak has increased while that of the other timbers registered a decline. The decline in the real prices of other timbers could be due to the phenomenal increase in import of other timbers during the second period.

The import and export data covering all channels such as roads, rail and sea are available only for the year 1987-88 (Table 7.6). It can be seen that while the production of teakwood from the forest

was 19,222 m<sup>3</sup>, the export was 19,288 m<sup>3</sup>. This shows the magnitude and volume of export in relation to the production of teakwood from the forests of Kerala. The export figure also includes teakwood produced from non-forest sources particularly home-gardens. The average annual export of teakwood during 1984-85 to 1993-94 through 5 major check-posts<sup>9</sup> shows that the average annual production from forest during the same period exceeded the annual export only by 480 m<sup>3</sup>. When the other check-posts and other export channels are also included, the quantity of export will be even higher.

A regression analysis through origin has been carried out, taking first-order differenced real price of teakwood as regressand and first-order differenced quantity of teakwood exported as regressor, to check the relation between real price and quantity exported. No significant relationship has been found. Therefore, the price of teakwood in Kerala is not influenced by the quantity of teakwood exported. However, it cannot be ruled out that the market for teakwood and other high quality decorative wood outside Kerala influences the price of teakwood in Kerala. The national market being very large, the quantity of teakwood exported from Kerala is relatively very small to influence the price. The non-availability of time series data on the price of teakwood in the major markets outside Kerala is a handicap in this study. Discussions with traders and other knowledgeable persons have revealed that the teakwood prices in Kerala are very much influenced by the prices of teakwood in the national market.

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<sup>9</sup> The destination of teakwood through Kotekar forest check-post is Bombay, while that through the Vazhikadavu is Bangalore and Tamil Nadu. The export through remaining three viz Walayar, Vaniyampara and Arienkavu is to Madras and other urban centres in Tamil Nadu.

To sum up, the major conclusions that emerge from the analysis presented in this chapter are: (i) teakwood price during a year is teakwood in a girth-class is related to the prices of teakwood in proximate girth-classes, (iii) the teakwood price is not related to the prices of other timbers, (iv) the teakwood price is not related to the current year's production from forests, but related to one and two year lagged production, (v) the influence of internal demand on the price of teakwood is negligible perhaps because the use of teakwood among all timbers is low and (vi) no significant relation has been seen between teakwood price and the quantity exported, though the prices of teakwood in the external market is likely to influence the prices of teakwood in Kerala.

## FORECASTING OF TEAKWOOD PRICES USING ARIMA MODELS

In this chapter, autoregressive integrated moving average (ARIMA) models are described and used for forecasting future prices of teakwood in girth-classes 1, 2 and 3 in Kerala from their current and past prices.

### 8.1 ARIMA Models

Time series is a set of observations obtained by measuring or realized by a variable regularly over a period of time. It is regarded as a realization of a stochastic process. It is said to be stationary if it has a constant mean, constant variance and the correlations between observations at time  $t$  and  $t+k$  are the same as the correlations between observations at times  $t+t_1$  and  $t+t_1+k$ . These correlations are called autocorrelations. The series of average annual current prices computed from prices of teakwood sold in monthly auctions in the government depots in Kerala forms a time series.

ARIMA models are flexible and widely used in time series analysis<sup>1</sup>. Applications of ARIMA models to time series of timber prices reported in the literature are very few. In this context, it is relevant to note that ARIMA models have been used to predict monthly prices of commercial timbers in Taiwan<sup>2</sup> and USA<sup>3</sup>.

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<sup>1</sup> Box, G. E. P. and Jenkins, G. M. (1976). *op.cit.*

<sup>2</sup> Cheng, C. C. and Jen, J. A. (1980). *op.cit.*

<sup>3</sup> Oliveira, R. A., Buongiorno, J. and Kmiotek, A. M. (1977). *op.cit.*

In India, the present analysis of time series of teakwood prices using the ARIMA models is a pioneering work.

There are three types of processes that combine an ARIMA model. They are i) autoregression ii) differencing to strip off the integration of the series and iii) the moving average which are based on random disturbances or shocks. Each of the processes is described below.

### 8.1.1 Autoregressive models

In the autoregressive (AR) model, the current values of the process,  $Z_t$ , are expressed as a finite linear sum of previous values and a random shock  $a_t$ . The series  $Z_t$  is assumed to be stationary and  $a_t$  to be randomly distributed  $N(0, \sigma_a^2)$ . The values of a process  $Z_t$  at equally spaced times  $t, t-1, t-2, \dots, t-p$  are denoted by  $Z_t, Z_{t-1}, Z_{t-2}, \dots, Z_{t-p}$ . If  $\mu$  is the mean of the series,  $\bar{Z}_t, \bar{Z}_{t-1}, \bar{Z}_{t-2}, \dots, \bar{Z}_{t-p}$  are the deviations from  $\mu$ , such that  $\bar{Z}_t = Z_t - \mu$ . Then

$$\bar{Z}_t = \phi_1 \bar{Z}_{t-1} + \phi_2 \bar{Z}_{t-2} + \dots + \phi_p \bar{Z}_{t-p} + a_t$$

is called the autoregressive (AR) process of order  $p$ . It is convenient to write an autoregressive model in terms of backward shift operator  $B$ , where  $B^j Z_t = Z_{t-j}$  so that

$$\bar{Z}_t = \phi_1 B \bar{Z}_t + \phi_2 B^2 \bar{Z}_t + \dots + \phi_p B^p \bar{Z}_t + a_t$$

$$\text{ie; } (1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p) \bar{Z}_t = a_t$$

$$\text{ie; } \phi(B) \bar{Z}_t = a_t$$

where  $\phi(B) = (1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p)$ .

$\phi(B)$  is called the autoregressive operator of order  $p$ . The model contains  $p + 2$  unknown parameters  $\mu, \phi_1, \phi_2, \dots, \phi_p, \sigma_a^2$  which are to be estimated from the data.  $\sigma_a^2$  is the variance of the white noise process  $a_t$ .  $\phi_i, i = 1, 2, \dots, p$  are known as autoregressive parameters related to the  $p$  previous values  $\bar{Z}_{t-1}, \bar{Z}_{t-2}, \dots, \bar{Z}_{t-p}$ .

### 8.1.2 Moving average model

In the autoregressive model, deviation  $\bar{Z}_t$  of the process is expressed as a finite weighted sum of  $p$  previous deviations  $\bar{Z}_{t-1}, \bar{Z}_{t-2}, \dots, \bar{Z}_{t-p}$  of the process plus a random shock  $a_t$ . Another model for representing observed time series is the moving average process, where  $\bar{Z}_t$  linearly depends on a finite number,  $q$ , of past values of the random shock series. Thus, the moving average (MA) process of order  $q$  is written as

$$\bar{Z}_t = a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2} \dots - \theta_q a_{t-q}$$

ie; 
$$\bar{Z}_t = a_t - \theta_1 B a_t - \theta_2 B^2 a_t - \dots - \theta_q B^q a_t$$

ie; 
$$\bar{Z}_t = (1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q) a_t$$

ie; 
$$\bar{Z}_t = \theta(B) a_t$$

where  $\theta(B) = (1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q)$ .

$\theta(B)$  is called the moving average operator of order  $q$ . This model contains,  $q+2$  unknown parameters  $\mu, \theta_1, \theta_2, \dots, \theta_q, \sigma_a$  which are to be estimated from the data.  $\theta_j, j = 1, 2, \dots, q$  are known as moving average parameters.

### 8.1.3 Autoregressive moving average model

The autoregressive moving average (ARMA) model is obtained by employing both autoregressive and moving average components in the same model. The ARMA process of order (p,q) is expressed as

$$\phi(B) \bar{Z}_t = \theta(B) a_t$$

having  $p+q+2$  unknown parameters  $\mu, \phi_1, \phi_2, \dots, \phi_p, \theta_1, \theta_2, \dots, \theta_q, \sigma_a$  which are to be estimated from the data.

### 8.1.4 ARIMA models

The AR and MA modelling procedures assume that the series is stationary. If the series is not stationary, it may be reduced to a stationary one by adopting a sufficient degree of differencing. The ARIMA model is a general model for a non-stationary process exhibiting homogeneity. Many series exhibits non-stationary behaviour and do not vary about a fixed mean. The non-seasonal differencing operator  $\nabla$  such that

$$\nabla Z_t = Z_t - Z_{t-1} = (1-B) Z_t$$

may be used to convert a non-stationary series  $Z_t$  containing random jumps in its level into a stationary series. Thus by employing the difference operator  $\nabla^d$  where  $d$  denote the degree of differencing, the ARIMA ( $p, d, q$ ) model can be represented as

$$\phi(B) \nabla^d Z_t = \theta(B) a_t$$

ie;

$$\phi(B) (1-B)^d Z_t = \theta(B) a_t .$$

In practice,  $d$  is generally 0, 1 or at most 2. When the degree of

differencing,  $d$ , is zero,  $Z_t$  is replaced by  $\bar{Z}_t = Z_t - \mu$ . The process defined above can be used for describing stationary and non-stationary series.

## 8.2 ARIMA Modelling in Teakwood Prices

The average annual current prices of teakwood in girth-classes 1 (logs with mid-girth 150 to 184 cm), 2(100 to 149 cm) and 3(75 to 99 cm) in Kerala were compiled for a period of 53 years from 1941-42 to 1993-94 and used in the present study (see Appendices 22 and 22.1)<sup>4</sup>. There were no missing values in the time series data for girth-classes 1, 2 and 3. Range-mean plots<sup>5</sup> showed that no transformation is required for prices of teak logs in the three girth-classes. The data have been analysed using the statistical computer package<sup>6</sup> SPSS PC+.

The Box-Jenkins methodology of model identification, estimation and diagnostic checking has been employed to the time series of annual teakwood prices<sup>7</sup>. The parameters in the models have been estimated by the method of maximum likelihood using the computer package SPSS. The ARIMA models identified for prices of teakwood in girth-class 1, 2 and 3 have been estimated and are presented in Tables 8.1, 8.2 and 8.3 respectively. From different models estimated for prices of each girth-classe, the best

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<sup>4</sup> Data prior to 1956-57 were compiled from various Divisional Forest Working Plans in Travancore and Cochin States and Malabar District (Madras Presidency) which conform to the present Kerala State.

<sup>5</sup> Jenkins, G. M. (1978). *Practical Experiences with Modelling and Forecasting Time Series*. Gwilym Jenkins & Partners (Overseas) Ltd., Jersey, UK.

<sup>6</sup> SPSS Inc. (1987). SPSS PC+ 'Trends'. 444 North Michigan Avenue, Chicago.

<sup>7</sup> Box, G. E. P. and Jenkins, G. M. (1976). *op.cit.*

Table 8.1 Summary statistics of ARIMA models fitted to current prices of teakwood in girth-class 1

	AIC	SBC	$\sigma_a$	Mean absolute prediction error
$(1+0.5320^{**}B) (1-B)^2Z_t = (1-0.3299^*B)a_t$ (0.17) <sup>#</sup> (0.19)	826.31	830.18	776.85	409.97
$(1+0.5123^{**}B) (1-B)^2Z_t = 60.1019 + (1-0.3941 B)a_t$ (0.18) (44.11) (0.19)	826.58	832.38	770.89	460.98
$(1-B)^2Z_t = (1-0.6839^{**}B)a_t$ (0.11)	830.79	832.72	820.69	416.22
$(1-B)^2Z_t = 51.5455 + (1-0.7348^{**}B)a_t$ (31.82) (0.11)	830.48	834.34	809.21	475.45
$(1-0.9602^{**}B) (1-B)Z_t = (1-0.7749^{**}B + 0.3211 B^2)a_t$ (0.18) (0.26) (0.18)	847.36	853.21	797.48	411.21
$(1-0.9331^{**}B) (1-B)Z_t = 870.02 + (1-0.7738^{**}B + 0.3283 B^2)a_t$ (0.16) (743.65) (0.23) (0.18)	848.23	856.04	800.14	455.68
$(1-B)^2Z_t = 63.3541 + (1-0.8763^{**}B + 0.3141 B^2)a_t$ (48.65) (0.15) (0.19)	828.38	834.17	784.92	465.48
$(1-B)^2Z_t = (1-0.8427^{**}B + 0.3284 B^2)a_t$ (0.15) (0.18)	827.94	831.81	789.58	416.80
$(1-0.9650^{**}B) (1-B)Z_t = 876.03 + (1-0.6648^{**}B)a_t$ (0.08) (784.96) (0.17)	851.10	856.95	832.79	452.36
$(1-B)Z_t = (1+0.2998^*B - 0.4681^{**}B^2)a_t$ (0.13) (0.14)	858.24	862.14	906.10	427.41

\* Statistically significant at 5% probability level and \*\* at 1% level

<sup>#</sup>The figure in parenthesis is the standard error of the parameter.

Table 8.2 Summary statistics of ARIMA models fitted to current prices of teakwood in girth-class 2

Estimated model	AIC	SBC	$\sigma_a$	Mean absolute prediction error
$(1-B)^2 Z_t = 44.5638 + (1-0.9686^{**}B + 0.2603 B^2)a_t$ (27.51)# (0.14) (0.20)	809.83	815.63	653.00	388.27
$(1-B)^2 Z_t = (1-0.9358^{**}B + 0.2947 B^2) a_t$ (0.14) (0.21)	810.17	814.04	662.22	333.56
$(1+0.1799B) (1-B)^2 Z_t = 40.2355 + (1-0.7194^{**}B)a_t$ (0.21) (23.20) (0.18)	810.66	816.46	658.52	396.56
$(1+0.1950B) (1-B)^2 Z_t = (1-0.6502^{**}B)a_t$ (0.22) (0.20)	811.31	815.17	670.19	336.59
$(1-B)^2 Z_t = (1-0.7754^{**}B)a_t$ (0.11)	810.46	812.39	671.01	335.92
$(1-B)^2 Z_t = 37.6936 + (1-0.7877^{**}B)a_t$ (21.23) (0.12)	809.68	813.54	658.70	397.54
$(1-B)Z_t = (1+0.3655^{**}B + 0.1966 B^2)a_t$ (0.14) (0.14)	844.63	848.53	797.63	380.61
$(1-0.9806^{**}B) (1-B)Z_t = (1-0.7170^*B)a_t$ (0.16) (0.32)	829.17	833.07	678.58	332.00
$(1-0.9826^{**}B) (1-B)Z_t = (1-0.8360^{**}B+0.1740 B^2)a_t$ (0.15) (0.26) (0.20)	829.54	835.39	671.78	331.00
$(1-0.9694^{**}B) (1-B)Z_t = 672.3125 + (1-0.7193^{**}B)a_t$ (0.06) (595.92) (0.15)	830.18	836.04	681.46	371.00
$(1-0.9691^{**}B) (1-B)Z_t = 809.99 + (1-0.9058^{**}B+0.2673 B^2)a_t$ (0.07) (742.07) (0.16) (0.19)	830.36	838.17	672.91	365.61

\* Statistically significant at 5% probability level and \*\* at 1% level

# The figure in parenthesis is the standard error of the parameter.

Table 8.3 Summary statistics of ARIMA models fitted to current prices of teakwood in girth-class 3

Estimated model	AIC	SBC	$\sigma_a$	Mean absolute Prediction error
$(1-B)^2 Z_t = (1-1.3140^{**}B + 0.8022^{**}B^2)\alpha_t$ (0.10) (0.10)	787.54	791.40	520.67	304.45
$(1+0.1322B)(1-B)^2 Z_t = 50.6649 + (1-1.4117^{**}B + 0.8975^{**}B^2)\alpha_t$ (0.19) (39.62) (0.10) (0.10)	789.16	796.89	514.86	328.51
$(1-B)^2 Z_t = 45.5123 + (1-1.3401^{**}B + 0.7910^{**}B^2)\alpha_t$ (32.30) (0.12)	787.71	793.51	516.94	327.26
$(1-0.1665B)(1-B)^2 Z_t = (1-1.4145^{**}B + 0.9006B^2)\alpha_t$ (0.19) (0.10) (0.11)	788.85	794.65	518.15	307.54
$(1-0.9721^{**}B)(1-B)Z_t = (1-1.1591^{**}B + 0.3995^{**}B^2)\alpha_t$ (0.10) (0.20) (0.18)	807.41	813.26	538.50	284.78
$(1+0.4851^{**}B + 0.5533^{**}B^2)(1-B)^2 Z_t = (1-0.6207B + 0.6167^*B^2)\alpha_t$ (0.19) (0.16) (0.19) (0.17)	787.83	795.56	515.11	277.25
$(1+0.4734^*B + 0.4894^{**}B^2)(1-B)^2 Z_t = 40.6038 + (0.7208^{**}B + 0.5224^*B^2)\alpha_t$ (0.24) (0.18) (29.61) (0.24) (0.23)	788.52	798.18	514.53	310.86
$(1-0.9650^{**}B)(1-B)Z_t = 755.76 + (1-1.2795^{**}B + 0.7584^{**}B^2)\alpha_t$ (0.07) (699.21) (0.12) (0.12)	807.61	815.41	530.90	321.44

\* Statistically significant at 5% probability level and \*\* at 1% level

# The figure in parenthesis is the standard error of the parameter.



Table 8.5 Price forecasts for teakwood in girth-class 1 in Kerala

(Current prices in Rs per m<sup>3</sup>)

Year	Price forecast	95% confidence limit	
		Lower limit	Upper limit
1994-95	27040	25478	28601
1995-96	29788	27423	32154
1996-97	32950	29353	36546
1997-98	35891	31038	40745
1998-99	38950	32652	45248
1999-00	41946	34113	49780
2000-01	44975	35483	54468
2001-02	47987	36739	59235
2002-03	51008	37905	64112
2003-04	54025	38975	69075
2004-05	57043	39958	74129
2005-06	60061	40857	79265
2006-07	63079	41674	84484
2007-08	66097	42414	89780
2008-09	69115	43078	95152
2009-10	72133	43669	100597
2010-11	75151	44188	106113
2011-12	78169	44639	111698
2012-13	81187	45022	117351
2013-14	84204	45340	123069
2014-15	87222	45593	128851

Table 8.6 Price forecasts for teakwood in girth-class 2 in Kerala

(Current prices in Rs. per m<sup>3</sup>)

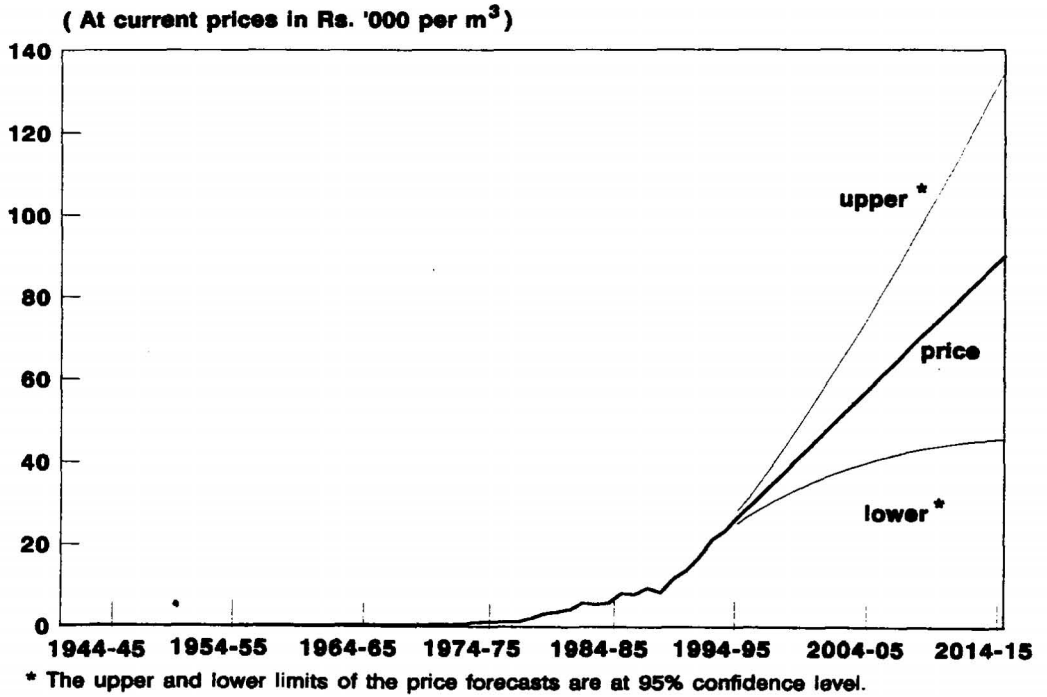
Year	Price forecast	95% confidence limit	
		Lower limit	Upper limit
1994-95	21349	20018	22680
1995-96	23725	21781	25669
1996-97	26101	23387	28815
1997-98	28477	24873	32082
1998-99	30853	26259	35448
1999-00	33230	27557	38903
2000-01	35606	28775	42437
2001-02	37982	29919	46044
2002-03	40358	30995	49721
2003-04	42734	32006	53463
2004-05	45110	32954	57267
2005-06	47487	33843	61130
2006-07	49863	34676	65050
2007-08	52239	35454	69024
2008-09	54615	36178	73052
2009-10	56991	36852	77131
2010-11	59367	37476	81259
2011-12	61744	38051	85436
2012-13	64120	38580	89660
2013-14	66496	39062	93929
2014-15	68872	39500	98244

Table 8.7 Price forecasts for teakwood in girth-class 3 in Kerala

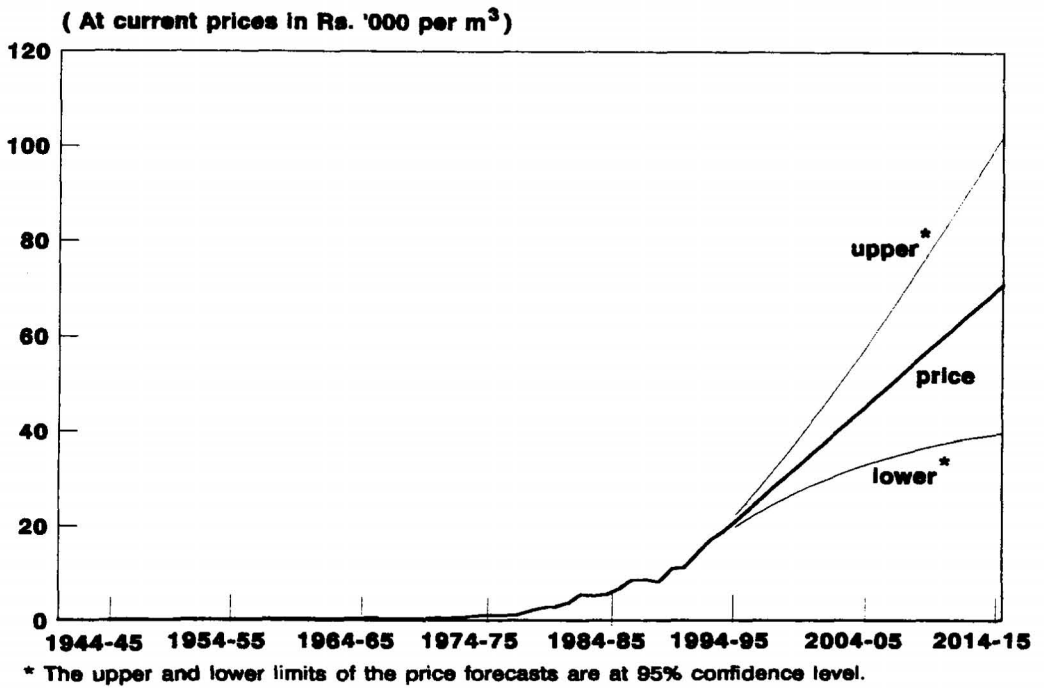
(Current prices in Rs. per m<sup>3</sup>)

Year	Price forecast	95% confidence limit	
		Lower limit	Upper limit
1994-95	16002	14956	17049
1995-96	18452	17183	19721
1996-97	20901	19134	22668
1997-98	23350	20871	25830
1998-99	25799	22450	29148
1999-00	28249	23908	32589
2000-01	30698	25261	36134
2001-02	33147	26524	39771
2002-03	35596	27702	43490
2003-04	38045	28804	47287
2004-05	40495	29833	51157
2005-06	42944	30793	55095
2006-07	45393	31688	59098
2007-08	47842	32521	63163
2008-09	50292	33294	67289
2009-10	52741	34009	71472
2010-11	55190	34668	75712
2011-12	57639	35273	80005
2012-13	60089	35826	84351
2013-14	62538	36327	88748
2014-15	64987	36779	93195

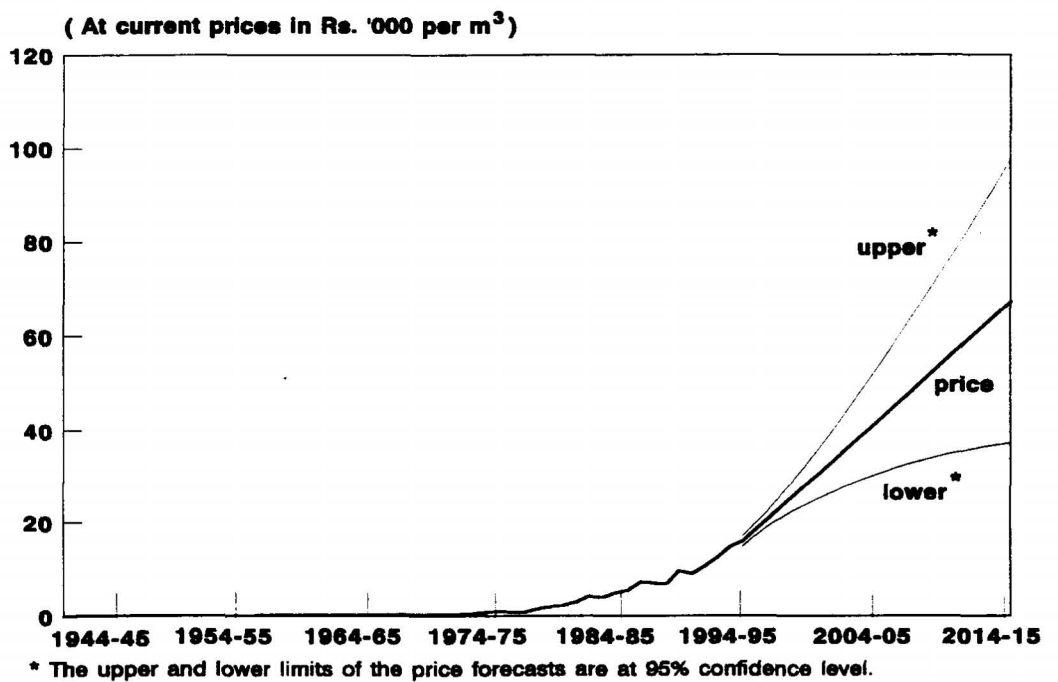
**Fig. 8.1 Price forecasts for teakwood in girth-class 1 in Kerala**



**Fig. 8.2 Price forecasts for teakwood in girth-class 2 in Kerala**



**Fig. 8.3 Price forecasts for teakwood in girth-class 3 in Kerala**



The price forecasts for teak logs in girth-class 1, 2 and 3 for the year 2014-15 at current prices are Rs. 87,000 per m<sup>3</sup> with 95% confidence limits from Rs 46,000 to Rs. 129,000 per m<sup>3</sup>, Rs. 69,000 per m<sup>3</sup> with limits from Rs. 40,000 to Rs. 98,000 per m<sup>3</sup> and Rs. 65,000 per m<sup>3</sup> with limits from Rs. 37,000 to Rs. 93,000 per m<sup>3</sup> respectively.

In this chapter, future prices of teakwood in girth-classes 1, 2 and 3 have been predicted for the years up to 2014-15 based on autoregressive integrated moving average models fitted using annual current prices from 1941-42 to 1993-94.

## CHAPTER 9

### FUTURE DEMAND, SUPPLY AND PRICE OF TEAKWOOD IN KERALA : A DISCUSSION

The supply-demand balance of teakwood in Kerala during the reference year 1987-88 is presented here. The future trends in the demand, supply and price of teakwood in Kerala in the medium-term and long-term are also discussed in this chapter.

#### 9.1 Demand and Supply in Kerala during 1987-88

The supply-demand balance of teakwood and other timbers in Kerala during the year 1987-88 is presented in Table 9.1. The internal supply (production) and internal demand (consumption) of

Table 9.1. Supply-demand balance of teakwood and other timbers in Kerala during 1987-88

(in '000 m<sup>3</sup> roundwood equivalent)

Timber	Internal supply			Internal demand	Net export
	Forest source	Non-forest sources	Total		
Teakwood	22	40	62	45	(+)17
Other timbers	261	1980	2241	2373	(-)132
Total timber	283	2020	2303	2418	(-)115

Source: Tables 3.4 and 4.5.

teakwood in Kerala during 1987-88 were 62,000 and 45,000 m<sup>3</sup> respectively with a net export of 17,000 m<sup>3</sup>, where the export and import of teakwood were 19,000 and 2,000 m<sup>3</sup> respectively. The internal supply and internal demand for other timbers in Kerala

during 1987-88 were 22,41,000 and 23,73,000 m<sup>3</sup> roundwood equivalent respectively, with a net import of 1,32,000 m<sup>3</sup>, where the import and export of other timbers were 1,88,000 and 56,000 m<sup>3</sup> respectively.

The analysis of supply-demand balance of other timbers in Kerala for the reference year 1987-88 reveals a net deficit of 1,32,000 m<sup>3</sup>. But the position of teakwood alone is found to be different. The internal supply of teakwood exceeded the internal demand by 17,000 m<sup>3</sup>. This surplus was the net export.

## **9.2. Future Demand, Supply and Price of Teakwood**

It is seen that prices of teakwood have increased substantially since 1976-77 (chapter 6) and the upward trend continues (chapter 8). The increase in price can dampen the demand and at the same time can make way for increased supply in the future. Trees, being slow growing crops, it is not possible to increase the timber production within a short period of time in response to the change in price. However, since the year 1990, several plantation companies have come up establishing large plantations of teak in farm and waste lands in and outside Kerala. Apart from this, teak growing in home-gardens has received a boost through the supply of seedling by the Kerala Social Forestry Project aided by the World Bank. In intensively cultivated areas, teak is planted along the boundaries of home-gardens. Whereas in areas like Palakkad District home-gardens are not intensively cultivated, teak trees are now densely planted. All these will result in increased supply of teakwood in the future. However, the increased production of teakwood can reach the market only after around 20 years, ie; say 2010-2015. Therefore, for assessing the future demand, supply and

price of teakwood in Kerala, two periods are adopted - the medium term (up to the year 2015) and the long-term (beyond 2015).

### 9.2.1. Future demand

To assess the future demand for teakwood, it is necessary to examine the trends in the demand in the household and industries sectors and for export. The future trend in the demand for teakwood will depend on the current pattern of use in various sectors and their determinants. The major component of the internal demand for teakwood is the rural household sector. An attempt has been made to identify the factors that influence the use of teakwood in rural households using the data collected during the sample survey<sup>1</sup> for the study by the author<sup>2</sup>. The variables considered are household income, household size, size of home-garden land holding, plinth area of the house constructed, number of rooms, source of timber, type of house, type of roof, etc. Separate data were available from the survey for households where timber was used for i) new house construction, ii) house repair or modification of house and iii) making furniture, fixtures and implements.  $V_N$ ,  $V_R$  and  $V_F$  represent the volume of teakwood used in the above three categories respectively. The multiple regression models that

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<sup>1</sup> Apart from the data on quantity of teakwood and other timbers used, information on source of timber such as own home-gardens, purchased from other home-gardens, purchased from saw-mills; price of timber if purchased, plinth area; type of house such as single or double storeyed and others; type of roof-frame made of i) bamboo and arecanutwood, ii) timber and iii) reinforced cement concrete; size of household, occupation of members, annual income, etc. pertaining to the sample households were also collected during the survey.

<sup>2</sup> Krishnankutty, C. N. (1990). *op.cit.*

describe the relationship of  $V_N$ ,  $V_R$  and  $V_F$  with the explanatory variables mentioned above are the following.

$$V_N = \rho_0 + \rho_1 HI + \rho_2 HS + \rho_3 SL + \rho_4 PA + \rho_5 NR + \rho_7 ST1 + \rho_8 ST2 + \rho_9 TH + \rho_{10} TR1 + \rho_{11} TR2 + \varepsilon_N \dots\dots\dots (9.1)$$

$$V_R = \tau_0 + \tau_1 HI + \tau_2 HS + \tau_3 SL + \tau_4 PA + \tau_5 NR + \tau_6 AH + \tau_7 ST1 + \tau_8 ST2 + \tau_9 TH + \tau_{10} TR1 + \tau_{11} TR2 + \varepsilon_R \dots\dots\dots (9.2)$$

$$V_F = v_0 + v_1 HI + v_2 HS + v_3 SL + v_4 PA + v_5 NR + v_6 AH + v_7 ST1 + v_8 ST2 + \varepsilon_F \dots\dots\dots (9.3)$$

where  $HI$  stands for the household annual income (Rs.);  $HS$ : household size;  $SL$  : size of home-garden land holding;  $PA$  : plinth area in  $m^2$ ;  $NR$ : number of rooms;  $AH$ : age of the old house in years;  $ST1$  and  $ST2$ : indicator variables for source of timber<sup>3</sup>;  $TH$ : indicator variable for type of house<sup>4</sup>;  $TR1$  and  $TR2$ : indicator variables for type of roof<sup>5</sup>;  $\varepsilon_N$ ,  $\varepsilon_R$  and  $\varepsilon_F$ : the random disturbance terms.

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<sup>3</sup> The different sources of timber are i) own home-garden, ii) purchased from other home-gardens and iii) purchased from sawmills or timber depots. The three levels of the source factor were modelled by two indicator variables  $ST1$  and  $ST2$  defined as  $ST1 = 1$ , if the source was own home-garden and  $ST1 = 0$ , otherwise;  $ST2 = 1$  if the source was purchased from other home-gardens and  $ST2 = 0$ , otherwise.

<sup>4</sup> Two types of house considered in this study were (i) single storeyed and (ii) double storeyed and others. The variable  $TH$  was defined for the type of house as  $TH = 1$  if the house was single storeyed and  $TH = 0$  otherwise.

<sup>5</sup> There are three categories of roof-frame made of i) bamboo and or arecanutwood ii) timber and iii) reinforced cement concrete. The three levels of the factor 'roof type' have been modelled by two indicator variables  $TR1$  and  $TR2$  defined as  $TR1 = 1$  if timber was used for roof,  $TR1 = 0$  otherwise;  $TR2 = 1$  if the roof was made of reinforced cement concrete and  $TR2 = 0$  otherwise.

The models (9.1), (9.2) and (9.3) have been estimated using step-wise regression procedure. None of the variables considered have statistically significant relationship with the volume of teakwood used in all the three models. The absence of any relationship could be due to either the non-use of teakwood or negligible quantities of use. To examine this, households where teakwood, even in very small quantities, was used were sorted. Out of the 262 new houses surveyed, only 23 households had used teakwood<sup>6</sup>. Even in the 23 households, the proportion of teakwood used in the total timber was quite negligible. Model 9.1 has been tried using the data for the 23 teakwood-using households. No statistical relationship has been found between the volume of teakwood used in new house construction and the other variables considered.

Taking the volume of all timbers  $V_N$  (*ALL TIMBERS*) as regressand and using the step-wise regression procedure, the model of the form 9.1 has been estimated and it is given below.

$$V(\text{ALL TIMBERS})_N = 3.5258^{**} - 2.2206^{*}TH + 0.0044^{**}SL, \dots\dots\dots(9.4)$$

(0.40)            (0.41)            (0.001)

$$\text{Adj. } R^2 = 0.76^{**}, n = 23$$

It is seen that the type of house and size of home-garden land holding influence the use of all timbers in the teakwood-using households. When the type of house is double storeyed, the use of all timber is higher. A step-wise regression analysis has been carried out for teakwood-using households for single and double storeyed new house separately. For the single storeyed new

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<sup>6</sup> The number of households where teakwood was used for house repair or addition to new house, and for making furniture, fixture etc. was very few.

houses, no relationship has been found. Only in the case of double storeyed new house, a relationship between teakwood-use and plinth area could be seen (model 9.5). But even there, the quantity of teakwood used is 0.002 m<sup>3</sup>/100 m<sup>2</sup> plinth area which is extremely small.

$$V_N = -0.0028 + 0.00002^{**}PA, \dots\dots\dots(9.5)$$

$$\text{Adj. } R^2 = 0.87^{**}, n = 13$$

The above analysis indicates that the quantity of teakwood-used in an average household is negligible. Apart from the double storeyed new houses where teakwood-use was higher, no other variables considered have any influence on the quantity of teakwood used.

An attempt has also been made to estimate a demand function for teakwood used in newly constructed houses in the rural household sector with the same data. The demand functions tried are for households (i) whose source of timber was own home-garden (ii) where timber was purchased from other home-gardens and (iii) where timber was purchased from saw-mills. The econometric model tried is

$$\ln V_N = \ln \omega_0 + \omega_1 \ln HI + \omega_2 \ln HS + \omega_3 \ln SL + \omega_4 \ln PA + \omega_5 \ln NR + \ln \varepsilon \dots\dots\dots (9.6)$$

where  $V_N$ ,  $HI$ ,  $HS$ ,  $SL$ ,  $PA$ ,  $NR$  are as defined earlier, 'ln' stands for the natural logarithm and  $\varepsilon$  the random disturbance term.

Besides the above model, another model including the term  $\ln P$ , where  $P$  represents the price of timber purchased from sawmill, has also been tried. Step-wise regression procedure has been employed

for variable selection and estimating the demand models. However, in all cases, no statistically significant relationships have been obtained.

As no reliable relationship for teakwood-use with the selected variables could be established, it is difficult to predict future demand for teakwood. The variables considered do not determine the present pattern of teakwood use nor they are sufficient to increase or decrease future demand for teakwood. While assessing the medium-term demand for teakwood in the household sector, it can be expected that the timber-use in the household sector will be reduced by adopting timber-saving technologies. Timber-saving technologies are being popularised by government agencies such as COSTFORD and *Nirmithi Kendras*. Changes in the energy scenario have also affected timber-use in agriculture. Teak water-wheels, for regulating irrigation water in paddy fields, have been replaced by electric or diesel pumps. Moreover, the increase in price of teakwood also reduces the future demand for teakwood in the household sector. Teak being a valuable and durable timber, increase in population and economic development will act to make up the short-fall in future demand. Therefore, future demand for teakwood in the household sector is expected to continue unchanged.

In the furniture industry, the competition from cheaper non-wood furniture will reduce the demand for inferior wooden furniture. This may not affect teakwood demand in the furniture industry, since quality conscious customers will continue to buy teak furniture as it is also a status symbol. Furniture making in the household sector is bound to reduce, as the family structure is changing towards nuclear families where timber availability and working space are scarce. When round logs are to be purchased, it

is not attractive to make a few pieces of furniture as there are economies of scale. Further, the hassles of purchasing roundwood, sawing, transporting and engaging carpenters can be avoided by purchasing furniture from outside. A peculiar difficulty with teak is that, even when it is purchased from home-gardens, it requires permission for cutting from both the village officer and the forest range officer. Transporting teakwood to and from sawmills also requires transit pass issued by the forest range officer. This involves several visits to these offices and informal expenses. All these factors shift the household production of teakwood furniture and other articles to the organised furniture industry which has frequent contact with pass issuing officials. The net effect of the shift in production of teakwood-furniture in the household sector to furniture industry will not affect the overall demand. Only the location of production will change.

The declining trend in teakwood export to other states in India since 1989-90 can be seen in Appendix 5. Export of teakwood to other countries from Kerala, which was around 1800 m<sup>3</sup> annually during 1974-75 to 1976-77, has declined drastically. Since 1983-84, the export of teakwood to other countries has declined and has reached very negligible quantities since 1990-91 (Appendix 6).

### **9.2.2. Future Supply**

The different sources of supply of teakwood are home-gardens, forests and import. Among these, home-gardens accounted for 63% of the total supply during 1987-88. While assessing the future supply, the potential supply from home-gardens is the most important. To examine the potential supply, the growing stock of teak and other trees in the home-gardens has been analysed. Table

9.2 presents the number of trees in the growing stock in home-gardens during 1988-89 (see Appendix 30 for botanical names of trees in home-gardens). The estimated total number of trees is 44,21,65,000 of which trees below 10 cm dbh account for 43 per cent. When coconut palms were excluded, trees in the lowest diameter class come to 55 per cent of the total number. While trees above 30 cm dbh accounted for only 4 per cent of the total number, new plantings of trees (less than 10 cm dbh) other than coconut palms accounted for 55 per cent. These show that efforts are being made at the household level in planting of trees in home-gardens. The estimated commercial volume of trees was 2,85,26,000 m<sup>3</sup> underbark (Table 9.3). The preference for planting and maintaining different trees in the home-gardens can be seen in Tables 9.2 and 9.3. Among around the 100 tree species<sup>7</sup> identified during the survey of growing stock, teak stood eighth in the case of number of trees and seventh in the case of commercial volume accounting for 4.11% and 2.04% respectively.

Multipurpose trees such as coconut, jack, mango, cashew, etc. accounted for 71 per cent of the total number of trees and 83 per cent of the total commercial volume (Appendices 28 and 29). Also among trees above 60 cm dbh, trees providing multiple benefits constituted 74 per cent of the total number and 85 per cent of total commercial volume. These indicate the preference for planting and maintaining multipurpose trees. Such a marked preference for multipurpose trees is reported for every district of Kerala<sup>8</sup>. Timber and multipurpose trees in the high value classes contribute to the timber supply.

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<sup>7</sup> *Ibid.* The survey schedules were re-examined for this purpose.

<sup>8</sup> Krishnankutty, C. N. (1990). *op.cit.*

Table 9.2 Number of teak and other trees in the growing stock in home-gardens of Kerala during 1988-89

(number in '000)

Trees	Diameter at breast height in cm.									Total (%)
	<10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	>80	
Coconut (CO)	-	-	94920	-	-	-	-	-	-	94920 (21.47)
<i>Murikku</i> (M4)	30434	13034	2053	287	58	30	0	0	0	45896 (10.38)
Cashew (M4)	14700	15109	8207	1959	857	155	116	21	0	41124 (9.30)
Mango (M3)	13641	10168	4672	1983	961	445	190	56	98	32214 (7.29)
Jack (M2)	11549	8624	5837	3146	1699	939	195	67	50	32106 (7.26)
<i>Vatta</i> (M4)	17999	7362	899	89	12	5	0	0	0	26366 (5.96)
<i>Matty</i> (T4)	13240	4658	356	114	25	17	11	0	0	18421 (4.17)
<b>Teak (T1)</b>	<b>11776</b>	<b>4638</b>	<b>1368</b>	<b>262</b>	<b>112</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>18160 (4.11)</b>
<i>Anjily</i> (T2)	4132	2415	1672	892	480	369	109	14	0	10083 (2.28)
Tamarind (M3)	4040	1454	730	314	155	71	26	14	1	6805 (1.54)
Bombax (T4)	2122	2081	757	157	55	7	7	0	0	5186 (1.17)
<i>Vaka</i> (T2)	1645	688	232	63	9	9	0	0	0	2646 (0.60)
Rosewood (T1)	1226	811	341	113	36	11	0	0	5	2543 (0.58)
<i>Maruthu</i> (T2)	521	1276	504	96	15	14	0	0	0	2426 (0.55)
<i>Pala</i> (T4)	788	561	158	51	14	18	0	4	8	1602 (0.36)
<i>Kudappuly</i> (M3)	702	370	202	127	25	27	0	0	0	1453 (0.33)
<i>Irul</i> (T2)	656	534	119	37	4	9	4	0	0	1363 (0.31)
<i>Thanni</i> (T2)	212	386	166	26	11	0	0	0	0	801 (0.18)
Other trees	60333	29175	6472	1463	345	198	37	9	18	98050 (22.16)
Total	189716	103344	129665	11179	4873	2328	695	185	180	442165
(%)	(42.91)	(23.37)	(29.32)	(2.53)	(1.10)	(0.53)	(0.16)	(0.04)	(0.04)	100.00

Source: Re-worked from Krishnankutty, C. N. (1990). *op.cit.*

Table 9.3. Commercial volume of teak and other trees in the growing stock in home gardens of Kerala during 1988-89

(Volume in '000 m<sup>3</sup> underbark)

Trees	Diameter at breast height (in cm)							Total	(% )
	20-30	30-40	40-50	50-60	60-70	70-80	>80		
Coconut(CO)	6834	0	0	0	0	0	0	6834	23.96
Jack(M2)	817	1605	1767	1586	477	222	236	6710	23.52
Mango(M3)	654	1011	1000	752	464	185	435	4501	15.78
Cashew(M4)	1313	999	788	212	216	50	0	3578	12.54
Anjily(T2)	200	187	221	306	150	14	22	1100	3.86
Tamarind(M3)	117	160	142	97	48	34	6	604	2.12
<b>Teak(T1)</b>	<b>369</b>	<b>118</b>	<b>91</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>583</b>	<b>2.04</b>
Murikku(M4)	329	146	53	41	0	0	0	569	1.99
Bombax(T4)	121	80	51	9	13	0	0	274	0.96
Vatta(M4)	144	45	12	6	0	0	0	207	0.73
Matty(T4)	50	58	26	29	27	0	0	190	0.67
Kudappuly(M3)	28	65	27	46	0	0	0	166	0.58
Maruthu(T2)	81	32	10	16	0	0	0	139	0.49
Pala(T4)	25	26	13	25	9	23	0	121	0.42
Rosewood(T1)	37	26	21	13	0	0	20	117	0.41
Vaka(T2)	37	32	9	13	0	0	0	91	0.32
Irul(T2)	17	14	3	10	8	0	0	52	0.18
Thanni(T2)	27	13	11	0	0	0	0	51	0.18
Other trees	1022	789	347	324	71	30	56	2639	9.25
Total	12222	5406	4592	3490	1483	558	775	28526	
(%)	42.85	18.95	16.10	12.23	5.20	1.95	2.72		100.00

Source. Re-worked from Krishnankutty, C. N. (1990). *op. cit.*

Table 9.4 presents the pattern of growing stock distribution of teak and important trees with high value timber in the home gardens of Kerala. The data shows the preference for different trees

Table 9.4 Pattern of growing stock distribution of teak and other high value timber trees in home-gardens of Kerala during 1988-89

Trees	Growing stock			
	Number (in '000)	% to total	Volume (in '000m <sup>3</sup> underbark)	% to total
Jack	32,106	45.8	6,710	75.9
<i>Anjily</i>	10,083	14.4	1,100	12.4
<b>Teak</b>	<b>18,160</b>	<b>25.9</b>	<b>583</b>	<b>6.6</b>
<i>Maruthu</i>	2,426	3.5	139	1.6
Rosewood	2,543	3.6	117	1.3
<i>Vaka</i>	2,646	3.8	91	1.0
<i>Irul</i>	1,363	1.9	52	0.6
<i>Thanni</i>	801	1.1	51	0.6
<b>Total</b>	<b>70,128</b>	<b>100.00</b>	<b>8,843</b>	<b>100.00</b>

Source. Re-worked from Krishnankutty, C. N. (1990). *op. cit.*

for maintaining in home-gardens by households. Just 8 species accounted for 20 per cent of total number and 41 per cent of the commercial timber volume of trees excluding coconut palms in home-gardens. Among the species, the prominent position of jack is clearly seen. Jack produces premium timber for construction and furniture. *Anjily*, which provides a long straight bole, is used for construction, truck and boat body-building, etc. Considering all diameter classes together, the growing stock of teak in home-gardens has been estimated as 1,81,60,000 numbers. The

commercial volume (>60 cm girth overbark) of teak in the growing stock in home-gardens has been estimated as 5,83,000 m<sup>3</sup> underbark. This is the potential supply base of teakwood from home-gardens of Kerala.

It is interesting to note that while jack, mango and *anjily* are present in all the diameter classes, teak is seen only in diameter classes up to 60 cm. The large number of teak in the lowest diameter class may be due to the greater availability of teak seedlings in the recent years. This can be felled and made available in the market only after a minimum period of 25 years. In the medium term, it is assessed that the current levels of production from the home-gardens will continue at the same level, whereas in the long-term supply of teakwood from home-gardens will increase considerably.

From the estate sector consisting of rubber, cardamom, coffee and tea plantations, no teakwood supply is expected. The area under teak plantations in the forests of Kerala is 1100 km<sup>2</sup> including 351 km<sup>2</sup> of teak mixed with other species. Of these, nearly 70% are less than 30 years of age<sup>9</sup>. These will come of rotation age and be ready for final felling only after the year 2015. That is the long-term supply from forests will increase substantially. In the medium term, the current production level is likely to increase slightly. However due to the stopping of selective felling and land clearance for non-forestry purposes, the supply of teakwood from natural forests will be substantially reduced. Therefore, it is assessed that in the medium-term the current level of teakwood production from

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<sup>9</sup> Jayaraman, K. and Krishnankutty, C. N. (1990). *Data bank for forestry sector in Kerala*. KFRI Research Report No. 66, Kerala Forest Research Institute, Peechi.

the forests will continue unchanged considering the cumulative effect of both the factors.

The trend in teakwood import is shown in Appendix 7. It can be seen that the average import per year during the period from 1984-85 to 1993-94 was 1256 m<sup>3</sup>. It is assumed to remain more or less at the same level in the medium-term and decline after the year 2015 when the currently young teak plantations of the forest department and teakwood from other non-forest sources come to the market in large quantities.

### **9.2.3 Future prices**

#### **Medium-term**

The assessment of future demand in different sectors and future supply from various sources indicate that the current levels in demand and supply will continue unchanged in the medium term. Using the ARIMA model, future prices have been forecasted and it is given in Tables 8.5, 8.6 and 8.7. The increasing trend seen during the period since 1976-77 will continue in the medium-term.

#### **Long-term**

In the long-term, supply will increase as extensive young plantations of the Kerala Forest Department will be matured for felling. Larger supplies of teak from the home-gardens and from private plantations will also reach the market. The trend in liberalisation of the economy since 1990 is bound to continue. High quality timber such as Myanmar teak<sup>10</sup> will flow into the

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<sup>10</sup> It was observed from entries in the registers maintained at the inter-state border forest check-posts that Myanmar teak is already coming to Kerala through Manglore Port.

country at competitive rate in the absence of trade barriers. In the long term, the demand trend is expected to continue unchanged. It is, therefore, expected that the price will decline in the long-term.

In this chapter, the demand-supply balance of teakwood and that of other timbers in Kerala for the reference year 1987-88 has been presented. The internal demand was 45,000 m<sup>3</sup>, while the production from forests and non-forest sources within Kerala was 62,000 m<sup>3</sup>. The surplus of 17,000 m<sup>3</sup> of teakwood was the net export. Whereas the analysis of supply-demand balance of other timbers has shown a net deficit of 1,32,000 m<sup>3</sup> which was the net import. The assessment of future demand and supply of teakwood in Kerala indicates that the future demand in the medium-term as well as in the long-term is expected to remain unchanged at the current level. The future supply will continue at the current level in the medium-term, while in the long-term it is expected to increase substantially. The future prices are, therefore, predicted to be on the increase in the medium-term and to be on the decline in the long-term.

## CHAPTER 10

### SUMMARY AND CONCLUSION

Teakwood has been an important export item from the forests of Kerala from very early times. In India, teak plantations were initiated in Nilambur in Kerala in the year 1842. At present, teak occupies more than half of the area under forest plantations in the state and teak has received the highest investment among different forest plantation crops. Teakwood, available from forests and non-forest sources in Kerala, has been in use in different sectors for various purposes. Estimates of sector-wise demand as well as source-wise supply of teakwood and its share in the total supply of all timbers in Kerala during the reference year 1987-88 and the results of the price analysis are summarised here. Future trends in the demand, supply and price of teakwood in Kerala are also indicated.

The study reveals that the effective demand for teakwood in Kerala during the year 1987-88 was 64,000 m<sup>3</sup> roundwood equivalent. The household sector accounted for the major share (39%) of the demand for teakwood, followed by export (30%). Demand for teakwood for furniture making in the industries sector was also substantial.

Of the supply of teakwood from forests and different non-forest sources in Kerala during the year 1987-88, supply from home-gardens was about double of that from forests. The supply through import from other states in India and from other countries was only 3 per cent of the total supply of teakwood.

The share of teakwood in the total supply of all timbers in Kerala during the year 1987-88 was only 2.6 per cent of the

estimated total supply of 24,93,000 m<sup>3</sup> roundwood equivalent. When wood of coconut, rubber and eucalypts are excluded from the estimate of total timber supply, the share of teakwood rises to 6 per cent, while the corresponding shares of jackwood and *anjily* used in the rural household sector alone come to 25% and 7% respectively. Nevertheless, the total value of teakwood used in all the sectors is higher than any of the other timbers except jackwood.

The analysis of supply-demand balance of teakwood in Kerala for the reference year 1987-88 shows that the production from forests and non-forest sources in Kerala was 62,000 m<sup>3</sup>, while the internal demand was 45,000 m<sup>3</sup>. The surplus of 17,000 m<sup>3</sup> was the net export, where the export and import of teakwood were 19,000 and 2,000 m<sup>3</sup> respectively. But the analysis of supply-demand balance of other timbers reveals a net deficit of 1,32,000 m<sup>3</sup> which was the net import, where the export and import of other timbers were 56,000 and 1,88,000 m<sup>3</sup> respectively.

The price of teakwood sold in monthly auctions in the government depots were examined taking into account the prices obtained for different lots, the preference of the buyers and also the competition among bidders. The number of bidders, their current requirements, their stock, the quantity put up for auction, the stock at the depot and their expectation on future prices, all seem to influence the price of teakwood.

Analysis of determinants of price of individual teakwood lot sold in auction in the depots shows that among the variables such as number of logs in the lot, mean girth, mean volume and mean length of logs in lots of different quality-classes, girth and quality are the important factors. Other things remaining the same, higher

girth of logs allows wider planks to be sawn and provides a higher out-turn of timber. That is, the higher is the girth of log, higher the price it commands. Likewise when the girth classes are the same, a higher quality class of logs fetches a higher price.

It was observed that there was variation in the prices of teakwood in different regions in Kerala in certain years. However, the variation in price between regions over time was not statistically significant.

The analysis of annual real prices of teakwood in different girth-classes and selected timbers during the period from 1956-57 to 1993-94 based on moving averages, shows that the overall trend is more or less similar for all timbers.

Among different trend models tried, the best fitting model identified for real prices of teak logs in different girth-classes and other timbers is the linear spline model with three knots. The price behaviour in each of the four periods from 1956-57 to 1968-69, 1969-70 to 1976-77, 1977-78 to 1983-84 and from 1984-85 to 1993-94 has been analysed based on the fitted linear spline model. In the first period before 1968-69, the real prices declined for all girth classes. In the other three periods, the prices have increased. During the period from 1969-70 to 1976-77, the rate of increase was moderate whereas the rate of increase was drastic during the period from 1977-78 to 1983-84. In the period from 1984-85 to 1993-94, although prices increased, the rate of increase was lower than that in the preceding period.

Price behaviour of selected timbers has been compared with that of teakwood (girth-classes combined). The price trends of all timbers showed similar behaviour from 1956-57 to 1983-84. In the period from 1984-85 to 1993-94, while the price of teakwood

continued to increase, the prices of most of the other timbers declined.

The inter-class price analysis for teaklogs in different girth-classes shows that the price of logs in a girth-class is related to the prices of logs in the proximate girth-classes. In relation with other timbers, teakwood price is not related to the prices of other timbers. Also, it has been found that teakwood price is not related to the total quantity of teakwood sold through all the government depots in Kerala together.

Teakwood price during a year is closely related to the price in the preceding year. This conforms to the fact that the auction price in a particular month is dependent on the preceding month's price due to the procedure adopted for auction confirmation. Therefore, the relationship between current year's real price and preceding year's real price is a reflection of the successive dependence of monthly auction prices.

Teakwood price is not related to the current year's production from forests, but related to one or two year lagged production. However, the two-year lagged production has only little influence on price. For the teakwood to be sold in auction in government depots, there exists a time lag for transporting logs from the forests or plantations to the depots and for classifying logs according to dimension, grouping into lots as well as auction procedure. This is the reason for the relationship between price and lagged production.

Internal demand for teakwood is highest in the rural household sector. The influence of internal demand on the prices of teakwood is negligible, perhaps due to the fact that teakwood-use among all timbers is very low. The other component of demand is

export. Although, the price of teakwood in the external market is likely to influence the teakwood prices in Kerala, in the analysis, no statistically significant relation was seen between teakwood price and the quantity of teakwood exported.

Based on annual current prices of teakwood in girth-classes 1, 2 and 3, during the period from 1941-42 to 1993-94, autoregressive integrated moving average (ARIMA) models have been built. Using the best fitting models, prices of teakwood in different girth classes have been predicted up to the year 2014-15 with 95% confidence limits. The price forecasts for the year 2014-15 at current prices for teakwood in girth-classes 1,2 and 3 are Rs. 87,000, Rs. 69,000 and Rs. 65,000 per m<sup>3</sup> respectively.

The assessment of future demand, supply and price of teakwood in Kerala indicates that the future demand in the medium-term as well as in the long-term is expected to remain unchanged at the current level. The future supply will continue at the current level in the medium-term, while in the long-term it is expected to increase substantially. The future prices of teakwood are, therefore, predicted to be on the increase in the medium-term and to be on the decline in the long-term.

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## LIST OF APPENDICES

No.	Title	Page
1	Criteria for classification of teakwood and other timbers followed by the Kerala Forest Department	175
2	List of government timber depots	176
3	List of sample villages selected for the survey	177
4	List of forest check-posts, railway stations, ports for import-export data	178
5	Export of teakwood and other timbers from Kerala to other states in India through 5 major inter-state forest check-posts from 1980-81 to 1993-94	179
6	Export of teakwood and other timbers from Kerala to other countries through Cochin Port from 1971-72 to 1992-93	180
7	Pattern of timber-use (in roundwood equivalent) in rural household sector of Kerala during the year 1987-88	181
8	Import of teakwood and other timbers to Kerala through 5 major inter-state forest check-posts from 1980-81 to 1993-94	182
9	Average current and real prices of teak logs in girth-class <i>E</i> and different quality classes in Kerala during the period from 1975-76 to 1993-94	183

No.	Title	Page
10	Average current and real prices of teak logs in girth-class 1 and different quality classes in Kerala during the period from 1975-76 to 1993-94	184
11	Average current and real prices of teak logs in girth-class 2 and different quality classes in Kerala during the period from 1975-76 to 1993-94	185
12	Average current and real prices of teak logs in girth-class 3 and different quality classes in Kerala during the period from 1975-76 to 1993-94	186
13	Average current and real prices of teak logs in girth-class 4 and different quality classes in Kerala during the period from 1975-76 to 1993-94	187
14	Average current prices of teak logs in girth-class <i>E</i> in different regions in Kerala during the period from 1975-76 to 1993-94	188
15	Average current prices of teak logs in girth-class 1 in different regions in Kerala during the period from 1975-76 to 1993-94	189
16	Average current prices of teak logs in girth-class 2 in different regions in Kerala during the period from 1975-76 to 1993-94	190
17	Average current prices of teak logs in girth-class 3 in different regions in Kerala during the period from 1975-76 to 1993-94	191

No.	Title	Page
18	Average current prices of teak logs in girth-class 4 in different regions in Kerala during the period from 1975-76 to 1993-94	192
19	Average current prices of teak logs (girth-classes combined) in different regions in Kerala during the period from 1975-76 to 1993-94	193
20	Average real prices of teakwood (girth-classes combined in different regions in Kerala during the period from 1975-76 to 1993-94	194
21	Production of teakwood from forests in different regions in Kerala during the period from 1956-57 to 1992-93	195
22	Average current prices of teak logs in different girth-classes in Kerala during the period from 1956-57 to 1993-94	196
22.1	Average current prices of teak logs in different girth-classes in Kerala during the period from 1941-42 to 1955-56	197
23	Average real prices of teak logs in different girth-classes in Kerala during the period from 1956-57 to 1993-94	198
24	Average current prices of selected timbers in Kerala during the period from 1956-57 to 1993-94	199

No.	Title	Page
25	Average real prices of selected timbers in Kerala during the period from 1956-57 to 1993-94	200
26	Quantity of teakwood and selected timbers sold through all the government timber depots during the period from 1956-57 to 1992-93	201
27	Timber production from the forests of Kerala and Tamil Nadu	202
28	Number of trees in the growing stock in home gardens of Kerala during the year 1988-89	203
29	Commercial volume of growing stock of trees in home gardens of Kerala during the year 1988-89	204
30	Local and botanical names of trees in home gardens of Kerala	205-206

## Appendix 1

### Criteria for classification of teakwood and other timbers followed by the Kerala Forest Department

#### 1. Girth classification :

Timber	Girth-class	Middle girth(in cm)
Teakwood	Export* ( <i>E</i> )	185 and above
	1	150 - 184
	2	100 - 149
	3	75 - 99
	4	60 - 74
Other species	1	125 and above
	2	upto 124

\* In this study, girth-class 'Export' is referred as *E*.

#### 2. Length classification :

Timber	Length-class	Length (in m)
Teakwood	SL (short log)	Above 1 and below 2.5
	LL (lengthy log)	Above 2.5 - 7.3
	LLL (long lengthy log)	Above 7.3
	Other* species	LL (lengthy log)

\* There is no classification of short and long lengthy logs.

#### 3. Quality specification :

Teakwood	<b>A class</b> : Logs straight and sound without any defect. <b>B class</b> : Fairly straight and sound logs. <b>C class</b> : Defective and crooked logs.
Other species	<b>A class</b> : Straight and sound logs. <b>B class</b> : Defective logs.

## Appendix 2

### List of government timber depots

Southern Forest Circle	Central Forest Circle **	Northern Forest Circle
1. Achencoil *	1. Chalakkudy *	1. Aruvacode *
2. Angamoozhi	2. Kothamangalam	2. Bavali *
3. Areekkakavu*	3. Kumily *	3. Chaliyam *
4. Arienkavu *	4. Mudickal *	4. Kannothe
5. Kadakkamon*	5. Parampuzha*	5. Kuppadi*
6. Konni*	6. Thalakode *	6. Mysore*
7. Kulathuputha *	7. Veetoor *	7. Nanjangode *
8. Pathanapuram *	8. Vettikkad*	8. Nedumgayam *
9. Thenmala *		
10. Veeyapuram *		

\* Timber depots selected for the study

\*\* Includes depots belonging to High Range Circle.

## Appendix 3

### **List of sample villages selected for the survey**

Villages selected for the sample surveyes for the study on 'demand and supply of wood in Kerala and their future trends'<sup>1</sup> for the estimation of growing stock of teak and other trees in home-gardens and estimation of quantity of timber used in building construction and by unregistered industrial units were the following : Karumkulam and Karakulam in Thiruvananthapuram District, Kalluvathukkal and Kulathupuzha in Kollam District, Pramadam in Pathanamthitta District, Ramankary in Alappuzha District, Vellavoor and Melukavu in Kottayam District, Elappara, Konnathady and Kodikulam in Idukki District, Maneed and Parakkadavu in Ernakulam District, Mattathur, Chenthrappini, Koorkanchery and Peringandoor in Thrissur District, Elavanchery, Ambalappara-1 and Anakkara in Palakkad District, Angadippuram and Pulikkal in Malappuram District, Unnikulam and Vanimel in Kozhikode District, Vengappally and Thavinjal in Wayanad District, Edakkad and Pariyaram in Kannur District, Karindalam and Meenja in Kasargod District.

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<sup>1</sup> Krishnankutty, C. N. (1990). *op.cit.*

## Appendix 4

### **List of forest check-posts, railway stations, ports for import-export data.**

For estimating the quantity of teakwood and other timbers imported and exported, registers maintained at the following check-posts, railway stations and offices were referred to for the study on 'demand and supply of wood in Kerala and their future trends'<sup>1</sup>.

Forest check-posts : Kotekar, Ukkuda, Jalsur, Iritty, Muthanga, Noolpuzha, Tholpetty, Vazhikadavu, Walayar, Vaniyampara, Parambikulam, Kumily, Achencovil, Arienkavu and Parasala.

Railway Stations : Kallai, Thrissur, Chalakkudy, Aluva and Ernakulam.

Ports : Cochin and Calicut Chambers of Commerce and Industry.

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<sup>1</sup> Krishnankutty, C. N. (1990). *op.cit.*

## Appendix 5

### Export of teakwood and other timbers from Kerala to other states in India through 5 major inter-state forest check-posts from 1980-81 to 1993-94

(Quantity in m<sup>3</sup> roundwood equivalent)

Year	Timber <sup>1</sup>				Rubber-wood and others <sup>2</sup>	Total
	Teakwood	Rosewood	Other timbers	Total		
	(1)	(2)	(3)	(4)		
1980-81	9758	163	26039	35960	221528	257488
1981-82	10856	222	22352	33430	231948	265378
1982-83	6925	257	22651	29833	261381	291214
1983-84	9208	59	28073	37340	220188	257528
1984-85	15305	135	23920	39360	246317	285677
1985-86	25209	132	22958	48299	307797	356096
1986-87	12379	363	16486	29228	304010	333238
1987-88	11235	126	13386	24747	351015	375762
1988-89	18821	219	22608	41648	223076	264724
1989-90	25215	319	13882	39416	244761	284177
1990-91	21791	185	11496	33472	235868	269340
1991-92	23205	160	21759	45124	234011	279135
1992-93	18420	215	16356	34991	268192	303183
1993-94	14434	125	24453	39012	242911	281923

<sup>1</sup> Includes sawn timber which was converted into roundwood equivalent using the conversion factor 1 m<sup>3</sup> of sawn timber equals 1.33 m<sup>3</sup> of roundwood and does not include wood-products like packing case, veneers, plywood, etc.

<sup>2</sup> This mainly includes packing cases of rubberwood, mangowood, etc. and sawn timber of other species also.

Source : Compiled from the registers maintained at the forest check posts at Kotekar, Vazhikadavu, Walayar, Vaniyampara and Arienkavu.

## Appendix 6

### **Export of teakwood and other timbers from Kerala to other countries through Cochin Port from 1971-72 to 1992-93**

(Quantity in m<sup>3</sup>)

Year	Teakwood	Rosewood	Other timbers	Total
1971-72	45	220,912	147	21,104
1972-73	73	25,721	173	25,967
1973-74	437	24,438	839	25,714
1974-75	2,015	8,835	1,110	11,960
1974-76	1,923	6,077	744	8,744
1976-77	1,444	18,633	2,709	22,786
1977-78	566	10,190	654	11,410
1978-79	142	2,929	368	3,439
1979-80	244	4,182	797	5,223
1980-81	190	2,717	247	3,154
1981-82	153	2,172	444	2,769
1982-83	120	1,522	688	2,330
1983-84	66	1,900	97	2,063
1984-85	112	1,397	288	1,797
1985-86	110	1,213	748	2,071
1986-87	62	1,577	238	1,877
1987-88	28	1,500	223	1,751
1988-89	41	1,355	258	1,654
1989-90	63	1,326	488	1,877
1990-91	2	1,221	179	1,402
1991-92	4	969	269	1,242
1992-93	19	745	195	959

Source : Compiled from the Annual Reports (various issues) of Cochin Chamber of Commerce and Industry.

Appendix 7

**Pattern of timber-use (in roundwood equivalent) in rural household sector of Kerala during the year 1987-88**

(Volume in m<sup>3</sup> roundwood)

Timber	Door frame and windows	Doors and shutters	Roof and ceiling	Other uses*	Total
Teakwood	8375 (0.9)	2806 (0.2)	9615 (1.0)	2051 (0.2)	22847 (2.3)
Jackwood	93856 (9.4)	42138 (4.2)	114803 (11.6)	14191 (1.4)	264988 (26.6)
Coconut-wood	5176 (0.6)	3553 (0.3)	452377 (45.4)	8663 (0.9)	469769 (47.2)
<i>Anjily</i>	24953 (2.5)	8576 (0.9)	41030 (4.1)	3041 (0.3)	77600 (7.8)
<i>Irul</i>	4459 (0.4)	410 (0.1)	2924 (0.3)	24 (0.00)	7817 (0.8)
Palmyra	156 (0.0)	97 (0.0)	7666 (0.8)	0 (0.00)	7919 (0.8)
Mango-wood	4787 (0.5)	13136 (1.3)	5256 (0.6)	1637 (0.1)	24816 (2.5)
<i>Maruthu</i>	722 (0.1)	199 (0.0)	2975 (0.3)	97 (0.0)	3993 (0.4)
Others	36596 (3.6)	9755 (1.0)	59601 (6.0)	10327 (1.0)	116279 (11.6)
<b>Total</b>	<b>179080 (18.0)</b>	<b>80670 (8.0)</b>	<b>696247 (70.1)</b>	<b>40031 (3.9)</b>	<b>996028 (100.00)</b>

\* Includes timber used for making furniture, fixtures, impliments, etc.

Source : Estimated from data collected through sample survey for Krishnankutty, C. N. (1990). *op. cit.*

## Appendix 8

### **Import of teakwood and other timbers to Kerala through 5 major inter-state forest check-posts from 1980-81 to 1993-94**

(Quantity in m<sup>3</sup> roundwood)

Year	Teakwood	Rosewood	Other timbers	Total
1980-81	159	838	27977	28974
1981-82	244	1683	29631	31558
1982-83	1308	1056	28490	30854
1983-84	165	866	31000	32031
1984-85	331	752	43153	44236
1985-86	447	363	45822	46632
1986-87	834	1507	94147	96488
1987-88	1105	1629	123354	126088
1988-89	3775	2969	105363	112107
1989-90	1239	1438	73391	76068
1990-91	851	1165	74510	76526
1991-92	448	2061	53727	56236
1992-93	1414	859	41637	43910
1993-94	2117	1033	30276	33426

Source : Compiled from the registers maintained at the forest check posts at Kotekar, Vazhikadavu, Walayar, Vaniyampara and Arienkavu.

Appendix 9

**Average current and real prices of teak logs in girth-class E and  
different quality-classes in Kerala during the period  
from 1975-76 to 1993-94**

(Price Rs. per m<sup>3</sup>)

Year	At current prices			In real prices		
	Quality-class			Quality-class		
	A	B	C	A	B	C
1975-76	1439	1039	1705	2340	1689	2772
1976-77	1189	1393	698	1893	2218	1111
1977-78	1998	1896	1528	3027	2873	2315
1978-79	2645	2580	2308	4008	3909	3497
1979-80	4844	3068	2921	6258	3964	3774
1980-81	5130	4118	4061	5607	4501	4438
1981-82	7401	4763	4115	7401	4763	4115
1982-83	8777	7535	4937	8555	7344	4812
1983-84	8502	6521	4378	7571	5807	3898
1984-85	8046	6946	4861	6688	5774	4041
1985-86	12647	8612	5833	9943	6770	4586
1986-87	13239	10337	6770	9887	7720	5056
1987-88	12914	10539	7301	8962	7314	5067
1988-89	10930	10826	8103	7065	6998	5238
1989-90	NA	9660	9364	NA	5830	5651
1990-91	15900	19614	12256	8703	10736	6708
1991-92	NA	24822	18132	NA	11945	8726
1992-93	36737	29194	20113	16063	12765	8794
1993-94	NA	31023	22297	NA	12519	8998

NA - Not available

Source: Current prices computed from the monthly auction files of the government timber depots. Real prices computed from the current prices.

Appendix 10

**Average current and real prices of teak logs in girth-class 1 and different quality-classes in Kerala during the period from 1975-76 to 1993-94**

(Price Rs. per m<sup>3</sup>)

Year	At current prices			In real prices		
	Quality-class			Quality-class		
	A	B	C	A	B	C
1975-76	1204	1479	1381	1958	2405	2246
1976-77	1720	1599	1308	2739	2546	2083
1977-78	1623	1664	1407	2459	2521	2132
1978-79	2840	2315	2199	4303	3508	3332
1979-80	4029	3498	2998	5205	4519	3873
1980-81	4976	3935	3615	5438	4301	3951
1981-82	7049	4618	4313	7049	4618	4313
1982-83	8284	6446	5134	8074	6283	5004
1983-84	7691	6266	4333	6849	5580	3858
1984-85	7988	6245	4814	6640	5191	4002
1985-86	10692	9731	5551	8406	7650	4364
1986-87	10894	9516	5780	8136	7107	4317
1987-88	9922	9857	9949	6885	6840	6904
1988-89	12392	9418	7131	8010	6088	4610
1989-90	14424	12956	9839	8705	7819	5938
1990-91	14169	15018	12190	7755	8220	6672
1991-92	20000	19189	14378	9625	9234	6919
1992-93	29651	23041	17745	12965	10075	7759
1993-94	28198	25978	19830	11379	10483	8002

Source : Current prices computed from the monthly auction files of the government timber depots. Real prices computed from the current prices.

Appendix 11

**Average current and real prices of teak logs in girth-class 2 and  
different quality-classes in Kerala during the period  
from 1975-76 to 1993-94**

(Price Rs. per m<sup>3</sup>)

Year	At current prices			In real prices		
	Quality-class			Quality-class		
	A	B	C	A	B	C
1975-76	1485	1369	1056	2415	2226	1717
1976-77	NA	1275	986	NA	2030	1570
1977-78	1319	1372	1103	1998	2079	1671
1978-79	2162	2145	1775	3276	3250	2689
1979-80	3339	2906	2497	4314	3755	3226
1980-81	3820	3053	2861	4175	3337	3127
1981-82	5330	3895	3615	5330	3895	3615
1982-83	7050	5984	4632	6871	5832	4515
1983-84	5937	5350	4323	5287	4764	3850
1984-85	6361	5654	5183	5288	4700	4308
1985-86	7654	6977	5388	6017	5485	4236
1986-87	9324	9111	6403	6963	6804	4782
1987-88	8991	8961	7490	6239	6219	5198
1988-89	10417	8847	6506	6734	5719	4206
1989-90	12983	11156	8542	7835	6733	5155
1990-91	12994	11718	9075	7112	6414	4967
1991-92	16026	14679	12008	7712	7064	5779
1992-93	20826	18648	13032	9106	8154	5698
1993-94	23217	20938	15388	9369	8450	6210

Source : Current prices computed from the monthly auction files of the government timber depots. Real prices computed from the current prices.

Appendix 12

**Average current and real prices of teak logs in girth-class 3 and  
different quality-classes in Kerala during the period  
from 1975-76 to 1993-94**

(Price Rs. per m<sup>3</sup>)

Year	At current prices			In real prices		
	Quality-class			Quality-class		
	A	B	C	A	B	C
1975-76	NA	1200	809	NA	1951	1315
1976-77	1303	1020	736	2075	1624	1172
1977-78	1048	1099	983	1588	1665	1489
1978-79	1817	1837	1626	2753	2783	2464
1979-80	2616	2330	1838	3380	3010	2375
1980-81	2771	2606	2190	3028	2848	2393
1981-82	3009	3190	2883	3009	3190	2883
1982-83	5117	4521	3892	4987	4406	3793
1983-84	3976	4221	3616	3541	3759	3220
1984-85	5828	5039	4382	4845	4189	3643
1985-86	6050	5635	4938	4756	4430	3882
1986-87	7504	7590	6460	5604	5668	4824
1987-88	7059	7134	6133	4899	4951	4256
1988-89	9111	7140	5782	5889	4615	3738
1989-90	NA	9907	7215	NA	5979	4354
1990-91	9729	9398	7612	5325	5144	4166
1991-92	9000	11139	9188	4331	5360	4422
1992-93	14233	13671	10028	6223	5978	4385
1993-94	NA	16621	12407	NA	6707	5007

Source: Current prices computed from the monthly auction files of the government timber depots. Real prices computed from the current prices.

Appendix 13

**Average current and real prices of teak logs in girth-class 4 and  
different quality-classes in Kerala during the period  
from 1975-76 to 1993-94**

(Price Rs. per m<sup>3</sup>)

Year	At current prices			In real prices		
	Quality-class			Quality-class		
	A	B	C	A	B	C
1975-76	NA	NA	571	NA	NA	928
1976-77	NA	1077	660	NA	1715	1051
1977-78	870	853	779	1318	1292	1180
1978-79	1901	1563	1326	2880	2368	2009
1979-80	1877	1847	3677	2425	2386	4751
1980-81	NA	1881	1759	NA	2056	1922
1981-82	NA	2653	2187	NA	2653	2187
1982-83	NA	3518	3124	NA	3429	3045
1983-84	NA	3131	2865	NA	2788	2551
1984-85	NA	3869	3767	NA	3216	3131
1985-86	NA	4324	4196	NA	3399	3299
1986-87	NA	5831	5263	NA	4355	3931
1987-88	7046	5338	5329	4890	3704	3698
1988-89	NA	5911	5600	NA	3821	3620
1989-90	NA	7625	6211	NA	4602	3748
1990-91	NA	7579	5912	NA	4148	3236
1991-92	NA	9335	7758	NA	4492	3733
1992-93	11149	10193	7799	4875	4457	3410
1993-94	NA	11839	9062	NA	4778	3657

Source: Current prices computed from the monthly auction files of the government timber depots. Real prices computed from the current prices.

Appendix 14

**Average current prices of teak logs in girth-class E in different regions  
in Kerala during the period from 1975-76 to 1993-94**

(At current prices in Rs. per m<sup>3</sup>)

Year	Southern	Central	Northern	Kerala
1975-76	1722	1374	1452	1435
1976-77	1460	1013	1541	1206
1977-78	1530	1393	1602	1506
1978-79	2486	2084	2611	2378
1979-80	3067	2749	3939	3057
1980-81	3876	4164	4257	4100
1981-82	4433	4649	4878	4575
1982-83	6870	6173	7465	6561
1983-84	6676	4835	6640	5361
1984-85	6687	5620	6721	6461
1985-86	8569	6322	7374	7468
1986-87	9522	7572	6257	8515
1987-88	9534	11472	7838	9647
1988-89	9946	6248	7283	9276
1989-90	9379	NA	11011	9442
1990-91	17450	12992	17903	16556
1991-92	20655	19111	22058	20475
1992-93	22847	25848	30300	23131
1993-94	25137	22810	18652	24034

Source : Computed from the monthly auction files of the government timber depots located in different regions in Kerala.

Appendix 15

**Average current prices of teak logs in girth-class 1 in different regions in Kerala during the period from 1975-76 to 1993-94**

(At current prices in Rs. per m<sup>3</sup>)

Year	Southern	Central	Northern	Kerala
1975-76	1408	1215	1423	1367
1976-77	1291	894	1456	1275
1977-78	1392	1259	1459	1406
1978-79	2133	1926	2423	2237
1979-80	3414	2758	3419	3340
1980-81	3609	3779	3833	3750
1981-82	4348	4336	4701	4490
1982-83	6351	5200	6974	6096
1983-84	6374	4568	6132	5641
1984-85	5906	5519	7147	6026
1985-86	10519	6823	6995	8417
1986-87	9581	6175	8884	8141
1987-88	9191	7679	12192	9754
1988-89	9058	4393	8324	8609
1989-90	11836	13645	11824	11954
1990-91	12652	14221	14411	13865
1991-92	15834	19215	17004	17295
1992-93	21969	21507	19979	21450
1993-94	22523	21028	26168	23516

Source : Computed from the monthly auction files of the government timber depots located in different regions in Kerala.

Appendix 16

**Average current prices of teak logs in girth-class 2 in different regions in Kerala during the period from 1975-76 to 1993-94**

(At current prices in Rs. per m<sup>3</sup>)

Year	Southern	Central	Northern	Kerala
1975-76	1242	1036	1226	1197
1976-77	1055	899	1129	1076
1977-78	1165	952	1198	1163
1978-79	1816	1555	2186	2009
1979-80	2749	3100	2717	2757
1980-81	2982	2831	2954	2946
1981-82	3861	3477	3932	3770
1982-83	5814	5416	5665	5596
1983-84	5563	4567	5272	5176
1984-85	5085	5742	6067	5595
1985-86	6812	6917	6584	6751
1986-87	8397	7461	9101	8624
1987-88	8090	8493	8990	8757
1988-89	8304	5305	8264	8225
1989-90	10302	11120	11554	10921
1990-91	10620	11421	11494	11115
1991-92	13152	14581	14214	14110
1992-93	16375	16535	19817	17178
1993-94	17249	18617	21499	18986

Source : Computed from the monthly auction files of the government timber depots located in different regions in Kerala.

Appendix 17

**Average current prices of teak logs in girth-class 3 in different regions in Kerala during the period from 1975-76 to 1993-94**

(At current prices in Rs. per m<sup>3</sup>)

Year	Southern	Central	Northern	Kerala
1975-76	871	782	1068	1030
1976-77	812	820	839	833
1977-78	622	809	1004	921
1978-79	1553	1245	1749	1700
1979-80	2278	1945	2026	2105
1980-81	2388	2452	2344	2374
1981-82	2809	2879	3102	2992
1982-83	4028	4325	4468	4312
1983-84	4208	3774	4187	4072
1984-85	3952	4664	5104	4905
1985-86	5298	5494	5568	5480
1986-87	6570	6664	7539	7327
1987-88	5237	6807	7601	7002
1988-89	5954	5778	7365	6847
1989-90	7491	8895	11960	9630
1990-91	7650	8903	9564	8956
1991-92	9557	10280	11215	10633
1992-93	10840	11565	14696	12572
1993-94	12873	13926	18062	14784

Source : Computed from the monthly auction files of the government timber depots located in different regions in Kerala.

Appendix 18

**Average current prices of teak logs in girth-class 4 in different regions in Kerala during the period from 1975-76 to 1993-94**

(At current prices in Rs. per m<sup>3</sup>)

Year	Southern	Central	Northern	Kerala
1975-76	673	727	773	768
1976-77	616	626	766	751
1977-78	697	697	867	855
1978-79	1253	1049	1441	1431
1979-80	3586	1403	1667	1873
1980-81	1909	1787	1805	1826
1981-82	2410	2377	2420	2404
1982-83	3439	3112	3579	3284
1983-84	3300	2825	3060	3000
1984-85	3384	3741	3638	3646
1985-86	3896	4428	4503	4386
1986-87	4854	5635	5444	5450
1987-88	4989	5065	5372	5271
1988-89	5780	4485	5749	5702
1989-90	6036	7171	7786	7357
1990-91	6371	6681	7052	6886
1991-92	7107	7583	9411	8786
1992-93	7831	7975	10319	9162
1993-94	9910	9491	11860	10375

Source : Computed from the monthly auction files of the government timber depots located in different regions in Kerala.

Appendix 19

**Average current prices of teak logs (girth-classes combined) in different regions in Kerala during the period from 1975-76 to 1993-94**

(At current prices in Rs. per m<sup>3</sup>)

Year	Southern	Central	Northern	Kerala
1975-76	1304	1246	1193	1221
1976-77	1094	914	1091	1052
1977-78	1146	1155	1174	1166
1978-79	1985	1820	2013	1980
1979-80	2904	2777	2440	2667
1980-81	3097	3041	3103	3092
1981-82	4029	3390	3680	3670
1982-83	5513	4907	5322	5180
1983-84	5278	4132	4358	4527
1984-85	5493	5031	4913	5107
1985-86	6293	6232	5495	5873
1986-87	8449	6870	7510	7508
1987-88	7199	6765	7740	7476
1988-89	7299	5305	7325	7251
1989-90	8413	9259	10308	9432
1990-91	9062	9318	9418	9299
1991-92	10367	11450	11624	11352
1992-93	13235	12405	14012	13326
1993-94	15133	14595	18246	15859

Source : Computed from monthly auction files of the government timber depots located in different regions in Kerala.

Appendix 20

**Average real prices of teakwood (girth-classes combined in different regions in Kerala during the period from 1975-76 to 1993-94**

(Real prices in Rs. per m<sup>3</sup>)

Year	Southern	Central	Northern	Kerala
1975-76	2120	2026	1940	1985
1976-77	1742	1455	1737	1675
1977-78	1736	1750	1779	1766
1978-79	3008	2758	3050	3000
1979-80	3752	3588	3152	3446
1980-81	3385	3323	3391	3379
1981-82	4029	3390	3680	3670
1982-83	5373	4783	5187	5049
1983-84	4700	3679	3881	4031
1984-85	4566	4182	4084	4245
1985-86	4947	4899	4320	4617
1986-87	6310	5131	5609	5607
1987-88	4996	4695	5371	5188
1988-89	4718	3429	4735	4687
1989-90	5077	5588	6221	5692
1990-91	4960	5100	5155	5090
1991-92	4989	5510	5594	5463
1992-93	5787	5424	6127	5827
1993-94	6107	5890	7363	6400

Source : Computed from the current prices from monthly auction files of the government timber depots located in different regions in Kerala.

Appendix 21

**Production of teakwood from forests in different regions  
in Kerala during the period from 1956-57 to 1992-93**

(Quantity in m<sup>3</sup>)

Year	Southern	Central	Northern	Kerala
1956-57	8744	20364	1660	30768
1957-58	3256	6905	8692	18853
1958-59	8521	5947	19142	33610
1959-60	8882	6200	10341	25423
1960-61	11598	10035	11979	33612
1961-62	11534	9755	16362	37651
1962-63	2797	13893	9785	26475
1963-64	9787	7784	16418	33989
1964-65	12434	7479	10433	30346
1965-66	11675	10604	16284	38563
1966-67	9388	12241	12920	34549
1967-68	19540	14005	13127	46672
1968-69	11474	19295	12875	43644
1969-70	9674	13535	19365	42574
1970-71	16239	8541	16577	41357
1971-72	12707	13124	14014	39845
1972-73	13919	8895	22280	45094
1973-74	15464	6722	20333	42519
1974-75	20554	10037	21318	51909
1975-76	13597	7993	33484	55074
1976-77	10821	6511	19197	36529
1977-78	13767	13417	12278	39462
1978-79	9651	9274	14764	33689
1979-80	16153	3310	19619	39082
1980-81	4824	4252	18442	27518
1981-82	1927	3674	12298	17899
1982-83	3570	10268	13834	27672
1983-84	4998	2189	18182	25369
1984-85	8154	3136	10530	21820
1985-86	4409	2294	7348	14051
1986-87	2533	2903	10816	16252
1987-88	12890	660	5639	19189
1988-89	2541	1712	3809	8062
1989-90	5686	4586	14447	24719
1990-91	5627	2705	7182	15514
1991-92	5660	5670	8420	19750
1992-93	8398	5911	18065	32374

Source : Compiled from Administration Reports (various years) of the Kerala Forest Department.

Appendix 22

**Average current prices of teak logs in different girth-classes  
in Kerala during the period from 1956-57 to 1993-94**

(At current price in Rs. per m<sup>3</sup>)

Year	Girth-classes					Average
	<i>E</i>	1	2	3	4	
1956-57	NA	406	306	244	NA	328
1957-58	NA	416	325	242	NA	327
1958-59	NA	425	344	258	NA	342
1959-60	NA	439	352	292	NA	356
1960-61	NA	452	360	283	NA	360
1961-62	NA	440	361	269	NA	357
1962-63	NA	459	361	254	NA	362
1963-64	NA	477	393	268	NA	379
1964-65	NA	483	425	298	NA	402
1965-66	NA	515	454	339	NA	435
1966-67	NA	547	483	379	NA	466
1967-68	NA	531	446	345	NA	382
1968-69	NA	531	442	374	NA	386
1969-70	NA	581	449	370	NA	441
1970-71	607	631	455	366	270	474
1971-72	650	646	542	385	291	550
1972-73	739	799	630	508	419	626
1973-74	1011	952	837	682	563	809
1974-75	1303	1271	1044	935	706	1152
1975-76	1435	1367	1197	1030	768	1221
1976-77	1206	1275	1076	833	751	1052
1977-78	1506	1406	1163	921	855	1166
1978-79	2378	2237	2009	1700	1431	1980
1979-80	3057	3340	2757	2105	1873	2667
1980-81	4100	3750	2946	2374	1826	3092
1981-82	4575	4490	3770	2992	2404	3670
1982-83	6561	6096	5596	4312	3284	5180
1983-84	5361	5641	5176	4072	3000	4527
1984-85	6461	6026	5595	4905	3646	5107
1985-86	7468	8417	6751	5480	4386	5873
1986-87	8515	8141	8624	7327	5450	7508
1987-88	9647	9754	8757	7002	5271	7476
1988-89	9276	8609	8225	6847	5702	7251
1989-90	9442	11954	10921	9630	7357	9432
1990-91	16556	13865	11115	8956	6886	9299
1991-92	20475	17295	14110	10633	8786	11352
1992-93	23131	21450	17178	12572	9162	13326
1993-94	24034	23516	18986	14784	10375	15859

Source : Computed from the monthly auction files of the government timber depots and various Working Plans of different Forest Divisions.

Appendix 22.1

**Average current prices of teak logs in different girth-classes  
in Kerala during the period from 1941-42 to 1955-56**

(At current price in Rs. per m<sup>3</sup>)

Year	Girth-class			Average
	1	2	3	
1941-42	78	58	49	60
1942-43	177	123	104	128
1943-44	196	159	96	146
1944-45	298	177	123	183
1945-46	265	196	124	184
1946-47	339	266	173	255
1947-48	233	209	141	192
1948-49	206	195	110	165
1949-50	175	182	118	155
1950-51	268	250	186	223
1951-52	348	284	197	268
1952-53	255	235	168	213
1953-54	232	213	139	190
1954-55	255	202	141	199
1955-56	301	251	160	237

Source : Computed from various Divisional Forest Working Plans in Travancore and Cochin States and Malabar District (Madras Presidency) which conform to the present Kerala State.

Appendix 23

**Average real prices of teak logs in different girth-classes  
in Kerala during the period from 1956-57 to 1993-94**

(In real price in Rs. per m<sup>3</sup>)

Year	Girth-classes					Average
	<i>E</i>	1	2	3	4	
1956-57	NA	2461	1855	1479	NA	1988
1957-58	NA	2447	1911	1424	NA	1924
1958-59	NA	2401	1944	1458	NA	1932
1959-60	NA	2386	1913	1586	NA	1935
1960-61	NA	2306	1837	1444	NA	1837
1961-62	NA	2245	1841	1372	NA	1819
1962-63	NA	2250	1770	1245	NA	1775
1963-64	NA	2208	1819	1241	NA	1756
1964-65	NA	2012	1771	1242	NA	1675
1965-66	NA	1996	1760	1314	NA	1686
1966-67	NA	1861	1643	1289	NA	1585
1967-68	NA	1619	1360	1052	NA	1166
1968-69	NA	1634	1360	1150	NA	1188
1969-70	NA	1636	1265	1097	NA	1275
1970-71	1710	1777	1282	1031	761	1335
1971-72	1733	1723	1445	1027	776	1466
1972-73	1789	1935	1525	1230	1015	1516
1973-74	2034	1915	1684	1372	1132	1627
1974-75	2095	2043	1678	1503	1135	1852
1975-76	2334	2223	1946	1674	1249	1985
1976-77	1920	2031	1714	1327	1196	1675
1977-78	2282	2130	1762	1396	1295	1766
1978-79	3603	3390	3044	2576	2168	3000
1979-80	3950	4315	3562	2719	2420	3446
1980-81	4481	4098	3220	2595	1996	3379
1981-82	4575	4490	3770	2992	2404	3670
1982-83	6395	5942	5454	4203	3201	5049
1983-84	4774	5023	4609	3626	2671	4031
1984-85	5371	5009	4651	4077	3031	4245
1985-86	5871	6617	5307	4308	3448	4617
1986-87	6359	6080	6441	5472	4070	5607
1987-88	6695	6769	6077	4859	3658	5188
1988-89	5996	5565	5317	4426	3686	4687
1989-90	5698	7214	6591	5812	4440	5692
1990-91	9062	7589	6084	4902	3769	5090
1991-92	9853	8323	6790	5117	4228	5463
1992-93	10114	9379	7511	5497	4006	5827
1993-94	9699	9490	7662	5966	4187	6400

Source : Computed from the current prices of timber from the monthly auction files of the government timber depots and various Working Plans of different Forest Divisions.

Appendix 24

**Average current prices of selected timbers in Kerala during the period from 1956-57 to 1993-94**

(At current price in Rs. per m<sup>3</sup>)

Year	Anjily	Irul	Maruthu	Jack	Thembavu	Venga	Venteak
1956-57	146	111	108	109	144	153	107
1957-58	149	109	111	109	152	147	108
1958-59	163	118	119	113	158	175	113
1959-60	158	121	128	121	159	158	115
1960-61	177	159	130	125	173	150	117
1961-62	171	136	119	135	169	163	113
1962-63	194	121	121	144	165	176	97
1963-64	207	134	114	186	157	193	114
1964-65	235	163	139	197	167	211	131
1965-66	248	165	140	208	177	221	165
1966-67	269	166	143	189	186	230	126
1967-68	277	163	146	199	203	257	164
1968-69	277	186	155	218	203	259	166
1969-70	275	185	163	258	221	282	178
1970-71	349	197	172	298	235	300	186
1971-72	340	206	211	374	254	332	221
1972-73	313	264	249	412	330	353	242
1973-74	381	322	319	515	362	403	291
1974-75	487	477	397	618	462	543	340
1975-76	627	477	422	681	461	683	403
1976-77	577	393	319	758	363	590	431
1977-78	710	531	451	656	510	738	521
1978-79	1197	917	830	1192	907	1140	924
1979-80	1742	1269	1217	1844	1226	1617	1241
1980-81	1780	1312	1194	1169	1278	1807	1222
1981-82	2125	1454	1360	1830	1578	1905	1642
1982-83	2632	2218	2247	2157	2207	2834	2419
1983-84	2621	2021	2476	2931	2316	3108	2713
1984-85	2840	2999	2886	3679	2626	3169	3009
1985-86	2875	3041	2468	2260	2181	3006	2817
1986-87	4046	3191	2859	1753	2986	2768	2961
1987-88	3922	2621	2336	3579	2497	2937	2800
1988-89	4513	2689	3102	3000	2826	2186	3046
1989-90	2229	3486	3016	3218	2466	1511	3670
1990-91	2773	3309	3053	2624	3318	2987	3720
1991-92	4422	4015	2726	7481	4260	5232	4374
1992-93	7474	4853	4537	2376	4688	4428	5201
1993-94	8224	6862	6051	7835	3492	6202	6061

Source : Computed from the monthly auction files of the government timber depots and various Working Plans of different Forest Divisions.

Appendix 25

**Average real prices of selected timbers in Kerala  
during the period from 1956-57 to 1993-94**

(In real price in Rs. per m<sup>3</sup>)

Year	Anjily	Irul	Maruthu	Jack	Thembavu	Venga	Venteak
1956-57	885	673	655	654	873	927	648
1957-58	876	641	653	641	894	865	635
1958-59	921	667	672	638	893	989	638
1959-60	859	658	696	658	864	859	625
1960-61	903	811	663	638	883	765	597
1961-62	872	694	607	689	862	832	577
1962-63	951	593	593	706	809	863	475
1963-64	958	620	528	861	727	894	528
1964-65	979	679	579	820	696	879	546
1965-66	961	639	543	806	686	856	640
1966-67	915	565	486	643	633	782	429
1967-68	845	497	445	607	619	784	418
1968-69	852	572	477	671	625	797	511
1969-70	816	549	484	765	656	837	528
1970-71	983	555	485	839	662	845	524
1971-72	907	549	563	997	677	885	589
1972-73	758	639	603	998	799	855	586
1973-74	767	648	642	1036	728	811	586
1974-75	783	767	638	994	743	872	547
1975-76	1020	775	686	1107	749	1111	656
1976-77	918	626	508	1207	578	940	687
1977-78	1075	805	684	994	773	1118	789
1978-79	1813	1389	1258	1806	1374	1727	1400
1979-80	2251	1639	1572	2383	1584	2089	1603
1980-81	1945	1434	1305	1278	1397	1975	1336
1981-82	2125	1454	1360	1830	1578	1905	1642
1982-83	2565	2162	2190	2102	2151	2762	2358
1983-84	2334	1800	2205	2610	2062	2768	2416
1984-85	2361	2493	2399	3058	2183	2634	2501
1985-86	2260	2391	1940	1777	1715	2363	2215
1986-87	3022	2383	2135	1309	2230	2067	2211
1987-88	2722	1819	1621	2484	1733	2038	1943
1988-89	2917	1738	2005	1939	1827	1413	1969
1989-90	1345	2104	1820	1942	1488	912	2215
1990-91	1518	1811	1671	1436	1816	1635	2036
1991-92	2128	1932	1312	3600	2050	2518	2105
1992-93	3268	2122	1984	1039	2050	1936	2274
1993-94	3319	2769	2442	3162	1409	2503	2446

Source : Computed from the current prices of timber from the monthly auction files of the government timber depots and various Working Plans of different Forest Divisions.

Appendix 26

**Quantity of teakwood and selected timbers sold through all the government timber depots during the period from 1956-57 to 1992-93**

(Quantity in m<sup>3</sup>)

Year	Teak	Anjily	Venteak	Vengai	Maruthu	Themba	Jack	Irul
1956-57	28647	1439	3339	1710	10447	3034	NA	1575
1957-58	30764	1800	5209	1921	9095	5477	NA	3335
1958-59	30710	1958	5318	2650	10328	7138	NA	5235
1959-60	26744	1704	9151	3476	13649	9227	NA	8697
1960-61	23441	2988	13371	3473	16695	8353	NA	8144
1961-62	37847	2760	13932	4708	21922	10423	NA	7763
1962-63	34732	1662	18060	3927	19053	10762	NA	6902
1963-64	31452	2607	23834	6344	26573	12168	NA	7739
1964-65	32082	4208	21621	4771	25248	8187	NA	10673
1965-66	32172	2393	20959	9688	29780	20907	74	12281
1966-67	31260	4042	22397	9561	37408	20585	30	12660
1967-68	47065	5236	25608	9699	37948	19179	1127	11785
1968-69	38064	3796	30981	8970	41911	13651	312	22422
1969-70	37438	8128	30096	7410	40472	14365	136	16149
1970-71	45028	5725	24019	9188	43942	14280	139	11224
1971-72	31190	1839	18107	5219	15488	2558	84	12868
1972-73	42712	5189	14742	7953	19959	12658	116	8123
1973-74	52362	6030	31686	4955	33607	11980	112	20678
1974-75	46843	6624	24917	9394	45373	12939	447	9251
1975-76	53984	9503	3332	12216	67801	34194	330	21122
1976-77	57861	14960	34757	15733	50259	29869	794	24249
1977-78	37438	3347	9253	6034	24351	13769	293	11413
1978-79	36298	2941	20498	5771	26949	17868	272	18913
1979-80	37983	3513	21590	7422	40241	13408	608	16663
1980-81	30562	4121	15793	5090	27868	8509	293	9547
1981-82	19252	2722	9121	3162	15319	4293	159	7561
1982-83	23781	1577	6475	1563	7999	3286	602	4015
1983-84	31697	1760	3385	1129	306	1020	191	1601
1984-85	18927	531	1563	727	2442	554	138	380
1985-86	24308	1295	2481	488	5697	1359	116	2825
1986-87	19197	1722	3518	914	6262	1515	1013	1747
1987-88	21896	885	1025	511	3720	211	234	434
1988-89	10987	293	1027	175	899	19	38	346
1989-90	21131	272	523	155	1144	152	105	734
1990-91	17280	100	370	388	835	171	22	635
1991-92	24517	487	793	525	2322	380	95	703
1992-93	22794	420	568	215	830	585	13	807

Source : Compiled from the Administration Reports (various years) of the Kerala Forest Department.

Appendix 27

**Timber production from the forests of Kerala and Tamil Nadu\***

Year	Production (in m <sup>3</sup> )		% of timber production in TN to that in Kerala
	Kerala	Tamil Nadu**	
1972-73	509401	39665	7.8
1973-74	541463	30810	5.7
1974-75	451632	29079	6.4
1975-76	492347	39306	8.0
1976-77	540643	37665	7.0
1977-78	528924	10623	2.0
1978-79	447090	NA	-
1979-80	434831	12215	2.8
1980-81	529768	5283	1.0
1981-82	255867	6404	2.5
1991-92	40527	378	0.9

\* Break-up of teakwood production is not shown since data on teakwood production was not available in the Administration Reports of the Tamil Nadu Forest Department.

\*\* Not available for the years from 1982-83 to 1990-91.

Source : Government of Tamil Nadu (1972-73 to 1981-82 and 1991-92).  
Administration Reports (various issues) of the Tamil Nadu Forest Department, Madras.

## Appendix 28

### Number of trees in the growing stock in home gardens of Kerala during the year 1988-89

(number in '000)

Trees	Diameter at breast height (in cm)									Total	%
	<10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	>80		
CO**	-	-	94920	-	-	-	-	-	-	94920	21.47
M2	11550	8624	5837	3146	1699	938	195	67	50	32106	7.26
M3	19700	12856	5908	2497	1191	560	216	70	100	43098	9.75
M4	87456	42322	12126	2652	937	208	116	28	0	145845	32.98
T1	14069	5607	1709	376	148	15	0	0	5	21929	4.96
T2	9869	7901	3475	1347	588	423	114	7	12	23736	5.37
T3	9242	8007	1870	242	84	24	4	5	0	19478	4.40
T4	37830	18027	3820	919	226	160	50	8	13	61053	13.81
Total	189716 (42.91)*	103344 (23.37)	129665 (29.32)	11179 (2.53)	4873 (1.10)	2328 (0.53)	695 (0.16)	185 (0.04)	180 (0.04)	442165	(100.00)

CO stands for coconut palms, M2 for jack, M3 for mango, tamarind, gooseberry, etc., M4 for cashew, breadfruit, guava, etc., T1 for teak, rosewood and sandal, T2 for *anjily*, *chadachy*, *irul*, etc., T3 for *kanjiram*, *manjakadambu*, *thanni* etc., T4 for *matty*, *mullilavu*, *ezhilampala* etc., For complete list see Krishnankutty, C.N. (1990). *op. cit.*

\* The figures in parenthesis are percentages to total.

\*\* Include only those coconut palms above 5 years old which have stem wood. The average diameter of coconut palm is assumed to be in 20-30 cm class.

Source : Krishnankutty, C. N. (1990). *op. cit.*

Appendix 29

**Commercial volume of growing stock of trees in home-gardens of Kerala during the year 1988-89**

(Volume in '000 m<sup>3</sup> underbark)

Trees	Diameter at breast height (in cm)							Total	(%)
	20-30	30-40	40-50	50-60	60-70	70-80	>80		
CO	6834	0	0	0	0	0	0	6834	23.96
M2	817	1605	1767	1586	477	222	236	6710	22.52
M3	844	1274	1220	921	512	219	440	5430	19.02
M4	1941	1352	863	284	216	67	0	4723	16.55
T1	406	144	112	18	0	0	20	700	2.45
T2	475	390	318	367	157	14	39	1760	5.17
T3	285	122	80	34	7	11	0	539	1.90
T4	620	519	232	280	114	25	40	1830	6.43
Total	12222	5406	4592	3490	1483	558	775	28526	
(%)	42.85	18.95	16.10	12.23	5.20	1.95	2.72		100.00

Source : Krishanankutty, C. N. (1990). *op. cit.*

## Appendix 30

### Local and botanical names of trees in home-gardens of Kerala

Local Name (Trade name)	Botanical Name
<i>Acacia</i>	<i>Acacia auriculiformis</i> A. Cunn.ex Benth.
<i>Albizia</i>	<i>Albizia falcataria</i> (Linn.) Fosberg.
<i>Anjily (Ayani)</i>	<i>Artocarpus hirsutus</i> Lamk.
<i>Chadachi (Dhaman)</i>	<i>Grewia tiliifolia</i> Vahl.
<i>Chandanam (Sandal)</i>	<i>Santalum album</i> Linn.
<i>Ezhilampala (Shaitan wood)</i>	<i>Alstonia scholaris</i> (Linn.) R. Br.
<i>Irul</i>	<i>Xylia xylocarpa</i> (Roxb.) Taub.
<i>Kadaplavu (Breadfruit)</i>	<i>Artocarpus cummunis</i> J.R. & G.Fors.
<i>Kanjiram</i>	<i>Strychnos nux-vomica</i> Linn.
<i>Kasumavu (Cashew)</i>	<i>Anacardium occidentale</i> Linn.
<i>Kudappuli</i>	<i>Garcinia gummi-gutta</i> (Linn.) Roës.
<i>Manjakadambu (Haldu)</i>	<i>Haldina cordifolia</i> (Roxb.) Ridsd.
<i>Matty</i>	<i>Ailanthus triphysa</i> (Dennst.) Alston.
<i>Mavu (Mango)</i>	<i>Mangifera indica</i> Linn.
<i>Mullilavu (Semul)</i>	<i>Bombax ceiba</i> Linn.
<i>Murikku</i>	<i>Erythrina stricta</i> Roxb.
<i>Nelly (Gooseberry)</i>	<i>Emblica officinalis</i> Gaertn.
<i>Pera (Guava)</i>	<i>Psidium guajava</i> Linn.
<i>Plavu (Jack)</i>	<i>Artocarpus heterophyllus</i> Lamk.
<i>Pulimaram (Tamarind)</i>	<i>Tamarindus indica</i> Linn.
<i>Silver oak</i>	<i>Grevillea robusta</i> A. Cunn

(Contd....)

Local Name (Trade name)	Botanical Name
<i>Thanni</i>	<i>Terminalia bellirica (Gaertn.) Roxb.</i>
<i>Thekku (Teak)</i>	<i>Tectona grandis Linn. f.</i>
<i>Thembavu</i>	<i>Terminalia crenulata Roth</i>
<i>Thengu (Coconut)</i>	<i>Cocos nucifera Linn.</i>
<i>Vaka</i>	<i>Albizia sp.</i>
<i>Vatta</i>	<i>Macaranga peltata (Roxb.) Muell-Arg.</i>
<i>Veeti (Rosewood)</i>	<i>Dalbergia latifolia Roxb.</i>
<i>Venga (Bijasal)</i>	<i>Pterocarpus marsupium Roxb.</i>
<i>Venthekku (Venteak)</i>	<i>Lagerstroemia microcarpa Wt.</i>

Source : Botanical names are taken from Sasidharan (1987). *Forest trees of Kerala : A check-list with an index to important exotic*. KFRI Handbook 1, Kerala Forest Research Institute, Peechi. For a detailed list of trees in home-gardens, see Krishnankutty, C. N. (1990). *op. cit.*

NB 4395