KFRI Research Report No: 493 ISSN 0970 - 8103

A DECISION SUPPORT SYSTEM FOR MONITORING AND FORECASTING TIMBER PRICES OF KERALA STATE

(Final Report of Project KFRI 607/2010)

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November 2013

ABSTRACT OF THE PROJECT PROPOSAL

1. Project Number	:	KFRI 607/2010
2. Title of the Project	:	A DECISION SUPPORT SYSTEM FOR MONITORING AND FORECASTING TIMBER PRICES OF KERALA STATE
3. Objectives	:	(1) To develop timber price indices for monitoring timber prices of various species considering size and quality attributes (2) To develop a decision support system which will have a suitable database and analytical models to produce temporal and spatial trends of timber price indices
4. Date of commencement	:	December 2010
5. Scheduled date of completion:	:	November 2013
6. Funding agency	:	KFRI Plan Grant
7. Investigator	:	Dr.M.Sivaram, Scientist (Forest Statistics) Dr.S.Sandeep (Soil Science, PI from Jul 2013)

CONTENTS

ACKNOWLEDGEMENT

ABSTRACT

CHAPTERS

1. INTRODUCTION 1
   - 1.1 What is DSS? 1
   - 1.2 MIS and DSS 1
   - 1.3 Motivation and Idea 1

2. LITERATURE REVIEW 3
   - 2.1 Decision Support System (DSS) 3
   - 2.2 Timber Price Indices 4
   - 2.3 Structure of Timber Market in India 5
   - 2.4 Importance of TMIS 6

3. DEVELOPMENT OF TMIS 9
   - 3.1 Main issue addressed in TMIS 9
   - 3.2 Major components of the TMIS 10
   - 3.3 Price Indices 10
   - 3.4 Models for Forecasting Timber Prices 13
     - 3.4.1 Forecasting models considered in TMIS 13
     - 3.4.2 Evaluation of forecasting models 13
   - 3.5 Scope and Major Functional Features of TMIS Version 1.0 14
     - 3.5.1 Scope 14
     - 3.5.2 Major Functional Features 14
     - 3.5.3 An Operation Manual of TMIS 16

4. APPLICATION OF TMIS VERSION 1.0- A CASE STUDY OF TIMBER MARKET OF KERALA STATE, INDIA 16

4.1 Study area and Database 16

4.2 Methods 17

4.3 Results and discussion 19

4.3.1 Teak Price Indices 19

4.3.2 Price Index of other Species 23

4.3.3 Forecasting of Timber Prices 23

4.3.4 Discussion 25

4.3.5 Potential users of TMIS 25

4.3.6 Future release of TMIS 25

5. REFERENCES 26

APPENDIX 28

ACKNOWLEDGEMENT

The author is thankful to

Dr.P.S.Easa, Director, Kerala Forest Research Institute (KFRI) for his kind support and encouragement,

Dr.E.A.Jayson, Research Coordinator and Dr.M.Balagopalan, Former Research Coordinator have always been very kind to provide his ideas and advices, .

Dr.V.V.Sudheendra Kumar, Scientist-F and Registrar (Retd.) KFRI greatly helped to have all administrative facilities for the execution of the project,

Dr.K.V.Sankaran, Former Director, KFRI greatly encouraged me for the successful completion of the project,

Mr.Jinesh Sam and Mr.Sujith K.Surendran, played a key role in developing the TMIS

Mr.Vipin P.Chandran helped to depict the results generated by TMIS in the website www.kfstat.com of KFRI

Mrs.Rini George helped in developing algorithms for the implementation of forecasting models and in the preparation of Operational Manual of TMIS.

Mrs.K.G.Nayana and Miss. Kavya helped in the data collection and analysis of data.

Various Timber Sales Divisions of Kerala Forests and Wildlife for providing required data to develop the database of timber prices and

The project was funded under KFRI Plan Grant.

ABSTRACT

The timber market in developing countries including India is mostly unorganized. There is no proper statistical system available to track the timber market trends. TMIS (Timber Market Intelligence System) is a computer based decision support system tool to gather, store, search, retrieve and analyze timber price trends. A large number of timber species is available in the market for sale. Timber quality is assessed mainly based on attributes such as girth, length, straightness and soundness of timber logs. The number of quality classes for a given species is huge. The timber classification system also varies within and across countries. If one wants to know the timber market trends, it is difficult to assimilate the timber prices of so many species across wide range of quality classes. However, it is possible to track the timber market if there is a timber price index summarizing the prices of various timber species and quality classes. In this regard, TMIS enables the user to organize a database on timber prices and develop timber price indices based on a standard methodology for his/her own region to monitor timber prices. TMIS produces graphs showing trends in timber price indices for decision making. Selected models for forecasting future timber price trends are also integrated in the system. The use of TMIS in monitoring timber prices has been demonstrated through a case study of timber market of Kerala State, India.

1. INTRODUCTION

1.1 What is DSS?

A properly designed computer decision support system (DSS) is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents, personal knowledge, or business models to identify and solve problems and make decisions. The history of the implementation of such systems begins in the mid 1960s (Power, 2007). DSSs serve the management, operations, and planning levels of an organization and help to make decisions, which may be rapidly changing and not easily specified in advance. DSSs can be organized into five broad categories: data driven, model driven, communication driven, documentation driven and knowledge driven (Power, 2007). Since the year 1995 the world-wide web and global internet provides a technology platform for further extending the capabilities and deployment of computerized decision support system.

1.2 MIS and DSS

Market Intelligence System (MIS) is one that systematically gathers and processes critical business information, transforming it into actionable management intelligence for marketing decisions (David Skyrme Associates, 2013). The value of a marketing intelligence system can be substantial since decision making regarding strategy has a direct impact on the bottom line. If the intelligence system provides timely and relevant information, then the value added by the system can be measured in terms of risk aversion. Minimizing risk and maximizing profit are a natural extension of the system. The use of computers and software tools as decision support system tools in the market intelligence of any product is the order of the day. The real life examples include online web based market intelligence systems such as equity markets and commodity markets.

1.3 Motivation and Idea

The idea for the Timber Market Intelligence System (TMIS) was based on the experiences gained from the development of software 'Kerala Forestry Statistical Database (KFSTAT)' which contain statistical data on various aspects of forest sector for data mining applications useful to sustainable forest management (Sivaram, 2008). It was felt that an automated system having an integrated database and relevant analytical models and tools inbuilt would form a kind of DSS. The main thrust of the DSS here is to transform data into information and to knowledge which in turn aid decision making (Fig.1). In order to transform data into information, data need to be subjected to a simple graphical technique to advanced modeling techniques including statistical and artificial neural network techniques. The projections and results produced by the DSS rely on varying input and model specifications provided by the user(s) under different options and assumptions. The proposed DSS is the first module of this kind, which would help essentially to know the past, present and future timber price trends.

The price is an important indicator of demand-supply condition of any product. The price index is an indicator of the average price movement over time of fixed baskets of goods and services. Therefore, construction of price indices summarizing the prices of various species over number of size and quality classes is addressed in TMIS for monitoring timber market. The models for forecasting future price movements have also been incorporated in TMIS. The application of TMIS is demonstrated through a case study of timber market of Kerala State, India.

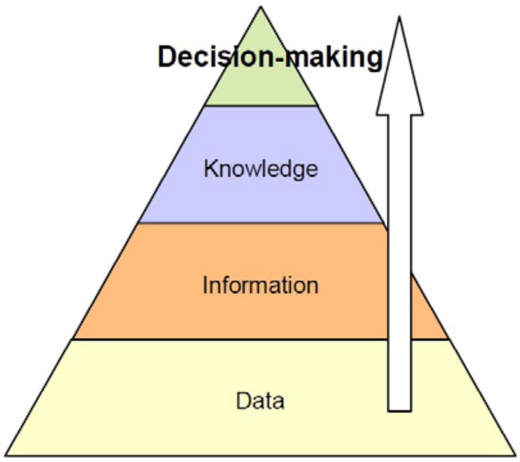


Figure 1. Data to decision-making process

2. REVIEW OF LITERATURE

2.1 Decision Support System (DSS)

Kersten and Yeh (2000) reviewed number of DSS applications to environmental decision making and assessment, water resource management and agriculture, forestry, manufacturing, medicine, business and organizational support and infrastructure. They also reviewed number of decision support systems in forestry sector mostly published in the later part of 1980s and in 1990s. The forestry applications of DSS include a tactical planning system to develop site specific treatment schedules; reforestation problems; ecosystem management; financial matters related to forest management; identification and treatment of diseases and pests; linear programming model to evaluate New Zealand's forests; planning of lumber harvests; converting tribal forests to more productive and valuable tree species, forest fire prevention and fighting; analysis of multi-resource forest management problems and to support district planning activities and manage legal, ecological and social information.

The 'State of the Art' in the field of decision support in forest management was reviewed in 2005 by Rauscher et al. covering experiences in the United States, Canada and Europe. The DSS literature covered include 'NED-2: A Decision-Support System for Integrated Forest Ecosystem Management'; growth and yield model system; the Forest Vegetation Simulator; DSS for the design, analysis and evaluation of Silvicultural treatment alternatives for Scots pine (*Pinus Sylvestris* L.) and Norway spruce (*Picea abies* (L.) *Karst.*); a stand level DSS tool for assessing the effects of alternative forest management practices; 'The forest Time Machine: a multi-purpose forestry projection model system' for the growth, regeneration, mortality and wood decay, forestry operations, economics, nutrient balances, and various indicators for forest biodiversity; 'The South-eastern Agro forestry Decision Support System (SEADSS)' to assist to evaluate potential sites and suitable tree and shrub species for agroforestry planning; DSS for providing advice for policy and planning decisions pertaining to the afforestation of agricultural land and DSS for finding the optimal assignation of forestry activities at the tree level. European approaches on the DSS focus primarily on the forest enterprise level with heavy emphasis on timber management support. North American approaches focus more heavily on non-timber forest products such as clean water, wildlife and aesthetics than their European Counterparts.

Review of DSSs by Ferretti et al. (2011) reported that the majority of decision support or rule-based expert systems implemented so far for landscape ecology, forest planning, wood production, forest protection and sustainable forest management to a very local contexts or oriented to forest spatial and growth projection models or even to silvicultural planning.

Rondeux et al. (2010) developed a silvicultural decision support system to predict the influence of silvicultural alternatives on larch stand evolution and help forest managers choose scenarios according to present goals. A GIS based evaluation model was designed to compare harvesting systems and select the best suitable systems in considerations of stake holder interests and environmental conditions (Kuhmaier and Stampfer, 2010). An interactive web-based DSS was developed to assist the analysis of harvesting costs and productivity of round wood operations (Jinzhuo et al. 2012). A DSS was developed for facilitating the application of complex economic models for spatial non-timber valuation problems (Akabua et al. 2000). A DSS was developed to aid forest managers to examine the harvesting techniques and interactions among stand, harvest and machines in terms of production, cost, traffic intensity (Yaoxiang, 2009). A DSS developed by Henniger et al. (2011) assist the management of Spruce budworm (SBW) infestations and defoliation in forests by estimating the marginal timber supply benefits of protecting stands against budworm defoliation. In the DSS developed by Palander and Ventilainen (2013) large scale and long term fuel procurement scheduling problems were considered for sustainable energy production.

It is evident from the above review that the computer based decision support systems on timber market intelligence are scarce. ITTO monitors timber market by collating international market information especially timber prices and publishes through annual reports and market information bulletins at the regular intervals. Indian Council of Forestry Research and Education (ICFRE), Dehradun publishes half yearly Timber/Bamboo Trade Bulletin covering timber species viz., teak, sal, shisham (*Dalbergia sissoo*), eucalypts, casuarina, poplar, chir pine and deodar (apart from bamboos) from 19 markets spread across the country. In India, there are only few studies conducted in analysing the trends in timber prices (Krishnankutty, 2002)

2.2 Timber Price Indices

Markets are tracked through indices. In stock market, indices are developed to track stock prices of important scripts. Sector specific stock indices like banking, oil, manufacturing are also developed. Recently, National Housing Bank (NHB) owned by Reserve Bank of India has released NHB Residex which tracks the movement of prices in the residential housing segment (National Housing Bank, 2012).

In India, there is no timber price index developed to track the changes in timber prices. However, Whole Sale Price Indices (WPI) are worked out and published regularly by the Office of the Economic Advisor to Government of India (2013). The WPI is also worked out separately for wood and wood products under the manufactured items. However, under the present WPI series the specification on - “logs and timbers” does not describe the specification completely and, therefore, leads to supply of price information on ‘non-comparable’ varieties by the source agency at different points of time. This vitiates the compilation and use of the index. The geographical coverage in the collection of price data is also very much limited.

Timber price indices have been developed mostly in some of the developed countries. In Great Britain, two price indices are in use. One is the Standing Sales Price Index adjusted for size mix and another is Softwood Sawlog Price Index (Forestry Commission, 2013). Global Softwoood Fibre Index which predominantly includes countries with natural conifer species in the Northern Hemisphere and Global Hardwood Fibre Index, which largely consist of wood fibre prices in non-conifer plantation forests, are calculated (Wood Resources International LLC, 2013). In France, Fodaq index is used to monitor Lumber Hardwood Prices (Fordaq, 2013). In Germany, HPE price index has been in use for sawn timber and wood based products for wooden packaging and palettes (HPE, 2013).

2.3 Structure of Timber Market in India

Timber demand in India arises mainly from construction and furniture making. The major timber supply sources are forest plantations, home-gardens, farm lands, private plantations, private estates and import. Timber sale in India is mainly through two channels viz., Timber Sales Depots of the State Forest Departments and sawmills. Timber from forest plantations are sold in Timber Sales Depots following auction cum tender method. Most of the participants in these auctions are sawmill owners or their agents. Timber from other sources are procured through middle men and sold by sawmills in sawn form. Most of the timber requirements are met from sources other than forest plantations. However, timber procurement and sale by sawmills are unorganized. There has been no national level systematic assessment on demand, supply and consumption of timber from time to time though very few reports are available at the state level (Krishnankutty et al. 2005).

2.4 Importance of TMIS

Timber continues to be the major forest products from forests. The contribution of forestry and logging sector to the Gross Domestic Product of India is Rs.88,000 crores during 2008-09 (ICFRE, 2010). Due to felling restrictions in forests, there has been increasing trend in the import of timber to meet the growing domestic demand. India imports mostly tropical industrial round wood volume of over 6 million m^3 worth about 1600 million US$ annually (Figs. 2 & 3), from Malaysia, Myanmar and Indonesia and also from Africa and Latin America (ITTO, 2013). The export volume and value of timber products have been very negligible (Figs. 4 & 5). The total trade deficit (export-import) of India is about 112 million US$ per year (Fig. 6). Consequently, there is a huge payout of foreign exchange. So, timber market is a subject to be monitored on regular basis.

The orientation of forest management has changed from timber production to environment conservation. In order to lessen the pressure on forests and minimize the timber import, it is essential to improve the timber resources outside forests. Tree farming is one way of developing timber resources outside forests. To promote tree farming, information on timber price trends should be made available to the public.

However, the timber market in India is unorganized and there is no statistical system avalable to track the market trends. TMIS enables quick analysis of timber price trends. It will help bringing in transparency, encourage more players to involve in the market and discover right price for timber. It will help producers with business plans and to guide the investment.

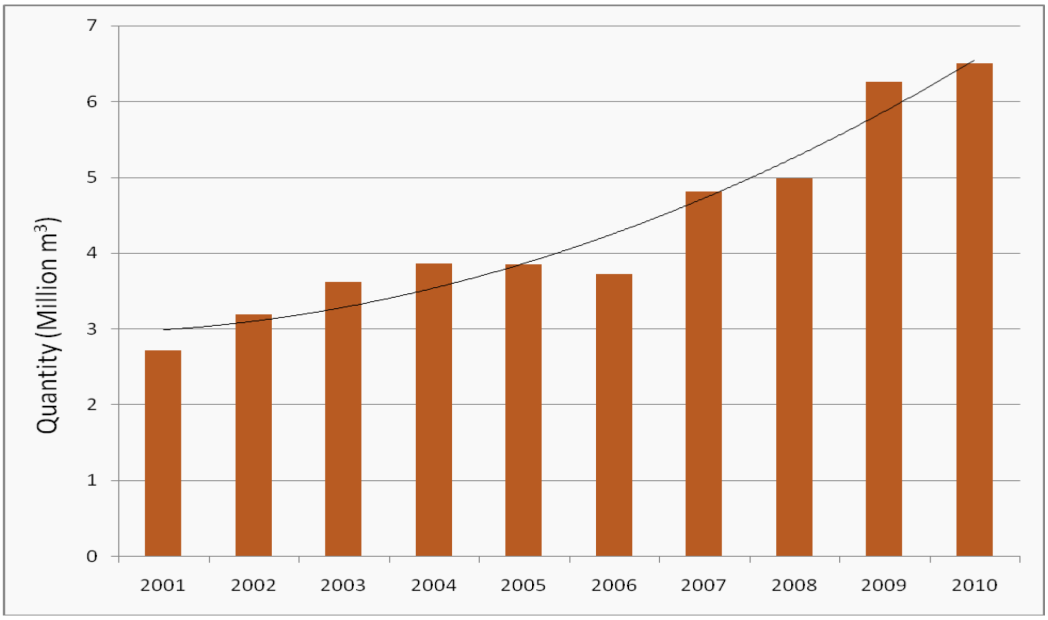


Figure 2. Import Quantity of Timber Products of India (2001-2010)

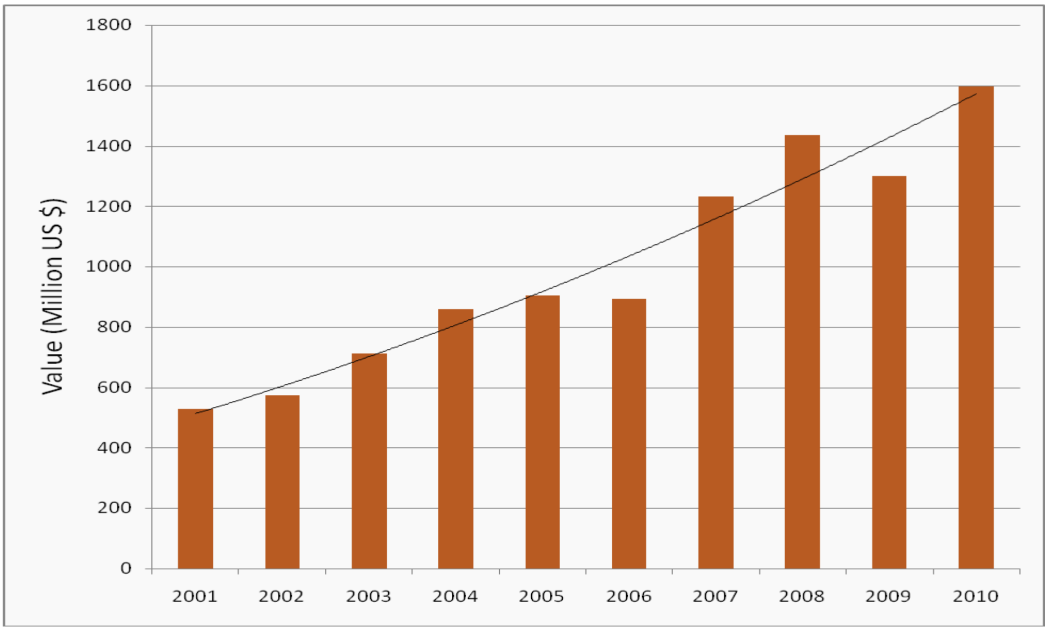


Figure 3. Import Value of Timber Products of India (2001-2010)

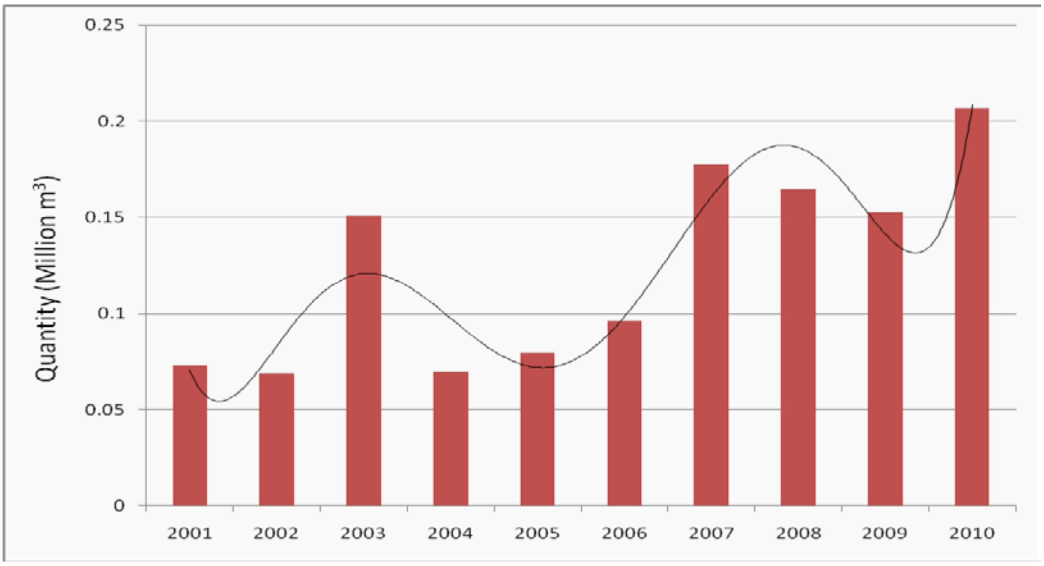


Figure 4. Export Quantity of Timber Products of India (2001-2010)

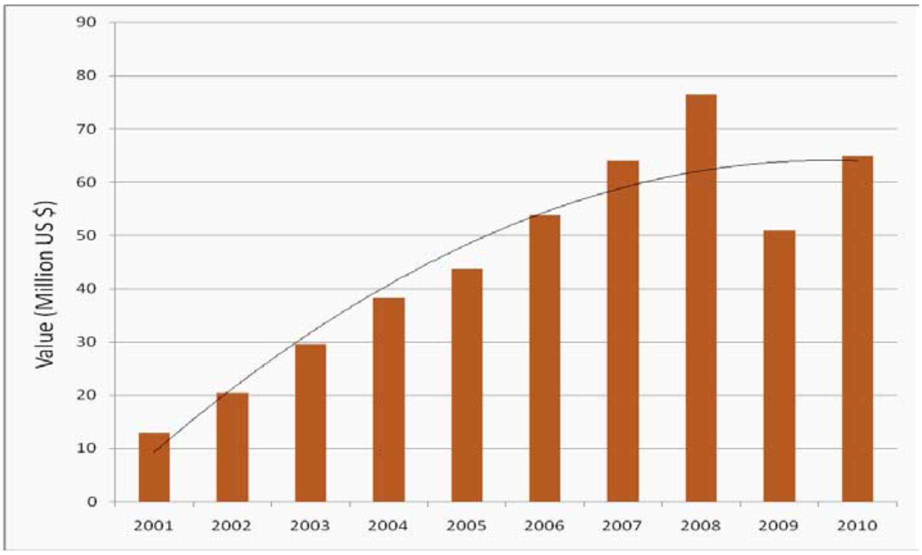


Figure 5. Export Value of Timber Products of India (2001-2010)

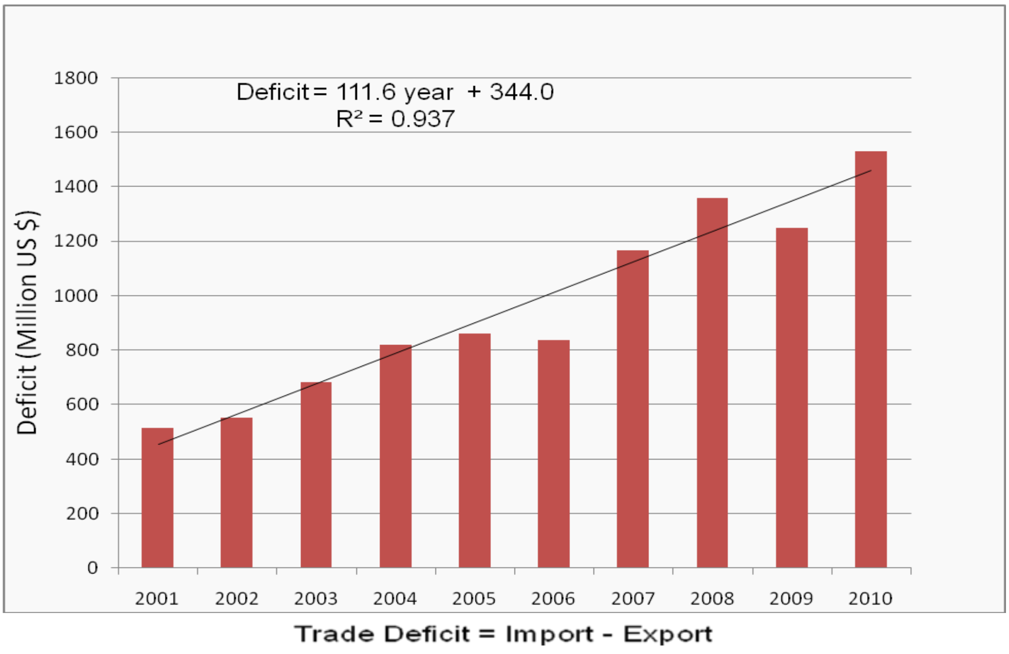


Figure 6. Trade deficit of India due to Timber Products (2001-2010)

3. DEVELOPMENT OF TMIS

3.1 Main issue addressed in TMIS

In India, large number of timber species is available in the market for sale. Timber qualities are assessed mainly based on attributes such as girth, length, straightness and soundness of timber logs. The hedonic price analysis of teak logs revealed that about 80% of the variation in teak wood prices was explained by girth, straightness and soundness of logs (Sivaram and Nayana, 2013). The number of quality classes for a given species is large. For example, round teak alone has over 60 classes in Kerala. The timber classification system also varies across states. If one wants to know the timber market trends, it is difficult to assimilate the timber prices of so many species across wide range of quality classes. However, it is possible to track the timber market if there is a timber price index summarizing the prices of various timber species and quality classes. In this regard, TMIS enables the user to develop timber price indices recursively and quickly based on standard methodology for his/her own region to monitor the timber prices.

3.2 Major components of the TMIS

The major components of the DSS proposed are depicted in Figure 7. The DSS has mainly one input-layer for the data input. The input to the DSS includes the following.

i) Price data from timber depots
ii) Price data from sawmills
iii) Factors influencing timber prices

The second major component in TMIS is the report generation which could be generated on temporal basis for different markets. The data search and retrieval could be for different timber attributes for chosen species. The third major component is to construct timber prices indices. This includes construction of traditional price indices and non-traditional price index approaches such as hedonic price index approach.

The fourth major component is on developing models for forecasting future timber price movements. The models include univariate forecast models based on past prices and econometric models with the factors that influence timber prices.

The fifth major component is about dissemination of price trends, price forecasts and other useful information to the stakeholders aimed at helping to take decisions.

3.3 Price Indices

3.3.1 Construction of Price Indices

The price index is an indicator of the average price movement over time of fixed baskets of goods and services. The timber price index weighted for various species, size and a quality characteristic of timber is useful for monitoring timber market. For the calculation of timber price index, the major species and quality classes that should have been frequented sufficiently in quantity over the base year and time horizon of interest have to be found out. The appropriate price index formula is to be chosen. The details of formulae of price indices and the Annual Growth Rate (AGR) and percentage volatility of price indices are as follows.

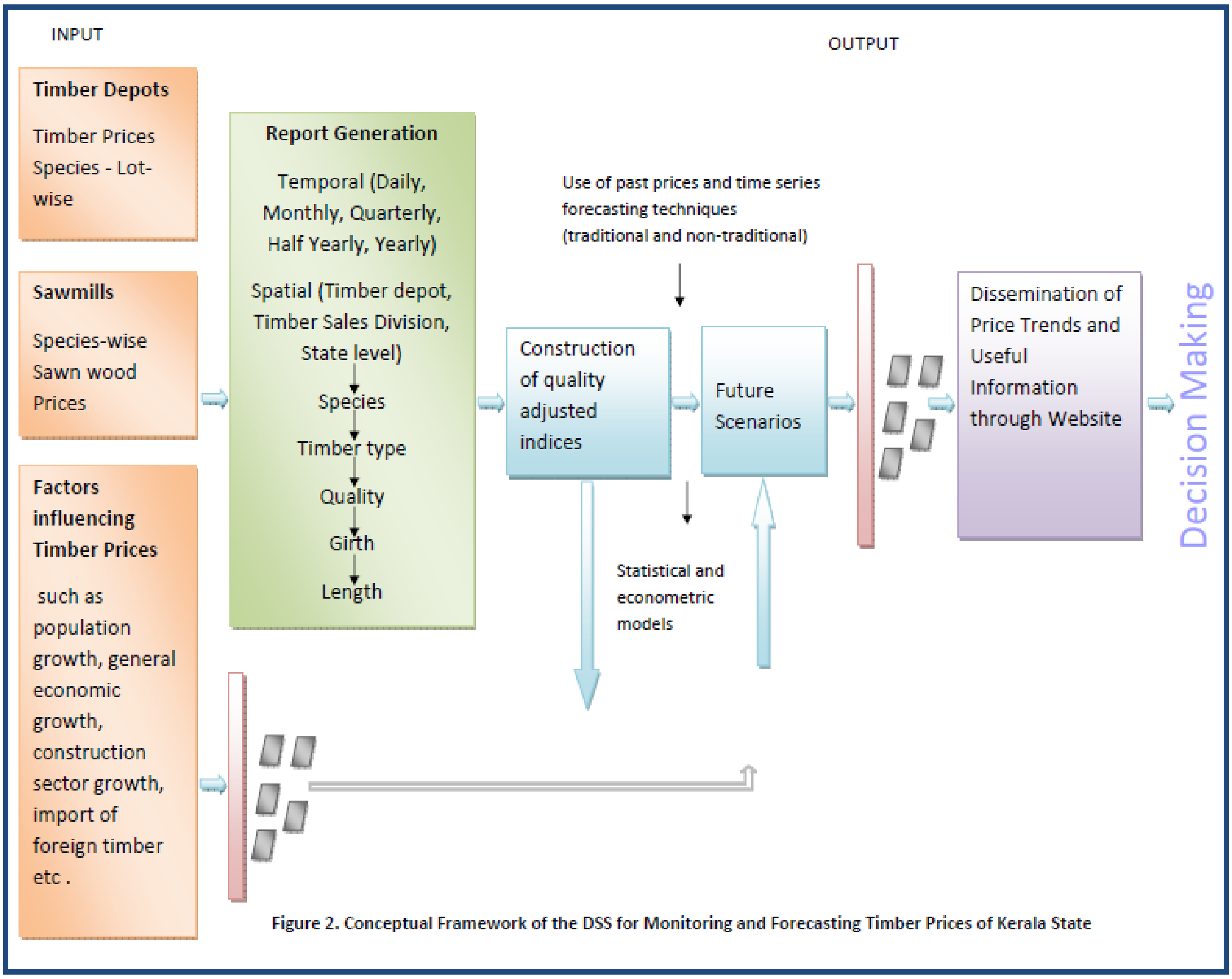


Figure 7. Schematic representation of the major components of the TMIS

i. Unweighted Price Index

Simple aggregate price index

$$P = \frac{\sum p_t}{\sum p_0} \times 100$$

where P is the price index , $\sum p_t$ is the sum of prices for the period t and $\sum p_o$ is the sum of prices for the base period.

ii. Weighted Price Index

Laspeyres Price Index (LPI)

$$P = \frac{\sum p_t q_0}{\sum p_0 q_0} \times 100$$

where P is the price index ,
p_t is the current price,
p_0 is the price in the base period and
q_0 is the quantity sold in the base period

Paasche Price Index (PPI)

$$P = \frac{\sum p_t q_t}{\sum p_0 q_t} \times 100$$

where P is the price index ,
p_t is the current price,
p_0 is the price in the base period and
q_t is the quantity sold in the current period

Fisher's Price Index

Fisher's price index is the square root of *LPI* and *PPI* given above.

iii. AGR

AGR is the ratio between the current year price index and previous year price index, expressed in percentage.

iv. Percentage volatility

Volatility is the ratio between the mean annual price index and its standard deviation, expressed in percentage.

3.3.2 Evaluation of Price Indices

The performance of price index constructed can be assessed by correlating with prices of its constituent items and prices of similar items but not being the part of the price index. If there is a significant correlation co-efficient exist then it can be inferred that the price index reflects the general trend in the prices of the set of all items of the product. Such exercise can be repeated with the prices of the product in other geographical areas to know how far the price index constructed reflects the price trends in other geographical areas.

3.4 Models for Forecasting Timber Prices

3.4.1 Forecasting models considered in TMIS

Curve fitting techniques are found useful in short term forecasting of prices based on past prices. The use of econometric price forecasting models requires information on endogenous and exogenous factors that influence prices and they need to be conceived and evaluated and then implemented in TMIS. However, at present TMIS considers only short term forecast models. The forecasting models and associated statistical tests regarded in TMIS are presented below.

i. Simple linear regression
ii. Exponential function
iii. Power function
iv. Logarithamic function
v. Parabola function
vi. Simple exponential smoothing and
vii. Double exponential smoothing

Tests of significance of parameters and 95% confidence interval for the parameters are also worked out for the above models.

3.4.2 Evaluation of forecasting models

The following fit statistics are employed in TMIS in order to enable user to evaluate various forecasting models and choose the best model.

i. Mean Square Error
ii. Root Mean Square Error
iii. Mean Absolute Error
iv. Mean Absolute Percentage Error
v. Coefficient of determination (R^2) and
vi. Adjusted R^2
vii. Akaike Information Criterion

3.5 Scope and Major Functional Features of TMIS Version 1.0

3.5.1 Scope

The major channels of sale of timber in India are i) Government Timber Depots for the timber extracted from forests and ii) Sawmills which cover both timber bought from Government Timber Depots and timber extracted from sources outside forests such as farm lands and home gardens. However, TMIS deals these two channels separately. The present version of TMIS deals with only Government Timber Depots. The sawmills are being considered for future release. In the case of construction, TMIS 1.0 considers only traditional approach. In recent years, hedonic approach is followed to account for temporal changes in quality attributes of the commodity while constructing prices indices. Such an approach will be considered in the future. The proposed DSS is data intensive and to some extent model intensive. The rules for DSS to make decisions by itself using knowledge gained from personal experiences as input will be considered for future developments. In TMIS 1.0, univariate forecasting models alone were considered. In the future release of TMIS, factors influencing timber prices such as timber supply from forests, import and export and the analytical models including econometric models will be considered.

3.5.2 Major Functional Features

Customizes data entry form

- It guides you to enter the species and define its major quality characteristics and their prices with meta data. Based on these data settings, it automatically creates a data entry form to input your data.

- Any time, you can display/edit/add/modify the data and its meta data.

A Data warehouse

- TMIS stores all transactional data over time and space and serves as a data ware house for data mining applications and future use.

Search engine

- TMIS facilitates to search your data at the lowest unit level (lot/record level) and based on search criteria such as location of the Timber Depot, species and its quality characteristics.

Report generation

The data displayed based on search criteria are also produced as reports with summary statistics and relevant graphs.

Export and Import

TMIS allows importing necessary data from Excel and also exporting your results to Excel.

Descriptive Statistics

TMIS provides a set of descriptive statistical measures for the chosen species and timber class which include amount received from sale of timber, quantity sold; range; trimmed mean; median; mode; sample variance; sample standard deviation; standard error; percentage volatility; skewness and kurtosis of the prices. These values will help to arrive at the timber classes to be included for the construction of price index.

Tracks timber price movements

TMIS aids you to develop timber price index based on prices of major species and quality classes to track the average timber price movement over time of one or more species. The formulae used for the price indices are presented in the previous section.

Forecasting of timber prices

TMIS also enables the user to forecast the prices of selected species and it s quality classes using univariate models based on past prices. The models used for forecasting are elaborated in the previous section.

Tabular and Graphical output

Once the formula is chosen, the trends in price indices are displayed for the specified species/all species and time period both in tabular and graphical form. The forecasts are displayed in both tabular and graphical form.

3.5.3 An Operation Manual of TMIS

A manual providing all the guidelines of TMIS has been prepared with relevant screen shots and examples (Appendix). The manual is also available with the help menu of TMIS.

4. APPLICATION OF TMIS VERSION 1.0- A CASE STUDY OF TIMBER MARKET OF KERALA STATE, INDIA

4.1 Study area and Database

The study was conducted in the state of Kerala, a narrow strip of land located in the south-west corner of the Indian Peninsula between north latitude 8 ^{o} 18` and 12$^{o}$ 48` and east longitude 74^{o} 52` and 77$^{o}$ 22`. It encompasses an area of 38,863 km^2. The state has a forest area of 11,309 km^2, of which about 13% is plantation forest. Teak is the major species contributing about 53% to the total area under forest plantations (KFD, 2009). In India, forests are managed by the Forest Departments of the State Governments under the guidelines of the Ministry of Environment and Forests, Government of India. The Kerala Forest Department is responsible for managing the forests including forest plantations in that State. The timber is felled only from forest plantations, timber felling from natural forests being banned.

Timber felled from forest plantations is deposited for sale in 30 Sales Depots across 6 Forest Sales Divisions. The timber supplied to each Forest Depot is mostly from neighbouring forest plantations. The major species sold through Sales Depots is teak. Round timber of teak is traditionally classified into 60 classes based on mid-girth, length and straightness and soundness of logs (Table 1) (KFD 2011). Though poles and billets were also graded, they are excluded here. Prior to sale, timber logs are arranged into lots based on quality attributes of the individual logs. A lot may contain one or more logs but the volume does not exceed 5 m^3.

Sale is by both tender and auction. The sales are awarded to the highest bidder. Timber grading and sale are carried out by the Manager of the Timber Depot under the supervision of the Officer of the Timber Sales Division.

Table 1 Criteria for major classification of teak wood and other species[2]

Straightness and soundness		Girth		Length	
Grade	Criteria	Girth class	Middle girth (cm)[a]	Length class	Length (m)
Teak					
A	Logs straight and sound without any defects	Export	185 and above	SL (Short log)	Above 1 and below 2.5
B	Fairly straight and sound logs	I	150 -184	ML (Lengthy log)	2.5 - 7.3
C	Defective and crooked logs	II	100 -149	LL (Long lengthy log)	above 7.3
D	Highly defective and crooked logs	III	75 – 99		
		IV	60 – 74		
Other Species					
A	Logs straight and sound without any defects	I	125 and above	ML	Above 1
B	Defective logs	II	Up to 124		

a. Middle log girth (under bark).

Price data were collected from Sales Depots by contacting them both in person and by mail at six monthly intervals, and were compiled for the analysis. The number of auctions covered during the period for the analysis was 421 which gave 4,518 data points over various quality attributes over a sale quantity of 60,811 m^3. The annual volatility of teak prices was expressed as the percentage of standard deviation to average current teak wood prices.

4.2 Methods

Because about 90% of timber sold is teak, it was decided to work out price index for teak and other species separately. To illustrate the computation of teak price index, round teak was alone considered. The possible number of round teak classes is 60 (excluding poles and billets). Out of this, major classes were worked out based on quantity sold (Fig. 8). About 82% of teak belongs to the classes viz., IIBML[2], IIIBML, IICML, IIICML and IVCML (Fig. 8). These major teak classes are transacted in all the years, consistently in considerable

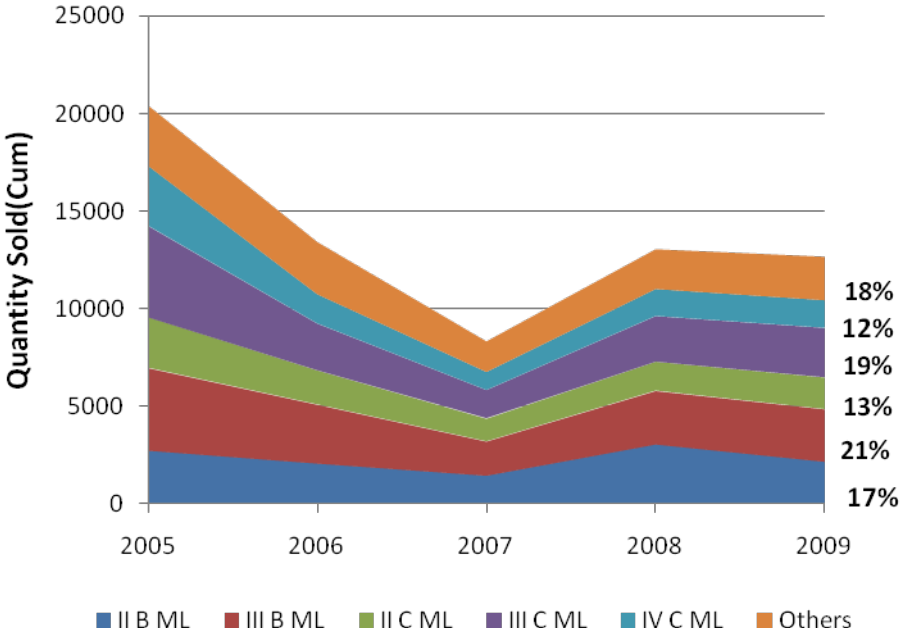


Figure 8. Quantity Sold According to Major Timber Classification (2005-2009)

quantity (over 10 percent to total quantity sold). Therefore, these classes could be indicative of teak price trends and used for developing a teak price index weighted for quantity sold. Three approaches in constructing price indices viz., Laspeyres Price Index (LPI), Paasche

Price Index (LPI) and Fisher's Price Index (FPI) were followed for tracking the teak wood prices. The price indices for other species *Artocarpus hirsutus, Grewia tiliifolia, Xylia xlocarpa, Terminelia paniculata, Terminelia bellirica, Terminelia tomentosa, Largerstroemia microcarpa* were worked out using Simple aggregate price index (unweighted) because those species were sold in small quantity. The combined timber price index excluding teak was also worked out by taking the average of the species-wise price index, excluding teak.

All the price indices were worked out with 2005 as base year (Base year 2005 =100). Based on year to year variation, the mean annual growth rate and annual percentage volatility of teak wood were also worked out.

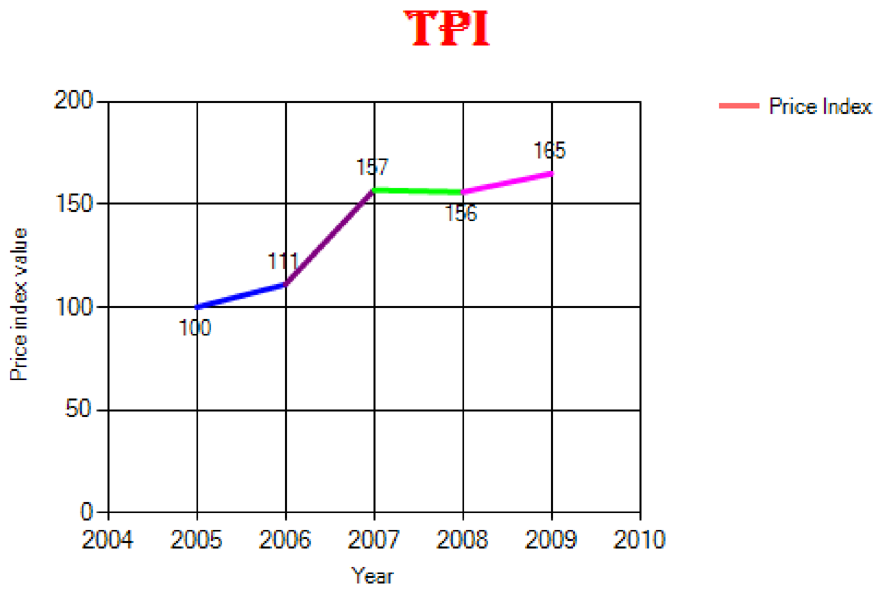
In order to know how far trends in price indices constructed using the three approaches reflect the trends in prices of various teak wood classes correlation analysis was carried out by relating the teak price indices with actual current prices of all the classes of teak wood.

4.3 Results and discussion

4.3.1 Teak Price Indices

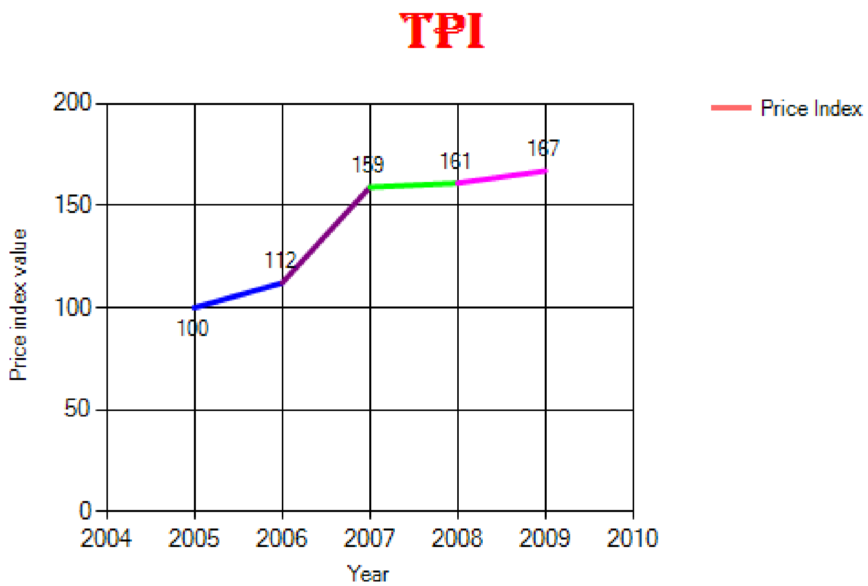
The teak price indices reveal that the maximum growth in teak prices was during the period 2006 to 2007 by about 46 points. This could be attributed to short supply of teak wood from forest plantations coupled with high timber demand from the unprecedented growth in house construction and furniture making. Only a marginal increase was seen from 2008 onwards, perhaps due to the impact of the global financial crisis.

The values of all the three types of weighted teak price indices (Laspeyre's, Pasche's and Fisher's) were almost showing the same trend (Fig. 9,10 & 11).



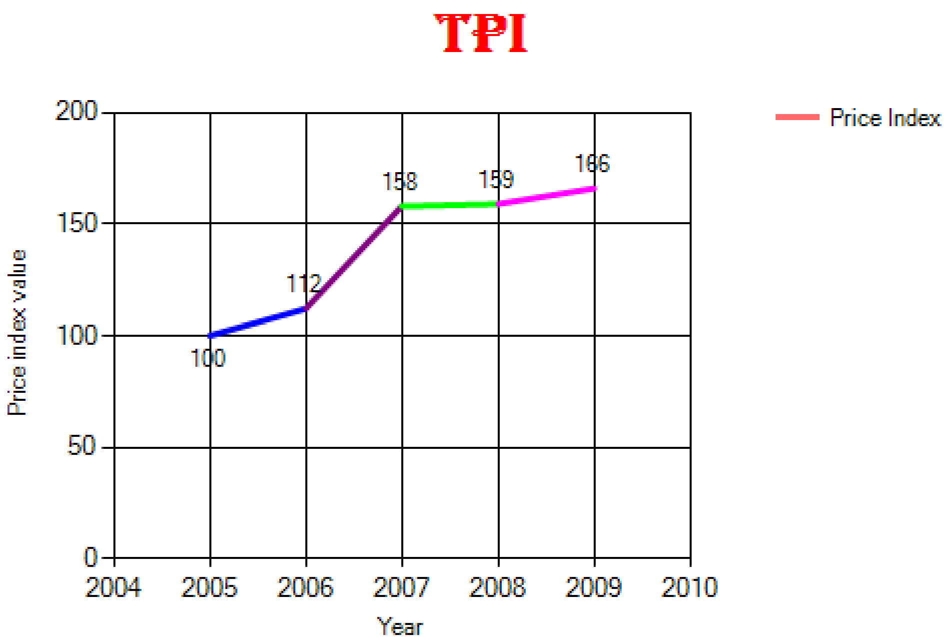
Mean Annual Growth: 11.52%; Annual Volatility: 22.73%

Figure 9. Trends in teak price index using Laspeyre's approach



Mean Annual Growth: 11.8%; Annual Volatility: 22.38%

Figure 10: Trends in teak price index using Pasche's approach



Mean Annual Growth: 11.62; Annual Volatility: 22.0

Figure 11. Trends in teak price index using Fisher's approach

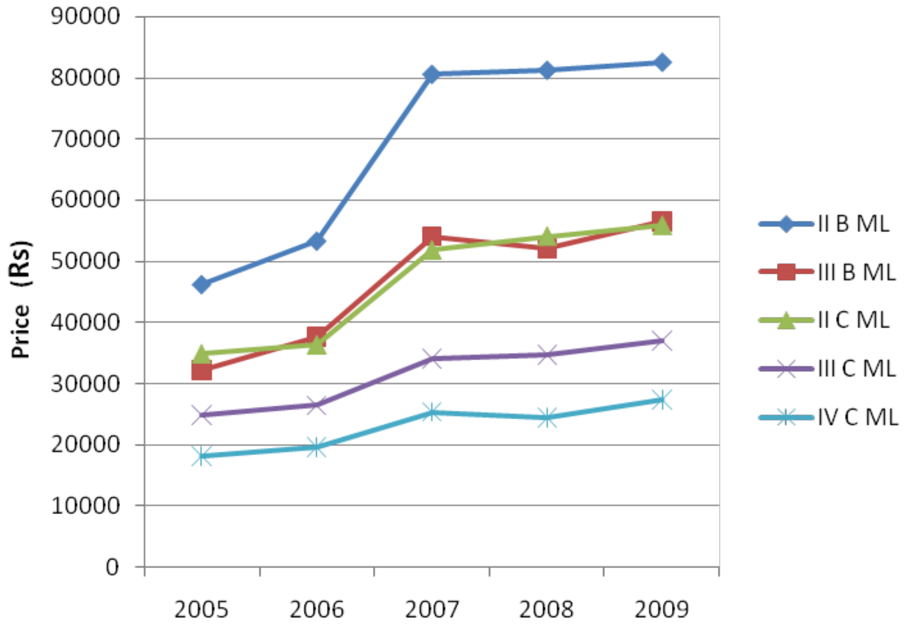


Figure 12. Price Trends of Major Quality Classes (2005-2009)

The mean annual growth rate based on these three approaches was almost same, ranging from 11.52 to 11.80. Similarly, the annual percentage volatility was also same (22 to 22.73).

The trends in all the three types of teak price indices as generated by TMIS closely resemble the trends in actual prices of selected classes shown in Figure 12. The correlation analysis also indicates that the trends in teak price indices by and large reveal the prices of different teak wood classes (Table 2). The non-significance of correlation coefficients in certain girth classes could be due to sample size and the inconsistent prices due to small quantity sold in those classes.

Table 2 Correlation matrix relating trends in Teak Price Indices and Prices of various Teak Classes

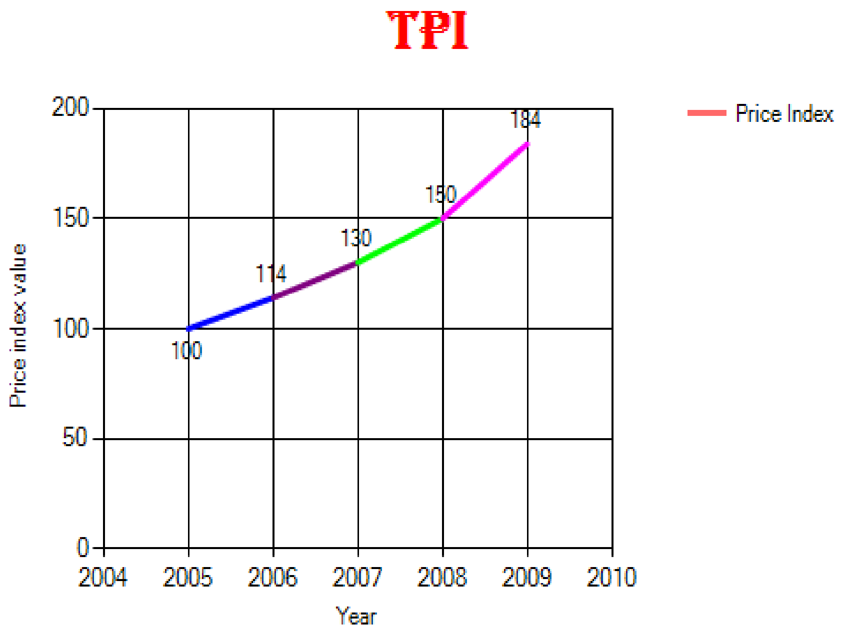
Class	Laspeyre's PI	Pasche's PI	Fisher's PI
A EXP ML	0.636	0.627	0.630
A I ML	0.714	0.741	0.731
A II ML	0.915*	0.930*	0.925*
A III ML	0.950*	0.957*	0.956*
A IV ML	0.918*	0.920*	0.919*
A II LL	0.495	0.494	0.493
A III LL	0.976**	0.967**	0.970**
A IV LL	0.340	0.379	0.366
A II SL	-0.500	-0.497	-0.494
A III SL	0.508	0.486	0.494
B EXP ML	0.968**	0.976**	0.973**
B I ML	0.976**	0.980**	0.978**
B II ML	0.997**	0.999**	0.998**
B III ML	0.997**	0.995**	0.996**
B IV ML	0.965**	0.968**	0.969**
B EXP LL	0.641	0.614	0.622
B I LL	0.888*	0.889*	0.890*
B II LL	0.859	0.858	0.860
B III LL	0.951*	0.947*	0.948*
B IV LL	0.952*	0.955*	0.955*
B EXP SL	0.508	0.486	0.494
B I SL	0.691	0.706	0.701*
B II SL	0.876	0.876	0.879
B III SL	0.469	0.476	0.478
B IV SL	0.853	0.858	0.859

Class	Laspeyre's PI	Pasche's PI	Fisher's PI
C EXP ML	0.763	0.782	0.775
C I ML	0.880*	0.895*	0.890*
C II ML	0.993**	0.995**	0.994**
C III ML	0.995**	0.994**	0.994**
C IV ML	0.986**	0.979**	0.982**
C EXP LL	-0.151	-0.159	-0.153
C I LL	0.934	0.948	0.944
C II LL	0.765	0.772	0.771
C III LL	0.959*	0.966**	0.964**
C IV LL	0.905*	0.914*	0.912*
C EXP SL	0.896*	0.901*	0.900*
C I SL	0.931*	0.919*	0.924*
C II SL	0.244	0.236	0.234
C III SL	0.417	0.409	0.407
C IV SL	0.955*	0.956*	0.957*
D EXP ML	0.340	0.379	0.366
D I ML	0.915*	0.918*	0.919*
D II ML	0.268	0.270	0.274
D III ML	0.463	0.453	0.461
D IV ML	0.568	0.553	0.562
D IV LL	0.508	0.486	0.494
D I SL	0.694	0.707	0.703
D IV SL	0.456	0.490	0.480

***=Significant at 0.05 level; **=Significant at 0.01 level**

4.3.2 Price Index of other Species

The combined unweighted price index of other species shows that the mean annual growth rate is 13.22%; which is higher as compared to teak price index. Similarly, the annual volatility (24.29%) was also higher than for teak price index. This indicates that there has been a preference for other timber species over teak in the timber auctions may be due to high prices of teak wood.



Mean Annual Growth: 13.22%; Annual Volatility: 24.29%

Figure 13. Combined Price Index of other Species excluding Teak (2005-2009)

4.3.3 Forecasting of Timber Prices

Forecasting of next year price is depicted in Figure 14 for the quality class BII. It is possible to forecast future prices upto next 5 years. However, the models integrated with TMIS are suitable for short term forecast (next year forecast). Figure 15 provides a number of fit statistics for the logarithmic model fit. Similarly, fit statistics can be obtained for each of the model fit for choosing the best model for forecasting with least error values such as average percentage error.

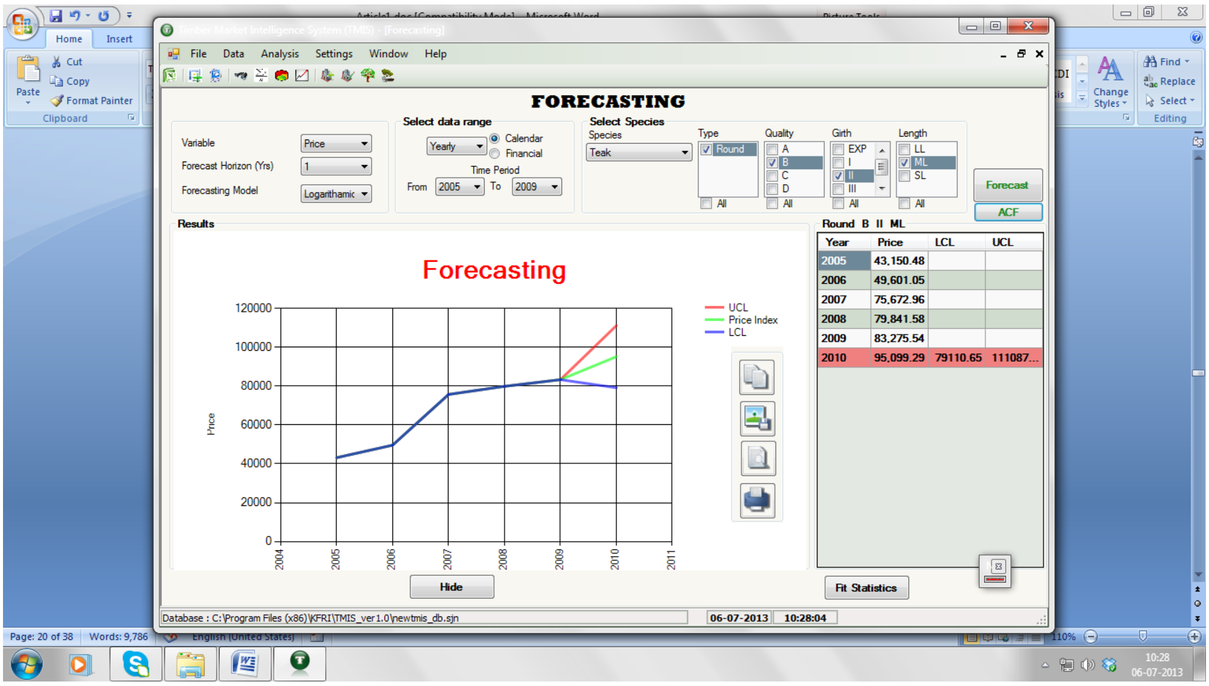


Figure 14. Graph showing next year forecast for the year 2010 for the quality class BII based on the prices from 2005 to 2009 using logarithmic model

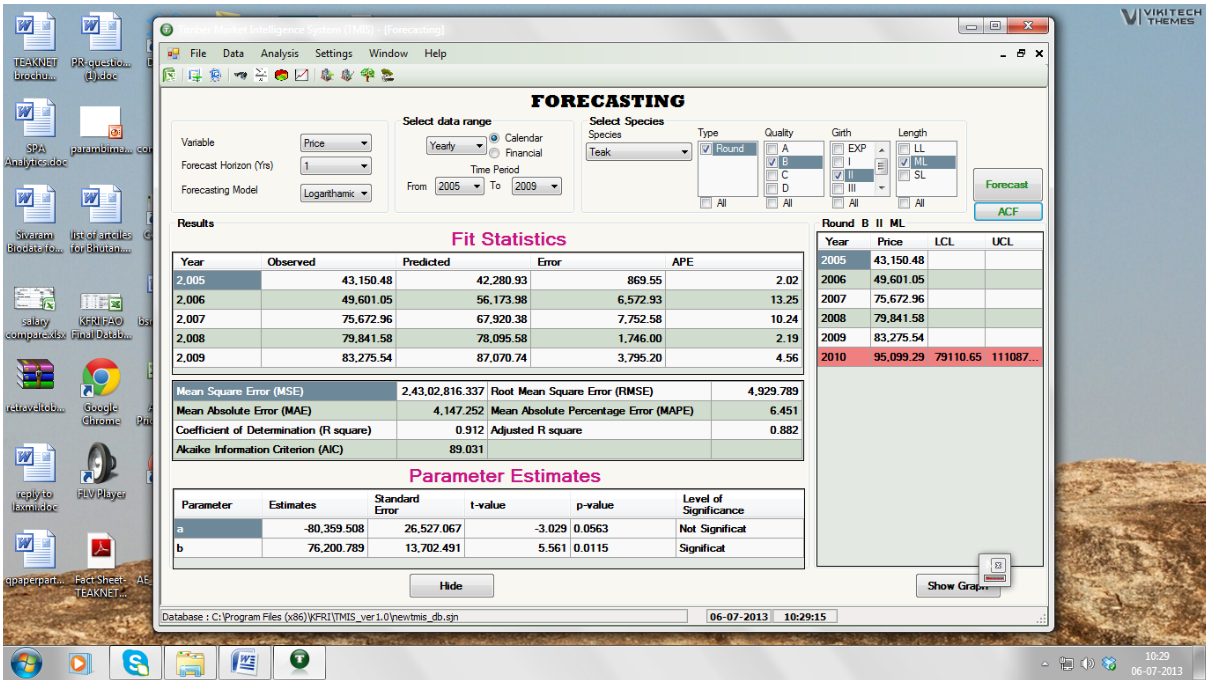


Figure 15. Fit statistics of the chosen logarithmic model for the next year forecast for the quality class BII base on the prices from 2005 to 2009

4.3.4 Discussion

It is evident that TMIS is a useful tool to monitor the prices of various timber species across number of quality classes. The results indicated that one of the three approaches of construction of price index (Laspeyre's, Pasche's and Fisher's) is sufficient to track the timber prices. In the case of other species *Artocarpus hirsutus, Grewia tiliifolia, Xylia xlocarpa, Terminelia paniculata, Terminelia bellirica, Terminelia tomentosa, Largerstroemia microcarpa* Simple aggregate price index was found useful

TMIS version 1.0 can be used as a standard tool in the most State Forest Departments of India and other countries to compile and retrieve price information of various species and work out summary measures like timber price indices to monitor the market. Since TMIS is a data based decision support system tool, the data availability has to be ensured at regular intervals for updating the database.

It is not possible to cover all the components of TMIS in a single development cycle. However, it is proposed to cover additional components of TMIS such as econometric timber price models in the future versions of TMIS.

4.3.5 Potential users of TMIS

TMIS will work out price index (a baromèter) to monitor the timber market, which will help to analyse trends in timber trade. It will benefit Central and State Governments especially Timber Sales Divisions, Timber Price Fixation Committees of the State Forest Departments, tree growers, timber traders, constructors and consumers.

4.3.6 Future release of TMIS

The future release of TMIS will consider timber transactions in saw mills and have in-built statistical and econometric models for forecasting timber prices.

5. REFERENCES

AKABUA, K. M., ADAMOWICZ, W. L. and BOXAL, P. C. 2000. Spatial non timber valuation decision support systems. *The Forestry Chronicle* **76**(2): 319-327.

DAVID SKYRME ASSOCIATES. 2013. Market Intelligence System (Mkis). (http://www.skyrme.com/insights/9mkis.htm). Accessed on 21 July 2013

FERRETTI, F., DIBARI, C., MEO, I. D., CANTIANI, P. and BIANCHI, M. 2011. Progettobosco: A data-driven decision support system for forest planning. *Mathematical and Computational Forestry & Natural-Resource Sciences* **3**(1): 27-35.

FORDAQ. 2013. Fordaq Timber Index. (http://timber.fordaq.com/fordaq/Wood-Price-Index.html). Accessed on 21 July 2013.

FORESTRY COMMISSION. 2013. Timber Price Indices. (http://www.forestry.gov.uk/forestry/infd-97hehe). Accessed on 21 July 2013.

HENNIGAR, C. R., WILSON, J. S., MACLEAN, D. A. and WAGNER, R. G. 2011. applying a spruce budworm decision support system to maine: projecting spruce-fir volume impacts under alternative management and outbreak scenarios. *Journal of forestry* 109(6): 332-342.

HPE. (2013). The HPE Price Index. (http://www.hpe.de/fakten-ampzahlen/hpe-preisindex/hpe-price-index/). Accessed on 21 July 2013.

ICFRE. 2010. *Forest Sector Report- India*. Indian Council of Forestry Research and Education, Dehradun.

ITTO. 2013. *Annual Review Statistical Database*. (http://www.itto.int/annual_review_output/). Accessed 21 July 2013.

JINZHUO, W., JINGXIN, W., YAOXIANG, L. and BEN, S. 2012. A web based decision support system for analyzing timber harvesting costs and productivity. *Northern Journal of Applied Forestry* 29(3): 141-149.

KFD. 2009. *Forest Statistics 2009*. Kerala Forests and Wildlife Department, Thiruvananthapuram, India.

KFD. 2011. *Forest Guide-2011*. Forestry Information Bureau, Kerala Forests and Wildlife Department, Thiruvananthapuram, India

KERSTEN, G.E. and YEH, Z. M. A. G. 2000. *Decision support systems for sustainable development: A resource book of methods and applications:* 391-407.

KRISHNANKUTTY, C. N. 2002. Factors influencing teak prices in Kerala. *Indian Journal of Forestry* **25** (1): 25-29.

KRISHNANKUTTY, C. N., THAMBI, K.B. and Chundamannil M. 2005. *Wood-balance study in Kerala and market survey*. KFRI Research Report No. 268. Kerala Forest Research Institute, Peechi.

KUHMAIER, M. and STAMPFER, K. 2010. Development of a multi-attribute spatial decision support system in selecting timber harvesting systems. *Croat. J. for. Eng* **31**(2): 75-88.

NATIONAL HOUSING BANK. 2012. *NHB Residex*. (http://nhb.org.in/Residex/residex.php). Accessed on 21 July 2013.

OFFICE OF THE ECONOMIC ADVISOR TO GOVERNMENT OF INDIA.2013. *Whole Price Index*. (http://eaindustry.nic.in/). Accessed on 21st July 2013.

PALANDER, T and VOUTILAINEN, J. 2013. A decision support system for optimal storing and supply of wood in a Finish CHP plant. *Renewable Energy*. 52: 88-94.

POWER, D.J. 2007. A Brief History of Decision Support Systems. DSSResources.COM, World Wide Web, (http://DSSResources.COM/history/dsshistory.html). Version 4.0, March 10, 2007.

RAUSCHER, H.M., REYNOLDS, K., VACIK, H. 2005. Decision-support systems for forest management. *Computers and Electronics in Agriculture* **49**(1): 1-5.

RONDEUX, J., HEBER, J., CLAESSENS, H. and LEJEUNE, P. 2010. *A silvicultural decision support system to compare forest management scenarios for larch stands on a multi criteria basis*. (**Error! Hyperlink reference not valid.** on 11th April 2013.

SIVARAM, M. 2008. *Computerized database on Kerala forest resources and data retrieval system*. KFRI Research Report No. 320. Kerala Forest Research Institute, Peechi.

SIVARAM, M and NAYANA, K.G. 2013. Hedonic price analysis of teak logs. *Small-scale Forestry*. (available first online) (hard copy is in print).(http://link.springer.com/article/10.1007%2Fs11842-012-9233-z). Accessed on 21 August 2013.

WOOD RESOURCES INTERNATIONAL LLC, 2013. *The Global Wood Fiber Index*. (http://www.wri-ltd.com/woodFiberIndex.cfm). Accessed on 21 July 2013.

YAOXIANG, L. 2009. Development of a computer-aided decision support system for timber harvesting operations in forestry industry. *Industrial Mechatronics and Automation. ICIMA 2009.* (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=5156672). Accessed on 11th April 2013.

APPENDIX