RETRACTED ARTICLE: Investigation into valuation of land using remote sensing and GIS in Madurai, Tamilnadu, India

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ABSTRACT
Assessing the value of property is important in the real estate activity. Important factor to assess the property value is the location of the property. In India, value of a property is mainly evaluated by the guideline value and the market value. This paper addresses the effect of different parameters that affect the market value in Madurai Corporation area. It also addresses the implementation of urban valuation on a Geographic Information System for better decision-making. The valuation of the land depends upon the popularity and also the facilities around in that area. The spatial data constitutes the location information of the assets and the attributes that contain the details of the assets. Quantum GIS software is used for the storage and analysis of the data. The effective use of GIS along with reliable data and predictive tools can provide a robust and near realistic solution in predicting real estate trends. It is found that, for land assets, the Geographic Information System approach is effective. In this paper, we have used the statistical methods in order to find the market value and modelled value using Voronoi Polygon Method.

Introduction
Indian system of property valuation is done by evaluation of the market value and the guideline value and it is normally delivered as a report. The property valuation is generally conducted on a wanted from an individual, or a contributing institution (such as a bank) that is looking to provide finance for the purchase of the property. Valuation includes property details – unit rate, the extent of the land and construction, physical details of the premises, the state of dwelling and information on any quick issues that may need direction as well as resources on comparative selling in the area. Valuation of property is estimated by three techniques, namely, cost technique, comparative technique and income technique. Fixation of market value plays an important factor for the property valuation.

Remote Sensing Data can assume a crucial part in valuation of land by mapping framework and other fundamental points of interest which are essential in choosing the estimation of a real estate parcel. To provide time and cost-effective solution.

Zhao (2011) a study on design and implementation of an object-oriented space-time GIS Data Model. In his study, he stated that Geographic data are closely related to both spatial and temporal domains. Geographic information systems (GIS) can capture, manage, analyze, and display spatial data. However, they are not suitable for handling temporal data. Models exhibit weaknesses in various aspects. He also argues that geodatabase data model can be used to store instantiated space-time objects.

Market value is defined as the highest price between an agreeable buyer, who would pay, and an agreeable seller, who would bear, both being fully knowledgeable. Market value is fixed by the demand of the property.

Demetriou (2016) has shown that this manual current procedure presents some weaknesses. In particular, the comparison of land parcel characteristics is mainly a result of an empirical analysis and subjective human judgment, which means the potential presence of inconsistencies across valuators, similar land parcels and the sub-regions of the study area and it is not the outcome of a robust, standardized analysis using appropriate tools such as a GIS. As a result, the process is not fully transparent and can lead to unfairness and bias against landowners.

The taxations based on the values of genuine bequest properties are of awesome budgetary significance to the state, bringing in around 10 billion a year (Waarderingskamer, 2016). The valuations commissioned by the Districts reflect the showcase esteem of a property at the primary of January of the past year. Since this esteem is not considered to be an up to date advertise esteem, they are for the most part alluded to as surveyed values. Other employments of evaluated values are deciding the sum of contract advances and the level of protections for genuine estate.

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This article has been retracted. Please see Retraction (http://dx.doi.org/10.1080/22797254.2020.1772118)
Guideline value is used primarily in calculating the amount of stamp duty one has to pay while registering a transaction. Guideline values may vary for different survey numbers in the same village and in the same locality. This may be because of the history of transaction in each survey number. Guideline value in Tamil Nadu state is fixed and can be obtained from the Tamil Nadu government web portal (www.tnreginet.net).

Statistical modelling is established to analyse the data and to formulate the regression modelling. Correlation coefficient is a numerical measure of the linear relationship between a dependent variable Y and an independent variable X. The value of the correlation coefficient also indicates the strength of the relationship. The expansion of GIS is Geographic Information System. GIS is a computer-based information system which makes different layers with various qualities and characteristics to geographical objects and helps in fixing the market value and decision-making said by Patra (2011). Geographic information system (GIS) is a new platform to represent the digitalisation of valuation. It represents a better image form to manipulate, analyse, manage and make a better decision about the properties. Quantum GIS software which we have used is open GIS software.

**Literature review**

The value of a property is basically by its location and is one of the main decision-making tools that is used to manage different aspects of the social, economic, technical and financial activities in that location. However, the objective of the land valuation is to ascertain the value, a term commonly started up by some sort such as market value or benefit value illustrated by Yomralioglu and Nisanci (2004).

Mukaka (2012) demonstrates how a correlation coefficient can be used as a statistical measure to interpret and define a functional relation between two variables. By a linear regression model, he investigated how the macroeconomic factors, namely, the unemployment, stock index, gross domestic product and industrial production are related to property value.

Grum and Govekar (2016) developed a predictive method to fix the market value of a property using economic analysis. Saginor et al. (2011) researched the effect of environmental issues on market value of the property. The experts modelled the value of 100 case studies by OLS (Ordinary Least Square) method.

A Geographical Information System (GIS) is useful in decision-making regarding properties. Valuation can be accomplished by analysing a certain level of land features in an equitable way using GIS. In order to make a requisite value for a land, Geographical Information System (GIS) is an easier computer-based instrument for mapping and economic analysis of the property. The GIS in real estate enables the user to capture, save, evaluate, and visualise the real property information data on a map with a geospatial context. GIS gives unique solutions in digitalised form which is far better than spreadsheet format that is less accurate in table or spreadsheet format said by Linne and Cirincione (2010).

Muli (2013) said that GIS constructs output layers as a map for the geo-referenced data and analyse it in various statistical methods using the data. GIS draws schemes and notion from various disciplines such as cartography, cognitive science, civil engineering, Eco science, geodesy, landscape architecture, law, photogrammetry, public policy, remote sensing, statistics and surveying and influences of society on GIS defined by Patra (2011).

Hedonic pricing is a valuation model that assesses the effect of the particular factors of a property on overall market value. Gatheru and Nyika (2015) developed a Hedonic Pricing Model (HPM) for the valuation of properties in Kenya.

S. Metzner (2017) stated that Spatial factors are the most important factors among evaluation criteria. A. C. Aydinoglu (2017) said that property valuation parameters can be determining by using local experts, investors and institutions opinions.

To perform valuations both building data and cadastral data are required (Isikdag et al., 2015). The valuation workplaces keep up their claim building data models and ask upon the Cadaster’s administrative data on boundaries and possession. This development delineates that not all valuation models depend on the same set of information.

**Modelling of valuation with GIS**

Maps with the value are very powerful decision-making tools which clearly show the geography of property values over space and time, said by Wyatt (1996). Spatial distribution of property values are illustrated by maps with values. This is an improved method compared to the paper-based analysis in the past. GIS can manage data input, calculations and the presentation of the results. GIS are used for acquiring, storing and retrieving information about land for the purpose of valuation. It is also useful for analysing and processing those data to produce meaningful land valuation, monitoring the market value of land parcel in relation to streets and other amenities, facilities and utilities by Thilakaratne et al. (2008).

McCluskey et al. (1997), researched the usage of GIS in Mass Appraisal. By using CAMA (Computer Assisted Mass Appraisal), the valuation can be assessed within a moment. It is useful for land taxation, legal and economical transaction in Ireland.

The study was done for finding the relation between the value of land and the factors that influence the
value by questionnaires survey and multivariate regression model analysis. By Hedonic Pricing Model (HPM), the value of the land can be assessed by parameters which consist of land size, accessibility to road, accessibility to school. It is recommended that the HPM and GIS can be used to do property valuation by Gatheru and Nyika (2015).

Hence, a study to find a relation between guideline rate and market value is proposed to make the fixation of the market value in a formulated way. In this study, it is attempted to develop a regression model, based on statistical analysis for the properties of Madurai. It is required to digitalise the valuation in urban cities for better decision-making.

**Scope and objective**

There are certain issues on conventional systems of property valuation. Market value is evaluated based on a non-standardised system by acquiring information that causes errors and variations in the property values. Basically, the market value is fixed by hearsay only. There is no certain defined relationship between guideline and market value. It is important to consider the market value as standardised one to control the vigorous cash flow. This paper addresses to establish a correlation between the guideline and market value based on real data by different parameters. The Parameters/points to be considered to assess the market rates are given in Table 1.

It is important to make the market values as transparent as guideline values which are still handled manually. This process is time consuming, work of repetitive nature, and less transparent. Location of the property is the important factor to evaluate the market value. Digitalised valuation is a user-friendly system of valuation techniques to the customer. Quantum GIS (QGIS) platform is used to store, represent and analyse the data.

**Methodology**

Step 1: From Madurai Corporation area, 400 data sets are collected which consist of all parameters. Each data set contains data from the year 2007 to 2015.

**Data collection and sample data**

To quantify the Value of a land, various parameters as discussed in section 2 are considered. The objective of the study is to quantify the effect of these parameters on property values. Four hundred numbers of data are collected with all parameters within the Madurai municipal area. These 400 property data are collected with geographic spatial coordinates, namely latitude and longitude using a GPS. For each property, the guideline and market rate is collected from 2007 to 2015. The sample data of a property in Madurai Corporation area with all parameters are shown in Table 2.

**Statistical analysis**

Correlation and modelling of the market value and the guideline value is done by analysing the correlation coefficient and NRMSE values. GRETL software was used to find the correlation and the modelling work. GRETL is a free GNU-based software for statistical modelling.

**Cross-correlation**

Cross-correlation among the variables was found using the cross-correlation module in the GRETL. The cross-correlation table is shown in Table 3.
The highest cross-correlation was found between the market value and the guideline value as 0.86. This indicates that there is a very strong positive correlation between market value, the fixing of guideline value and subsequent market and guideline values. The important parameters such as distance to the railway station (DTRS), distance to the bus stand (DTBS), distance to the nearest school (DTNS) and distance to the nearest hospital (DTNH) have a correlation of about −0.20 to the guideline value and the market value which indicates that as distance to prime facilities/amenities increases the land value decreases.

The plot between the market value and guideline value by taking whole data was found to be somewhat linear. Hence, linear least square fit was chosen as the modelling technique for establishing the relation between market value and guideline value.

### Least square linear fit between market value and guideline value

In this section, it is attempted to model the relationship between the market value and the guideline value by an ordinary least square fit for the whole data from 2007 to 2015. Market value is plotted against guideline value from the year 2007 to 2015 and shown in Figure 1.

From the graph, the model fit is of the form: \( Y = AX + B \)  
Where:  
\( Y \) = Market value  
\( X \) = Guideline value  
\( A, B \) = Model constants

The model obtained is

\[
Y = 1.54X + 282 \quad (1)
\]

This is a mass valuation model and represents the market value in terms of guideline value.

From graph, it can be seen that most of the transaction in the study area are in the guideline value less than Rs. 2000/Sq.ft case. Therefore, models were created for three different ranges of guideline value and the obtained models are tabulated.

The guideline values are subcategorised based on the money value. These ranges are below Rs. 1000/sq.ft, between Rs. 1000 to 2000/sq.ft and above Rs. 2000/sq.ft. Correlation coefficient and models are created

### Table 2. Sample collected data.

| ID | YEAR | LAT | LONG | CLS | GLR  | PMR  | DTA  | DTRS | DTBS | DTNS  | DTNH  | R_W  | FR | S_IMP | POP_MOV |
|----|------|-----|------|-----|------|------|------|------|------|-------|-------|------|----|-------|----------|
| 1  | 2015 | 9.993 | 78.147 | 5   | 200  | 1377 | 26   | 11   | 7    | 5     | 4     | 1    | 7   | 4.8 | 2   | 6       |
| 1  | 2013 | 9.993 | 78.147 | 5   | 185  | 918  | 26   | 11   | 7    | 5     | 4     | 1    | 7   | 4.8 | 2   | 6       |
| 1  | 2011 | 9.993 | 78.147 | 5   | 170  | 600  | 26   | 11   | 7    | 5     | 4     | 1    | 7   | 4.8 | 2   | 6       |
| 1  | 2009 | 9.993 | 78.147 | 5   | 150  | 560  | 26   | 11   | 7    | 5     | 4     | 1    | 7   | 4.8 | 2   | 6       |
| 1  | 2007 | 9.9939 | 78.147 | 5   | 150  | 500  | 26   | 11   | 7    | 5     | 4     | 1    | 7   | 4.8 | 2   | 6       |

- **CLS** – Classification  
- Resident number as 5  
- Commercial number as 10  
- Residential and commercial number as 15  
- **GLR** – Guideline rate in rupees  
- **PMR** – Prevailing market rate in rupees  
- **DTA** – Distance to airport (Madurai) in kilometre  
- **DTRS** – Distance to railway station (Madurai) in kilometre  
- **DTBS** – Distance to bus stand (Madurai – Mattuthavani) in kilometre  
- **DTNS** – Distance to the nearest school in kilometre  
- **DTNH** – Distance to the nearest hospital in kilometre  
- **DTNC** – Distance to the nearest college in kilometre  
- **R_W** – Road width in meter  
- **FR** – Frontage in meter  
- **S_IMP** – Site improvement (High class/Middle class/Low class)  
  - High class numbered as 1  
  - Middle class numbered as 2  
  - Low class numbered as 3  
- **POP_MOV** – Population movement (Developed/Developing)  
  - Developed numbered as 6  
  - Developing numbered as 12

### Table 3. Cross-correlation table.

|        | CLS | GLR  | PMR  | DTA  | DTRS | DTBS | DTNS  | DTNH  | R_W  | FR | S_IMP | POP_MOV |
|--------|-----|------|------|------|------|------|-------|-------|------|----|-------|----------|
| CLS    | 1   | 0.02 | 0.03 | −0.1 | −0.1 | −0.1 | −0.02 | 0.04  | 0.02 | 0.03 | 0.13  | −0.15    | 0.14    |
| GLR    | 0.02 | 1    | 0.86 | −0.11 | −0.2 | −0.21 | 0.21  | −0.18 | −0.24 | −0.05 | −0.1  | −0.23    | −0.25    |
| PMR    | 0.03 | 0.86 | 1    | −0.09 | −0.18 | −0.2  | −0.23 | −0.18 | −0.26 | −0.04 | −0.1  | −0.22    | −0.21    |
| DTA    | −0.1 | −0.11 | −0.09 | 1    | 0.35 | 0.07  | 0.26  | 0.03  | 0.25 | 0.06  | 0.02  | 0.05  | 0         |
| DTRS   | −0.1 | −0.2 | −0.18 | 0.35 | 1    | 0.38  | 0.36  | 0.25  | 0.23 | 0.05  | 0.09  | 0.12  | 0.05    |
| DTBS   | −0.1 | −0.21 | −0.2  | 0.37 | 1    | 0.35  | 0.29  | 0.04  | 0    | 0.16  | 0.1   | 0.14  |          |
| DTNS   | −0.02 | −0.21 | −0.23 | 0.26 | 0.36 | 0.35  | 1     | 0.49  | 0.49 | 0.07  | 0.15  | 0.07  | 0.19     |
| DTNH   | 0.04 | −0.18 | −0.18 | 0.03 | 0.25 | 0.29  | 0.49  | 1     | 0.45 | 0.05  | 0.21  | 0.1   | 0.2      |
| DTNC   | 0.02 | −0.24 | −0.26 | 0.25 | 0.23 | 0.4   | 0.49  | 0.45  | 1    | 0.02  | 0.12  | 0.16  | 0.1      |
| R_W    | 0.03 | −0.05 | −0.04 | 0.06 | 0.05 | 0     | 0.07  | 0.05  | 0.02 | 0.21  | −0.07 | −0.03 |          |
| FR     | 0.13 | −0.12 | −0.14 | 0.02 | 0.09 | 0.16  | 0.15  | 0.21  | 0.12 | 0.21  | 1     | 0.04  | 0.1      |
| S_IMP  | −0.15 | −0.23 | −0.22 | 0.05 | 0.12 | 0.1   | 0.07  | 0.1   | 0.16 | −0.07 | 0.04  | 1     | 0.18     |
| POPMOV | 0.14 | −0.25 | −0.21 | 0    | 0.05 | 0.14  | 0.19  | 0.2   | 0.1  | −0.03 | 0.1   | 0.18  | 1         |
for each set of data range. Table 4 shows the regression models for selected range of guideline value.

**Control plot**

Control plot has been plotted between guideline and market value by considering year as a control variable. Control plot shows the linear variation between the guideline and market value trend. The data were collected from 2007 to 2015. It also states that the market rate is increased by 1.5 times of guideline rate. Control plot of the guideline rate and prevailing market rate (least square fit) is shown in Figure 2. The control model for the year 2015 is found as:

$$Y = 1.52X$$  \hspace{1cm} (2)

where $Y = $ Market value and $X = $ Guideline value

**QGIS analysis**

The 400 data points with latitude and longitude are converted to CSV format so that they can be imported into QGIS and interpreted.

**Interpretation using QGIS**

The 400 data points were loaded as point data in QGIS. The market value and guideline value variations across the Madurai municipal area can be visualised clearly as shown in Figures 3 and 4. The impact of “location” on market value and guideline value can be visualised from Figures 3 and 4.

**GIS Analysis of modelled and actual market value**

The modelled market value obtained from statistical analysis was chosen as one more parameter along with the original observed data for the properties. These two values viz. actual market value and modelled market value which are displayed on a GIS layer as shown in Figure 5 for the year 2015. Thus, it can be easily visualised where the predicted model fits and where it does not fit.

**GIS analysis Voronoi polygon method**

Voronoi polygons were created to review the guideline and market value spread based on the area. Sample Voronoi polygons are shown in Figures 6 and 7 for guideline value as well as market value for the year 2015.

Through Voronoi polygons method, we can easily identify the denseness of high and low value of the land on the map. It can be seen that both high guideline and high market value areas of the Madurai Corporation are found in the central part of Madurai.

**Results and discussion**

Regression models for different range of guideline value in Table 4 show the dependency factor of each

| Sl. No | Guideline value range | Model     | Correlation coefficient of PMR & GLR | Dependency factor compared with other parameters | Trend of Percentage increment rate | NRMSE  |
|--------|-----------------------|-----------|-------------------------------------|--------------------------------------------------|-----------------------------------|--------|
| 1      | Full data             | $Y = 1.54X + 282$ | 0.86                                | Strong                                            | Decreases                         | 0.118  |
| 2      | Rs. 0 to 1000/Sq.ft. | $Y = 1.71X + 224$ | 0.71                                | Strong                                            | Decreases                         | 0.516  |
| 3      | Rs. 1001 to 2000/Sq.ft. | $Y = 1.59X + 241$ | 0.4                                 | Medium                                            | Decreases                         | 1.17   |
| 4      | Rs. Above 2000/Sq.ft. | $Y = 1.75X – 510$ | 0.6                                 | Medium                                            | Increases                         | 0.358  |
model based on their different guideline value range. When guideline value is below Rs. 1000/sq.ft., there is a strong relationship. But, above Rs. 1000/sq.ft., market value is moderately dependent on guideline value.

Models show that up to Rs. 1000/sq.ft., there is a decrement trend of increment percentage in the market value. But, in case of above Rs. 1000/sq.ft., it follows an increment trend of increment percentage. So, the overall representation is the negative trend of increment percentage between the guideline value and the market value. That is, if the amount of guideline value increases, prevailing market value also increases, but the percentage of increment rate follows a downward slope.

Therefore, Rs. 0 to 1000/sq.ft., range of guideline value changes higher percentage increment of market value (up to 100% increment). On the other hand, above Rs. 1000/sq.ft., does not show a high percentage increment (up to 70% increment only).

Also, control plot represents that the market value is approximately 1.5 times the guide line value.

These collected spatial data are easily visualised by the QGIS tool. QGIS gives efficient representation of rate spread across the Madurai Corporation area. Map of guideline and market value in spatial is represented in Figures 3 and 4. Figure 5 shows the comparison of the modelled market value and the observed market value.
Overall, it gives 50 to 60 percentage matching results. It is user-friendly and allows us to take quick decision.

Voronoi polygon gives the easy visualisation of rate, spread all over the Madurai Corporation. Weighted range of land values has been easily represented by using the Voronoi polygons.

**Conclusion**

The study to find the relation between guideline value and market value is done by statistical method and mapping the data using QGIS software. This study ultimately finds that land market rate is approximately 50% higher than guideline value. It also concludes that certain parameters considerably increase the market value and some parameters decrease the market value. Important factor to predict the market value of the property is the transportation facility near the land. Bus stand and railway station facilities near the location hike the value of the property. Voronoi polygons clearly indicate the under fluctuating market value also we can arrive at the realistic market value.

Four hundred numbers of data are collected with all parameters within the Madurai municipal area. These
400 property data are collected with geographic spatial coordinates, namely latitude and longitude using a GPS. For each property, the guideline and market rate is collected from 2007 to 2015.

By using the QGIS mapping software, value of the land can be represented in pictorial way. It is more helpful to the investor to make a clear decision regarding the land values. The effective use of GIS along with...
reliable data and predictive tools can provide a robust and near realistic solution in predicting real estate trends. This prediction is not only to help the government on policy planning and regulations, but also for sound economic decisions of the individuals, companies and investors in the future.

Disclosure statement

No potential conflict of interest was reported by the authors.

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