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Procedia Computer Science 57 (2015) 112 – 121

Procedia Computer Science

3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015)

# Forecasting the land price using statistical and neural network software

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**Abstract**

This paper focuses on the modelling and forecasting of land price in Chennai Metropolitan Area (CMA) in the state of Tamilnadu, India using multiple regression and neural network techniques. Thirteen locations spread over CMA are selected at random as study areas. The monthly average values of the selected factors from the year 1997 to 2011 are considered to develop the models. Both multiple regression and neural network models are validated with the market price in the year 2012 and 2013. After validation the models are used to forecast the land price in CMA for the years 2014 and 2015. Both the models are found to be well fit for the trend of land price; however the model using neural network shows better accuracy. A careful examination of the results of forecasting bring to lime light the surge in growth of land prices in the southern and western parts of CMA.

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Peer-review under responsibility of organizing committee of the 3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015)

*Keywords: Economical factors; Modelling of land price; Performance evaluation; Validation; Forecast*

## 1. Introduction

The study on land price trend is felt important to support the decisions in urban planning. The real estate system is an unstable stochastic process. Investors' decisions are based on the market trends to reap maximum returns. Developers are interested to know the future trends for their decision making. To accurately estimate property prices and future trends, large amount of data that influences land price is required for analysis, modelling and forecasting.

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Peer-review under responsibility of organizing committee of the 3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015)
doi:10.1016/j.procs.2015.07.377

The factors that affect the land price have to be studied and their impact on price has also to be modeled. An analysis of the past data revealed that the prices show a non- linear characteristic. It is inferred that establishing a simple linear mathematical relationship for these time-series data is found not viable for forecasting. Hence it became imperative to establish a non-linear model which can well fit the data characteristic to analyze and forecast future trends. As the real estate sector is fast developing in Chennai Metropolitan Area (CMA), the analysis and forecast of land prices using mathematical modeling and other scientific techniques is an immediate urgent need for decision making by all those concerned.

The present extent of CMA is 1189 sq. km. Apart from the Chennai Corporation, the CMA comprises of 16 municipalities, 20 town panchayats and 204 villages that forms part of 10 Panchayat Unions in the adjoining Thiruvallur and Kancheepuram districts (Development Plan for Chennai Metropolitan Area) [1]. The Chennai City is the core of CMA and is the nerve centre for all commercial and social activities as well as living area for majority of the population. Chennai has immense potential to become the cynosure of economic and cultural development. Recent past has witnessed a substantial growth in population in both Chennai City and Chennai Metropolitan Areas. Statistics reveal that the population in the year 2009 was 55 lakhs in the City and 70 lakhs in CMA. It has been found that the contribution of CMA to state Gross Domestic Product (GDP) is around 40%. Chennai alone accounts for 30% of National Auto Industry, 50% of leather exports and 15% of software export**s**. The increase in population as well as the industrial activity is attributed to various factors, the most prominent being the recent spurt in the knowledge sector viz. Information Technology (IT) and Information technology enabled services. Demand for land started of showing an upward trend and housing and the real estate activity started booming. All barren lands and paddy fields ceased their existence to pave way for multistoried and high rise buildings. Investments started pouring in Real estate Industry and there was no uniform pattern in the land price over the years. The need for predicting the trend in land prices was felt by all in the industry viz. the Government, the regulating bodies, lending institutions, the developers and the investors.

Over the last two decades there have been a large number of empirical studies analyzing land prices. Kilpatrick [2] showed the usefulness of time-series regression model which used economic data to provide forecast of Central Business District (CBD) land price in moving market. Wilson et al. [3] studied the residential property market accounts for a substantial proportion of UK economic activity. Valuers estimate property values based on current bid prices. In this paper, the national housing transaction data was trained using Artificial Neural Networks (ANN), which forecasts future trend of the housing market. Mark and John [4] developed a regression model with vacant land sales. The model explained up to 93% of the market values. Wang and Tian [5] used the wavelet Neural Network (NN) to forecast the real estate price index. This kind of wavelet NN integrated the merit of the wavelet analysis and the tradition NN. It also compared the forecasting result with smoothing method and the NN forecast.

Zhangming [6] forecasted the real estate price index by using the Back Propagation (BP) NN. The BPN used the sigmoid function. Tinghao [7] used the Auto Regressive Integrated Moving Average (ARIMA) model and carried the demonstrative analysis on year data from 1998 to 2006. He used the established model to make the forecast to the real estate price index of 2007. David and Paavo [8] documented Chennai's spatial development with detailed data on land use, population density and land values. A hedonic regression on the price of land suggested that de facto policy differences between political jurisdictions have had a significant effect on land prices between1970 and 1980. Steven and Albert [9] used 46,467 residential properties spanning 1999 - 2005 and demonstrated that using matched pairs that relative to linear hedonic pricing models, ANN generate lower dollar pricing errors, had greater pricing precision out-of-sample, and extrapolate better from more volatile pricing environments. ANN is better suited to hedonic models that utilize large numbers of variables. Sampathkumar and Santhi [10] studied the land price trend of Sowcarpet which is the central part of Chennai city. They developed statistical model using economic factors and predicted that the annual rise in land price would be of 17%.

Urmila [11] reported that the past trends were analyzed to ascertain the rate of growth or decline and the trends are used in forecasting. Economic parameters might be introduced to formulate more realistic relationship. A survey by 99acres.com [12] revealed that the property price trends for the Chennai region had seen an escalation in 2011

over 2010. Chennai market was relatively strong and stable in nature as indicated by the year on year healthy price increase. Chennai North shows that the property prices of Ambattur at 7% increase, Porur in Chennai West witnessed price appreciation by 17%. Chennai South, in Thiyagaraya Nagar saw prices appreciate in the range of 20%. ICICI Property services [13] reported that the micro markets closer to the city would continue to show homebuyer interest. The micro markets of Oragadam and Sriperumbudur are witnessing key infrastructural developments, which would help to improve connectivity to the city. In the current scenario, the products in this segment are expected to a moderation in pricing of 5% - 10% over a 12-month horizon. ICICI Property services [14] showed that over the long term, it is expected that the residential real estate prices in Chennai to increase at 7-10% every year as the city emerges into a major IT, automobile and electronic manufacturing hub. Although many factors are responsible for land price at any locality, it is learnt that using economic attributes as influencing factors would give reliable results. The present study aims to bring out the significance of economic and social attributes pertaining to the modeling and forecasting of land price in CMA.

The list of significant attributes which influence the land price trend are shown in Table 1. Modelling is based on the relationship between the indicators and the price of land (dependent variables). The price of land in CMA is influenced by various factors. In order to know the average land price of any area in CMA, the market price is collected from 13 locations spread over CMA. The selected areas lie in 6 zones of CMA, namely Central, North, North West, South East, South West and West. The zone-wise distribution sample locations in CMA are presented in Table 2 and the locations of various study areas in CMA are shown in Fig. 1.

Table 1. List of Independent variables

| Variable names | Abbreviation |
|---|---|
| Gross Domestic Product (%) | GDP |
| Cost of Crude Oil ($) | Croil |
| Dollar equivalence to Indian currency (₹) | Doll |
| Rate of inflation (%) | Infla |
| Gold and Silver price per gram (₹) | Gold, Sil |
| Mumbai and National share index | BSE, NSE |
| Population in the study area | Pop |
| Interest rate on home loan (%) | HL |
| Unit cost of construction per Square foot (₹) | CC |
| Guideline value per ground (₹) | GLV |
| Time factor (Year and Month) | Time |

Table 2 Study areas

| Zones | Name of the Locations |
|---|---|
| Central | Sowcarpet, Chindadripet |
| North | T hiruvottiur, Tondiarpet |
| North West | Madavaram |
| South East | Thiruvanmiyur, Neelankarai, Sholinganallur |
| South West | T.Nagar, Tambaram |
| West | Avadi, K.K.Nagar, Ambattur |

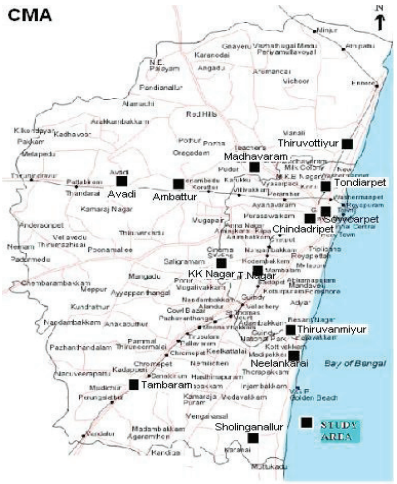


Fig. 1 Location of study areas in CMA

## 2. Analysis and modeling of land price

### *2.1 Data collection*

The study involves both primary and secondary data. Primary data has been collected through interviews and personal visits to the various companies to know the present situation of the market and the secondary data is collected through newspapers, magazines, internet and Reserve Bank of India review. The data between January 1997 and December 2013 are used in the analysis. The data is useful for assessing the performance of property as a key to future investment.

### *2.2 Multiple regression technique*

Regression analysis is widely used for forecasting. Regression analysis is used to understand which among the independent variables are related to the dependent variable, and to explore the forms of these relationships. If more independent variables are added, it is able to determine an estimating equation that describes the relationship with greater accuracy. Multiple regressions look at each independent variable and test whether it contributes significantly to the way the regression describes the data.

The general multiple regression equation is

$$Y = a + b1x1 + b2x2 + \cdots bnxn \quad (1)$$

Where, Y = Estimated value corresponding to the dependent variable, a = Y intercept; x1, x2…xn = values of n independent variable, x1 = Guideline value (GLV) in rupees (₹), x2 =Population , x3 = Bombay Sensex (BSE) Index, x4 = National Sensex (NSE) Index, x5 = GDP (%), x6 = Inflation (%), x7 = Crude oil per barrel ($), x8 = Gold price per gram (₹), x9 = Silver price per gram (₹), x10 = Dollar equivalence (₹), x11 = Cost of construction per Square foot (₹), x12 = Home loan interest (%) and x13 = Time (Year & Month)
b1, b2…bn = slopes associated with x1,x2…xn respectively.

### *2.3 Neural network technique*

NN is a computational technology from the artificial intelligence discipline whose architecture emulates the network of nerve cells in the human brain. A NN is a parallel distributed information-processing structure consisting of processing elements (PEs) which contains local memory. NN architecture such as a standard BP NN can be developed by using the various indicators as PEs to be investigated upon. The approach presents the application of NN for modelling the land price trend with the support of economic and social factors. NN model is constructed with 13 indicators that are PEs with one bias node as input. All the input values are normalized using the MinMax. The principle behind normalization process is given in Eq. (2).

$$\text{Normalized value, } N = \frac{[\text{Original value} - \text{Minimum value}]}{[\text{Maximum value} - \text{Minimum value}]} \tag{2}$$

where, $0 \leq N \leq 1$

Initially 204 sets of exemplars are generated as monthly basis from the year 1997 to 2013 for 13 parameters (GDP, cost of crude oil, dollar equivalence, rate of inflation, gold and silver price, Mumbai and National Share Index, etc) as input and unit land price as output parameter. The NN architecture, used in this study, is a multilayer feed forward network. Levenberg – Marquardt algorithm is used for training in multilayer NN. A five layered BPN has been developed with three hidden layers and one output layer. The architecture which provides the best fit for the data is the networks with 3 hidden layers and an output layer is shown in Fig.2. The neurons in the hidden layers are 20, 13, 13 respectively and one neuron in the output layer. The learning and momentum parameters are 0.6 and 0.9 respectively and error convergence to fall below 0.01%. Tan sigmoid is the activation function chosen for hidden layers and pure linear is the function for output layer which are the real time values. The network is efficiently trained with 204 exemplars and the weights are properly updated. In order to implement the trained network for land price validation and forecasting the updated weights are copied from NN tool box as the weights of BPN. The weights are obtained in layers as input to first hidden layer, first to second hidden layer and second to third hidden layer and with bias values. The 24 exemplars are used to validate the network for the years 2012 and 2013 and 24 exemplars of 2014 and 2015 are used for forecasting the land price for which the trained network runs again.

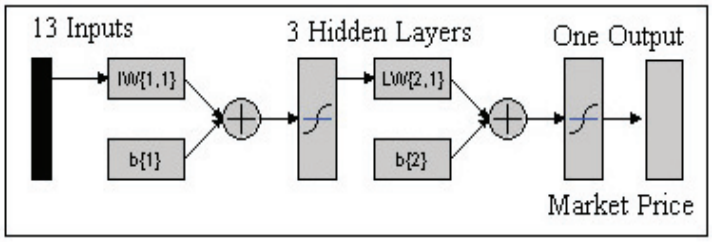


Fig.2 Neural network architecture

## 3. Results and Discussion

### *3.1 Interaction of Influencing Factors*

To measure the magnitude of linear relationship of land price (Y) on individual factor (X), correlation analysis is performed. Correlation analysis is a statistical tool, which is used to determine the degree of which one variable is linearly related to another. The general form of correlation is given by Eq. (3).

$$\text{Correl}(x,y) = \frac{\sum (x-x')(y-y')}{\left[\sum (x-x')^2 \sum (y-y')^2\right]^{1/2}} \quad (3)$$

The interaction of all the selected factors on land price is analyzed and is shown in Table 3. Other than Inflation, Dollar equivalence and home loan interest all factors show good closeness. Multiple regression analysis is performed with 95 % confidence level and 5 % error significance and the analysis explains the trend very closely with a $R^2$ ranges between 0.97 and 0.99.

Table 3 Interaction of the selected factors on land price

| Factors | Thiruvottiyur | Tondiarpet | Madhavaram | Sowcarpet | Chindadripet | K.K Nagar | Ambattur | Avadi | T.Nagar | Tambaram | Thiruvanmiyur | Neelankarai | Shollinganallur |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GLV | 0.92 | 0.88 | 0.94 | 0.88 | 0.76 | 0.86 | 0.90 | 0.53 | 0.86 | 0.91 | 0.79 | 0.90 | 0.78 |
| Pop | 0.90 | 0.70 | 0.90 | 0.95 | 0.88 | 0.98 | 0.69 | 0.69 | 0.95 | 0.91 | 0.83 | 0.86 | 0.90 |
| Time | 0.88 | 0.96 | 0.90 | 0.96 | 0.89 | 0.99 | 0.94 | 0.94 | 0.95 | 0.88 | 0.85 | 0.88 | 0.85 |
| BSE | 0.86 | 0.89 | 0.87 | 0.90 | 0.94 | 0.84 | 0.90 | 0.90 | 0.86 | 0.87 | 0.92 | 0.87 | 0.93 |
| NSE | 0.86 | 0.92 | 0.88 | 0.93 | 0.97 | 0.87 | 0.92 | 0.92 | 0.89 | 0.87 | 0.93 | 0.89 | 0.95 |
| GDP | 0.39 | 0.60 | 0.44 | 0.64 | 0.62 | 0.59 | 0.56 | 0.56 | 0.53 | 0.41 | 0.45 | -0.18 | 0.50 |
| Infla | -0.21 | -0.05 | -0.21 | 0.03 | 0.02 | -0.05 | -0.09 | -0.09 | -0.04 | -0.19 | -0.13 | 0.44 | -0.08 |
| Croil | 0.88 | 0.89 | 0.88 | 0.88 | 0.87 | 0.88 | 0.90 | 0.90 | 0.85 | 0.88 | 0.88 | 0.86 | 0.87 |
| Gold | 0.96 | 0.93 | 0.97 | 0.91 | 0.93 | 0.88 | 0.95 | 0.95 | 0.92 | 0.97 | 0.99 | 0.97 | 0.97 |
| Sil | 0.88 | 0.92 | 0.90 | 0.93 | 0.96 | 0.88 | 0.93 | 0.93 | 0.91 | 0.89 | 0.94 | 0.91 | 0.96 |
| Doll | -0.10 | -0.03 | -0.16 | -0.04 | -0.16 | 0.07 | -0.09 | -0.09 | 0.08 | -0.13 | -0.19 | -0.11 | -0.20 |
| CC | 0.99 | 0.97 | 0.99 | 0.94 | 0.94 | 0.96 | 0.98 | 0.98 | 0.97 | 0.98 | 0.98 | 0.99 | 0.96 |
| HL | -0.47 | -0.64 | -0.47 | -0.67 | -0.54 | -0.69 | -0.59 | -0.59 | -0.55 | -0.47 | -0.39 | -0.45 | -0.41 |

### *3.2 Behaviour of land price in CMA*

The market price of land from the year 1997 to 2011 used to develop Multiple Regression and ANN models. The models are validated for the years 2012 and 2013. The model for the entire CMA is developed using the details of data collected from all the 13 study locations and is given in the eq. (4). The land price performance using multiple regression and ANN models for the CMA is plotted in the Fig. 3. It can be seen that the behaviour of actual land price goes well along with the NN prediction than regression.

$$\begin{aligned}\text{Land price per 5.5 cents of CMA} &= -1.245E9 + 1.737 * x1 + 3.954 * x2 + 495.572 * x3 - 937.873 * x4 - 46827.42 * x5 \\ &- 100853.013 * x6 - 66334.343 * x7 + 667.16 * x8 + 56462.602 * x9 - 129139.534 * x10 \\ &- 3848.863 * x11 + 2508025.019 * x12 + 624568.165 * x13 \quad (4)\end{aligned}$$

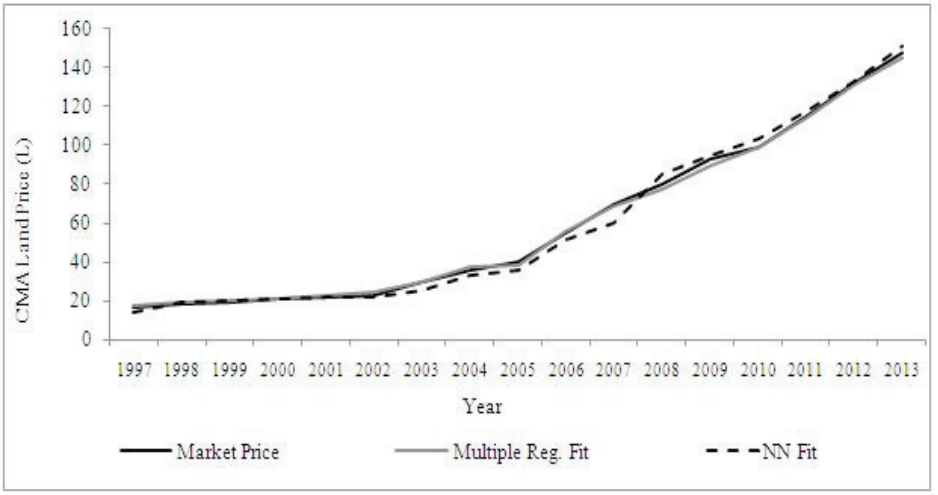


Fig.3 Validation of land price at CMA

### *3.3 Performance evaluation of the model*

Accuracy of model is examined using standard measures, such as Chi-square test ($\chi^2$), Mean Absolute Percentage Error (MAPE) and Percentage Root Mean Squared Error (PRMSE). The consolidated results of model evaluation by Chi-Square Test, MAPE and PRMSE are tabulated in Table 4. Null hypothesis is assumed in the chi-square test that there is no significant difference between the observed and expected price of land. The $\chi^2$ values are obtained for all the 13 locations under study. The Table value of $\chi^2$ is 21.03 with 5% level of significance. It can be seen that the $\chi^2$ values are much lower than the table value, so the null hypothesis is accepted and proved that the models developed are significant. MAPE is commonly used in quantitative forecasting methods because it produces a measure of relative overall fit. In this investigation it is observed that the MAPE values obtained from Regression is less than 15% and the same from ANN model is lesser than 5%. This observation reveals that both the models are found good for the prediction of land price in CMA. In PRMSE, both regression and NN models show errors less than 12% which demonstrates the significance of the modelling methods. The low PRMSE values (< 5%) indicate the performance of NN in predicting the system.

Table 4 Model evaluation

| | Chi-Square test | | MAPE | | PRMSE | |
|---|---|---|---|---|---|---|
| Location | Regression | NN | Regression | NN | Regression | NN |
| Thiruvottiyur | 0.50 | 0.22 | 6.78 | 0.00 | 7.03 | 0.05 |
| Tondiarpet | 0.10 | 0.09 | 1.80 | 0.72 | 4.46 | 0.84 |
| Madhavaram | 0.18 | 0.48 | 1.80 | 3.82 | 6.18 | 3.11 |
| Sowcarpet | 0.75 | 1.66 | 1.80 | 3.85 | 3.60 | 4.69 |
| Chindadripet | 1.89 | 0.79 | 9.60 | 0.80 | 8.44 | 0.03 |
| K.K.Nagar | 0.03 | 0.02 | 1.80 | 0.34 | 1.22 | 0.01 |
| Ambattur | 1.57 | 1.40 | 13.15 | 0.20 | 6.20 | 0.04 |
| Avadi | 0.61 | 0.43 | 1.80 | 1.00 | 7.38 | 1.03 |
| T,Nagar | 1.23 | 1.09 | 1.80 | 0.80 | 4.95 | 0.05 |
| Tambaram | 0.80 | 0.47 | 11.03 | 0.88 | 9.61 | 0.06 |
| Thiruvanmiyur | 1.72 | 1.36 | 8.91 | 0.87 | 11.69 | 0.12 |
| Neelankarai | 2.41 | 4.20 | 8.86 | 2.63 | 10.66 | 0.12 |
| Sholinganallur | 0.70 | 0.74 | 11.75 | 0.79 | 10.08 | 0.03 |

*3.4 Forecasting of Land Price in CMA*

To forecast the future price of land, predicted values of factors are plugged into the model. Gold price, Silver price and Home loan interest are predicted by polynomial method and rest of the factors by least square method for the period of 2014 and 2015. The interest on home loan is expected to climb by 2015 and its growth is projected as 9% annual. Construction cost is believed to rise by 6%. The GDP is expected to increase by 3% and the inflation will remain at comfort level of 5%. A marginal annual rise of 0.6% on Dollar equivalence and 7% on crude oil price is expected. Based on the past trends, the Consumption of precious metals, gold and silver show a remarkable increase in price of more than 15%. As far as increase in stock is concerned, the projected increase is 6% and 5% on BSE and NSE respectively to reflect a progressively healthy economy. An annual increase in population in study areas are assumed as per development authority's draft. These above assumptions on the factors are plugged in the regression and neural network model, trained and the hypothetical data is allowed to test. The average increase in land price for the next 2 years of 2014 and 2015 is forecasted for all the selected thirteen locations in CMA and is presented in Fig. 4.

The five factors such as GLV, silver price, population in study area, cost of crude oil and unit cost of construction itself has more than 80% influence on the unit land price, which is the output. Independent and combined effect of factors such as home loan interest, inflation, GDP and cost of construction are tested as different scenarios on the regression models of all the areas. Home loan interest assumed at an acceptable level of 6 to 8%, inflation at a comfortable zone of 4 to 6%, GDP at a better range between 8 and 10% and cost of construction at a tolerable level of Rs 1000 to 1100 per one square foot area. The results show that a small Increment in home loan interest will drag the land price and rise in remaining three factors further lifts the land price. Combination of 8% home loan, 6% inflation and GDP of 10% will have good control on the land price and pulls down the price upto 4%. The reduction in cost of construction will pull down well the price of land and has one to one ratio in percentage. So the policy focus should be on bringing down the construction cost by having control on material cost, by usage of alternate affordable materials and advanced cost effective construction methodologies in a large scale will have enough control on land price rise in future.

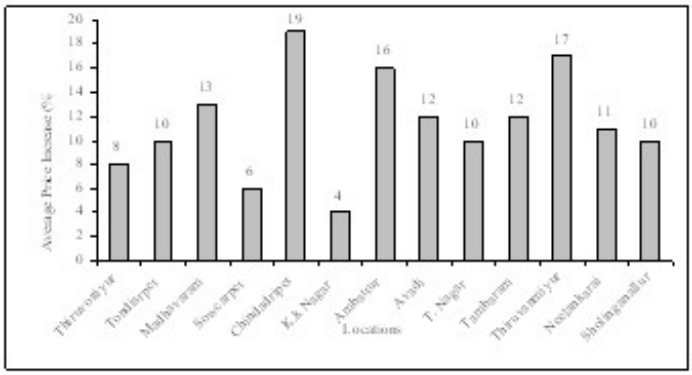


Fig. 4 Average increase of land price (2014-2015)

## 4. Conclusion

The research focuses on the modelling and forecasting of land price at 13 different locations in CMA with economic and social attributes as influencing factors. The modelling and forecasting of land price in the selected study areas is made using multiple regression and neural network techniques. The data between January 1997 and December 2011 are used in the models.

Based on the analysis, the following conclusions are drawn:

- The study reveals that economic factors influence land price more than the social factors.
- The interaction of the selected factors (X) on land price (Y) is analyzed. It is found that four factors viz. GLV (84%), silver price per gram (92%), population (86%) and cost of crude oil (88%) have more positive effect on land price in CMA.
- Economic factors such as Inflation (5%), Dollar equivalence (9%) and home loan interest (53%) show negative correlation with land price in all thirteen locations.
- The forecast envisages that central (Chindadripet 19%), South east (T.Nagar 10%, Tambaram 12%) and South West (Thiruvanmiyur 17%, Neelankarai 11% and Sholinganaluur 10%) zones of CMA are poised for growth in the forthcoming years. As a consequence, price rise will be more in these areas compared to other zones.
- The land price model of Sowcarpet within CBD explains the price trend upto 90% which is closer than the time-series regression model developed by Kilpatrick [2] . It explained about 83% of real trend. The annual price rise in Sowcarpet was found to be about 17% by Sampathkumar and Santhi [10] but it will decrease to 6% in 2014-2015 in current study due to saturation.
- The study shows that the annual price rise of Ambattur and T.nagar in 2014 and 2015 will be about 5% and 7% respectively and the same was 7% and 20% between 2010 and 2011 as per the study by Sampark Public Relations Pvt Ltd [15].
- The model forecasts the price rise of Sholinganallur as 6% between 2013 and 2014 and it matches with the prediction made by ICICI Property Services in 2013 [14].
- Even though both the models are found to be well fit with the data set of the land price in all locations, the model using NN (correlation 98%) shows better accuracy than the regression model (correlation 96%).
- The forecast predicts the average growth in the next two years will be an average of 11% in all the selected locations of CMA. The common CMA model explains the trend upto 88% which is lesser the regression model made by Birch and Sunderman [16] which explained up to 93 % of the market values.

The outcome of this study can be used in annual revision of guideline value of land which may add more revenue to the State Government while land transaction is made. This study will support the policy makers to relook the movement of the identified factors to have control on rise in the land price and stabilize it. Since there is a greater need for good long term data analysis about land price, general land market behaviour and spatial development, the results produced in this research may be of great use for Government and non-Government agencies which involve in land administration.

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