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# Development of a Land Price Model for a Medium Sized Indian City

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Land price plays a crucial role in the development of a region, which serves as an indicator of the features of a property. The primary goal of this paper is to explore the relationship between land price and various geographical and accessibility parameters and thereby arrive at a model to predict the land price. Based on literature surveys, the parameters that influence land price are identified further through which data collection from primary surveys, the creation of a road network map, a geographic information system (GIS) analysis to determine the distance to the central business district (CBD), measurement of road density and access road width, assessment of employment opportunities through establishment surveys, and identification of various land use parcels in the study region are accomplished. The land prices are collected from recently sold parcels in each of the zones in the study region. A negative and significant correlation is observed between land price and distance to the CBD. Positive correlations are observed between land price and other factors considered, such as road density, availability of educational facilities, employment opportunities, and the extent of commercial and residential land use areas. A non-linear regression model is developed that can predict land price depending on the significant parameters.

**Keywords**

Land price, Central business district, Employment, Regression, Land use.

# 1. Introduction

Land markets are not transparent and market information is often difficult to obtain. In determining the economic value and the attractiveness of a specific site, the land price provides insight into its amenities. Planning for development can be more precise and beneficial if the local government and planners have a clear understanding of the price of the land. A vibrant land and property market is crucial for sustainable economic growth and urban well-being. For more scholarly and policy-oriented research, it is crucial to describe the situation of the market.

The population data of India from Census (2011) shows that there was a 17.70% decadal growth from 2001 to 2011. The growing population continues to affect the land-human ratio, and as a result, land prices are on the rise. This situation creates immense concerns for the development process in urban areas and leads to an increase in the budget planned for development. Also, the implementation of planning can be hampered because of the price and limited area. An increase in land price is observed in the urban areas of India (Swamidurai, 2014). Thus, the demand for land is a reflection of the utility that is derived from its use by current or possible users. Competing for sites depends on whether they can take advantage of accessibility and usability within the urban context (Jordaan et al., 2004).

The most distinctive characteristic of urban areas, which distinguishes them from rural areas, is the high concentration of activities and people. In urban areas, the price of land tends to be higher because of the competition from different uses that attempt to access the amenities afforded by highly accessible sites. In places with high accessibility, changes in agglomeration also tend to occur.

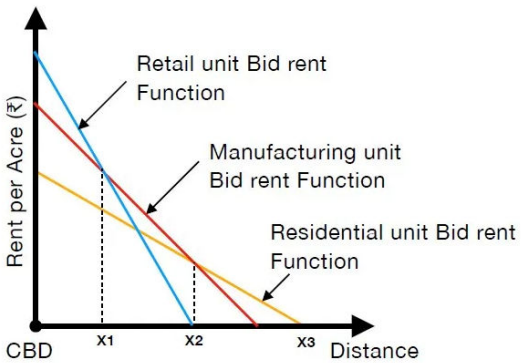
In the case of developing countries, India has the most urbanization characteristics. From 1901 to 2011, the number of urban agglomerations/towns in India grew from 1827 to 7935, while the population of urban areas increased from 25.8 million to 377.1 million (Census, 2011). This reflects the increasing trend of urbanization. The process of urbanization in India has accelerated to a point where urban development has increased commercial land use which drives up the land price. All of the major activities are primarily concentrated in the central business district (CBD) due to ease of accessibility and with distance from the CBD, the activities are reduced and thereby the land price. As the area develops, there will be migration and the need for residential areas increases, thereby, all available vacant and underutilized land are used for residential purposes. This change has also indirectly increased the land prices in and around the CBD area.

Land price is a measure of the specific features of a property, excluding buildings and other developments (Binoy et al., 2020). Land price varies depending on the economic, geographic, and political aspects of a location. The change in land use is very rapid in urban areas, which results in changes in the urban structure. This change also leads to scarcity of land for all human activities and thereby increases the land price. This paper aims to identify the relationship between land price and various geographical and accessibility parameters in the study area.

## 2. Literature Review

Alonso (1964) proposes a concept wherein a buyer acquires both land and location in a single transaction, thus simplifying the process by making a single payment for both elements. This approach allows for the trade-off between land quantity and specific location, as elucidated by the bid-rent curve in Figure 1. The residential bid price curve within this framework represents the prices at which individuals can purchase land at varying distances from the city center while maintaining a consistent level of satisfaction. As individuals evaluate residential locations farther from the city center, they consider the amount of land and other factors that offer equivalent utility compared to those of the city center. According to this model, the bid price function indicates the prices that a firm is willing to pay at different distances from the city center to achieve a certain profit level.

**Figure 1 Bid - Rent Curve (Alonso, 1964)**




Land is a fundamental asset for all individuals (Saefuddin et al., 2012), especially in rapidly growing cities where population growth often outpaces available infrastructures and services. Social, environmental, and political concerns frequently revolve around the demand for residential land (Tamba et al., 2011). Developers must understand the trends to make informed decisions

for the future (Sampathkumar et al., 2015). Urban development projects have broad positive impacts on the economy, health, education, and sustainability, thus benefiting the entire community (Glumac et al., 2019). In urban planning, understanding land price trends is crucial to support decision-making (Sampathkumar et al., 2015). Accurate and up-to-date land price maps empower market participants to make informed choices (Derdouri and Murayama, 2020). To develop compact cities, high land prices are often necessary due to land supply constraints (Bertaud, 2015). The factors that influence land prices must be studied, and their effects on prices need to be modeled (Sampathkumar et al., 2015).

The different factors that influence land prices are detailed in Table 1, with prominent ones including land use (Derdouri and Murayama, 2020); topographic features like elevation (Derdouri and Murayama, 2020; Tamba et al., 2011); demographic features such as population (Sampathkumar et al., 2015; Tamba et al., 2011; Wang, 2009); population density (Bertaud, 2015; Derdouri and Murayama, 2020); socio-economic factors like income (Bertaud, 2015; Derdouri and Murayama, 2020; Tamba et al., 2011; Wang, 2009); proximity to various facilities like railway stations (Derdouri and Murayama, 2020), highways, markets, public health, security and educational facilities (Saefuddin et al., 2012); zoning regulations such as floor-area ratio (FAR), green space percentage, building density, height restrictions, public services, parking arrangements, set back restrictions, and prohibited passageways (Wang and Hou, 2021); neighborhood features like social status (Tamba et al., 2011), safety, and crime rates (Saefuddin et al., 2012); and land properties like status (certified, not certified), and developed/not developed land (Saefuddin et al., 2012). The effects of the COVID-19 pandemic have substantially impacted property prices and rents, with variations depending on the type of city. Additionally, certain property attributes, such as location and community-level COVID-19 infection rates, may command different prices (Yang et al., 2022). Business and trade-friendly locations generally have higher land prices than less convenient areas, and locations with extensive road access tend to be more expensive than those without such access (Ha et al., 2022). A land price model can help property sellers and real estate agents to make rational decisions in the property market (Ho et al., 2021).

Land price distribution is uneven, often reflecting factors like flat terrain and the presence of densely populated, well-connected economic hubs (Derdouri and Murayama, 2020). The price of land is also influenced by factors like proximity to influential figures such as parliamentarians and high-ranking citizens, which leads to higher prices in certain areas (Tamba et al., 2011). Barriers to land circulation can result in increased land prices (Wang and Hou, 2021). Large metropolises experience more rapid growth in land price compared to smaller ones, and fluctuations in house prices directly affect land prices (Davis et al., 2021). Additionally, the number of floors in a building on a plot can impact land prices, with high-rise buildings often commanding higher prices than medium or single-floor structures (Pan et al., 2018). According to

the bid-rent theory, commercial land prices are highest in the city center, followed by residential areas at the periphery (Li, 2008). Generally, commercial land prices exceed residential land prices, except in suburban or outer central urban areas where land prices for various uses tend to converge (Wang, 2009). Beyond common factors, the subjective judgment of an individual of residential location choice can also influence land prices (Chen et al., 2022).

From the literature review, the parameters and their relation with land price along with the references are summarized in Table 1.

**Table 1 Land Price Model Parameters**

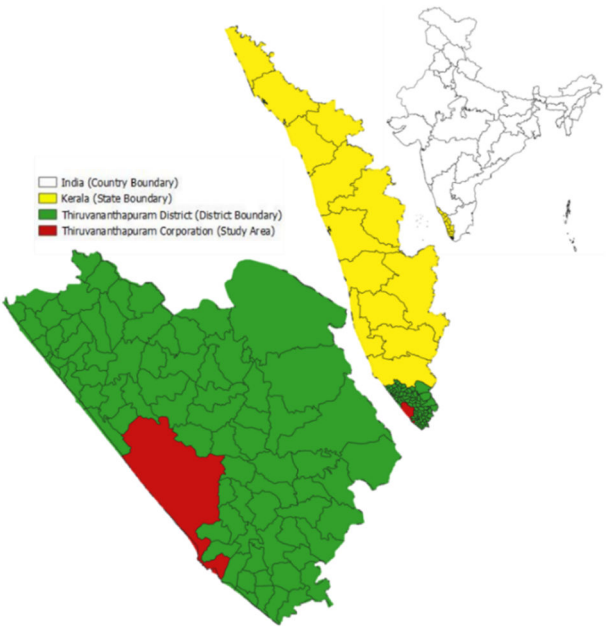
| Parameter | Relation with land price | Reference |
|---|---|---|
| Distance to CBD | - | Pa et al., 2001; Jordaan et al., 2004; Wang, 2009; Tamba et al., 2011; Yowaldi, 2012; Rakhmatulloh et al., 2018; Glumac et al., 2019; Surianto, Nidar and Damayanti, 2019; Binoy et al., 2020; Davis et al., 2021; Ho et al., 2021; Pan et al., 2021; Chen et al., 2022;Yang et al., 2022; Ha et al., 2022 |
| Road density | + | Binoy et al., 2020; Derdouri and Murayama, 2020; Glumac et al., 2019; McGreal and de la Paz, 2012; Pa et al., 2001 |
| Number of educational facilities | + | McGreal and de la Paz, 2012, Saefuddin et al., 2012 |
| Number of employment opportunities | + | Binoy et al., 2020; Pan et al., 2018 |
| Land Use | + | Pa et al., 2001; Tamba, Kabba and Li, 2011; McGreal and de la Paz, 2012; Cellmer et al., 2014; Rakhmatulloh et al., 2018; Nakamura, 2019; Binoy et al., 2020; Wang and Hou, 2021; Pan et al., 2021; Chen et al., 2022; Ha et al., 2022 |
| Width of the access road | + | Pa et al., 2001; McGreal and de la Paz, 2012; Yowaldi, 2012; Pan et al., 2018; Glumac et al., 2019; Binoy et al., 2020; Derdouri and Murayama, 2020; Pan et al., 2021; Chen et al., 2022; Ha et al., 2022 |

## 3. Profile of Study Area

The study area under consideration encompasses the urban part of Thiruvananthapuram district. Thiruvananthapuram city is the capital of Kerala, a southern Indian state, located in the extreme southwest of the country. As the capital, Thiruvananthapuram serves as the epicenter of political activities. The city is renowned for its historical temples, museums, educational institutes, and vibrant art and cultural scenes. The harmonious coexistence of lush greenery and modernity makes Thiruvananthapuram stand out from many other Indian cities.

Thiruvananthapuram Municipal Corporation is situated in the southwest part of India along the Malabar Coast as shown in **Error! Reference source not found.**. The city corporation is the oldest (created in 1940) and largest (by area and population) in the state of Kerala. Thiruvananthapuram Municipal Corporation is strategically located on the southern tip of the Indian subcontinent, bordered by the Arabian Sea to the west. Its geographical landscape is characterized by undulating low coastal hills, creating a picturesque backdrop for its narrow, winding streets and bustling commercial alleyways. The city has a rich historical heritage that dates back to ancient times. Thiruvananthapuram served as a prominent center for the Travancore Kingdom, one of the princely states of pre-independent India. The city played a pivotal role in the social, cultural, and political developments of the region.

**Figure 2 Study Area**



The region is well-endowed with natural resources and boasts a highly skilled and competent human workforce. Thiruvananthapuram is home to some of the top healthcare institutions in the country, and as such, it is a hub for medical tourism. The worldwide appeal of this city as a tourist destination adds another dimension to its significance.

The Thiruvananthapuram Corporation Council, following the Legislative Assembly, ranks as the second-largest democratically-elected body in Kerala. A phased expansion increased the number of zones in this area from 24 zones that covered 30.66 sq km in 1941 to 100 and its area to 214.36 sq km in 2010, as shown in Table 2.

**Table 2 Area and Population Changes**

| Year | Area ($km^2$) | Number of Zones | Population |
|---|---|---|---|
| 1941 | 30.66 | 24 | 128,365 |
| 1951 | 30.66 | 24 | 191,343 |
| 1961 | 44.56 | 38 | 239,815 |
| 1971 | 74.93 | 46 | 409,627 |
| 1981 | 74.93 | 50 | 483,086 |
| 1991 | 74.93 | 50 | 524,006 |
| 2001 | 141.74 | 81 | 744,985 |
| 2011 | 214.36 | 100 | 957,730 |

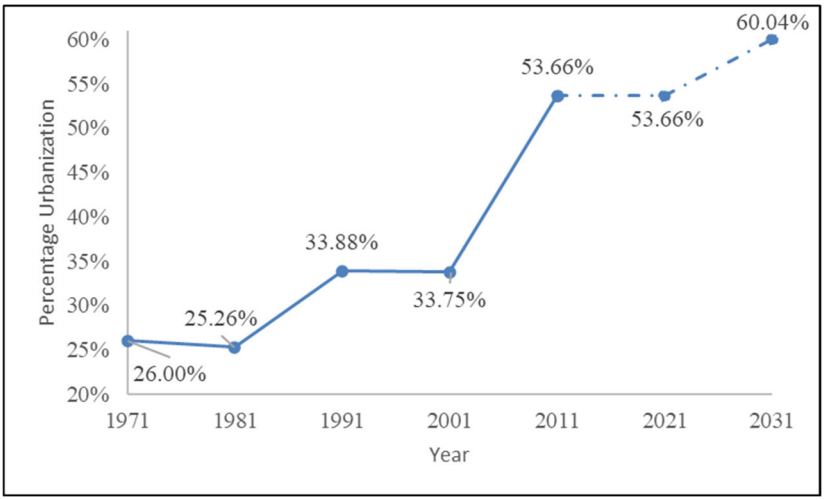
One of the major drivers of the economic growth in Thiruvananthapuram is the information technology sector. For example, Technopark is an IT park that was established to promote the development of electronics and information technology. Thiruvananthapuram is home to around 20 government-owned medium- and large-scale industrial units, as well as 60 privately owned ones. A proposed international container port at Vizhinjam, about 16 km from the Thiruvananthapuram International Airport, is anticipated to bring in more business and jobs in trade-related logistics.

### 3.1 Urbanization

Urbanization is a natural process associated with economic and demographic growth. Of the 14 districts in Kerala, the Thiruvananthapuram District has the highest rate of urbanization and greatest increase in urban population density from 1971 to 2021. Of the total population in the Thiruvananthapuram Municipal Corporation, 50% live in urban regions as per the 2011 census. An increasing urban population along with migration for employment opportunities from the rural to urban areas has exerted undue pressure on the various basic amenities. The degree of urbanization has shown a progressively upward trend from 1971 to 2021 and is predicted to continue to increase as shown in **Error! Reference source not found.**.

The proportion of the urban population to the total population steadily increased from 26 to 33 percent from 1971 to 1991. With the introduction of the 74th Constitutional Amendment Act in 1994, all the Town Panchayats (administrators of smaller towns) were brought under the urban fold. As a result, there was a significant rise in the proportion of the urban population to 33.75 percent in 2001. In 2011, the proportion moved up to 53.6 percent. This proportion of the urban population is significantly higher than that of all the levels in India (31.2%) (https://censusindia.gov.in/census.website/data/census-tables). This is expected to be increased up to 60 percent by 2031.

**Figure 3 Urbanization Trend**



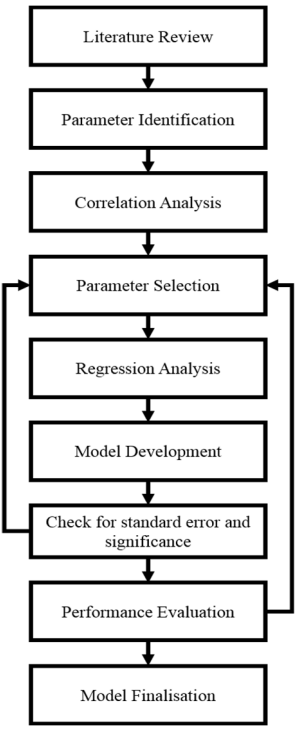

## 4. Data and Methodology

### 4.1 Methodology

The objective of this study is to show the correlation between land price and various geographical and accessibility factors. The data for land prices are obtained from a primary survey conducted in the study area. The research also provides a relevant literature review and identifies the key factors that influence land prices, including distance to the CBD, land use, road density, access road width, and number of employment opportunities and educational institutions. To analyze the distance to the CBD, a distance matrix is developed by using a geographic information system (GIS). Land use maps, obtained from the Department of Town and Country Planning, are also utilized in this study. For the modeling process, individual land parcels are treated as data points. A buffer area of 500 meters is created around each data point, and factors such as road density, number of educational institutions and employment opportunities, and area of different land uses within this buffer area are included for future

analysis. To determine the linear relationship between the variables, a correlation test is performed on the collected data, which are compared with land prices. The factors that exhibit a strong correlation with land prices are selected for the subsequent modeling. A graphical representation of the methodology is illustrated in Figure 4.

**Figure 4 Methodology**




## 4.2 Demarcation of CBD

The CBD is the heart of a town or city, characterized by an area with a large number of government buildings. The CBD is mostly accessible from all parts of the city, and has the tallest buildings (Verma, 2018), highest land price (Verma, 2018, Pardeshi, 2010, Battino et al., 2012) and largest concentration of offices, commercial buildings and retail stores. There is the absence of a residential population (Verma, 2018, Pardeshi, 2010, Battino et al., 2012). The CBD is accessible by both rail and road (Pardeshi, 2010). In this study, land price, the number of shops and offices, and distance to the nearest railway station are considered. Of the 100 zones in the study area, the municipal zones of Palayam, Thycaud, Valiyasala, Chalai, Manacaud, Thampanoor, and Vanchiyoor are identified as the CBD; that is, all of these zones are grouped to form the CBD, as shown in **Error! Reference source not found.**.

### 4.3 Land Price Data

To obtain the market price of land, the authors conducted direct surveys in 2021 with the use of a prepared questionnaire, which is attached in Appendix I. A total of 690 land parcels in which land transactions were made recently were visited with local land dealers. These parcels are either open spaces or marked as residential land uses on the land use maps. Since there is no existing land use policy in Kerala, these land uses can be utilized for any purpose such as residential or commercial. The major land use seen in the municipal corporation area is mixed land use.

The surveyed locations are spread over all of the 100 zones in the study area. Along with the land price, the questionnaire collected data on the plot area, price of plot, land price in that area (per unit), type of access (national or state highway, public works department road (major road, corporation /municipality/Panchayat road (roads owned by local bodies, private roads, two and three wheeler access roads), land use, whether filled up/wetland, distance to shopping area, and availability of public transport, medical, educational, and recreational facilities, etc.

The coordinates of the filtered land parcels are added to the Google Earth platform as points. These points are further exported into GIS for further analysis. As per the data collected, the highest land price of rupees (Rs.) 42.91 million per are[1] (equivalent to 0.52 million USD) is seen in the Chalai zone which falls within the CBD, and the lowest land price of Rs. 0.86 million per are (0.01 million USD) is seen in the Vettucaud zone which is nearly 10 km away from the CBD. The land price based on zone is shown in **Error! Reference source not found.**.

### 4.4 Distance to CBD

The distance of the individual land parcels to the centroid of the CBD is measured by using the distance matrix in the GIS.

### 4.5 Road Density and Road Width

The availability of access roads along with type and width of these roads is a major factor that affects the land price (Binoy et al., 2020, Derdouri and Murayama, 2020). The road network of the study area is shown in **Error! Reference source not found.**. The details of the access roads are collected from field surveys and the corresponding database is then prepared. The road density (expressed as length per sq km area) and the width of the closest road are determined by using the nearest neighbor analysis in GIS. The highest road density of 6 km per sq km is seen in the Thampanoor zone which is located within the CBD and the lowest is 100 m per sq km as is seen in the Vellar zone located nearly 12 km away from the CBD.

[1] 1 Are = 100 sq. m

### 4.6 Number of Educational Institutions

As per the National Achievement Survey conducted by the National Council of Educational Research and Training (NCERT), Thiruvananthapuram is the best educational city in Kerala (NCERT, 2019). One of the largest school in Asia, St. Mary's Higher Secondary School, is located in the study area. Thiruvananthapuram is home to several institutions that conduct research in space science, information technology, physical science, biotechnology, engineering, and medicine. These institutions in the study area includes the University of Kerala, the APJ Abdul Kalam Technological University, and other universities. There is also the Government Medical College, Thiruvananthapuram, one of Kerala's premier medical schools. The city has several prominent engineering colleges, business schools, and legal education institutions like the Government Law College, which was founded in 1875 and one of the oldest legal education institutions in India, as well as major colleges of fine arts, like the Swathi Thirunal College of Music, the first music academy in Kerala. One of the two physical education schools that are affiliated with the Sports Authority of India is the Lakshmi Bai National College of Physical Education, which is also located in the study area. The number of educational institutions within the buffer region of land parcels is determined by using Google Maps.

### 4.7 Number of Employment Opportunities

Being the administrative headquarters of the state and district, the city has a characteristic economic base centered on services. Most of the workforce is employed by the public sector. The contribution of the primary and secondary sectors to the labor pool of the city is very low, and they are mainly concentrated in the peripheral regions of the city, which explains for the concentration of marginal workers. The concentration of workers in the central areas of the city is attributed to the number of other types of workers mostly in the tertiary sector. This confirms the service character of the town from an economic standpoint.

Employment data are not readily available as secondary data. To identify the employment opportunities in the area, the number and type of establishments in a zone are required. To obtain the establishment details, Google Maps is used to collect the name of the institution, its type, category (private or government firm), and contact details. The collected data are again ground-checked for verification in three zones. The on-ground data and data collected online are compared to identify the correction factors for each type of establishment. The online data lack information on small grocery stores, bakeries, and vegetable and meat shops. After applying the respective correction factors, the total number of establishments in each category is identified. A primary survey is then conducted to collect details on the type of establishment and number of employees. The average employment for each category is estimated by using

the total samples collected. The number of employment opportunities available in the buffer zone of land parcels is then assessed.

### 4.8 Land Use

Land use refers to the predominant activity on a parcel of land, such as residential, commercial, industrial, public/semi-public, agriculture, etc. For any spatial plan, land use analysis is indispensable as it facilitates the understanding of the principal economic activity of a region and gives a sense of how the city will develop in the future, depending upon the amount of land available. The land use map of the study region is obtained from the Town and Country Planning Department and shown in **Error! Reference source not found.**. The land use area is determined by using GIS. Of the 215.86 sq km of total land area, 120.34 sq km is used for residential purposes (56%), followed by agricultural purposes (46.654 sq km; 22%) as shown in **Error! Reference source not found.**. According to the land use distribution, agricultural areas are mainly located at the periphery of the city, in the Veli - Akkulam area, and near Vellayani Lake. Approximately 13% of the land area is used for public and semi-public purposes. With the increased land use for the public and semi-public sectors, the city demonstrates its status as a service town that serves as the administrative capital of the state. Transportation land use covers 3%, including the airport area. The total area of water bodies is 3%, and commercial and industrial areas are 1% each. It is the core area of the city that has the highest concentration of commercial activity. Industrial areas are found mostly in Pappanamcode, Veli, and Kazhakootam. For the model development, the area of land uses that falls within the 500 m buffer of data points is calculated and utilized.

**Figure 5 Percentage Distribution of Land Use**

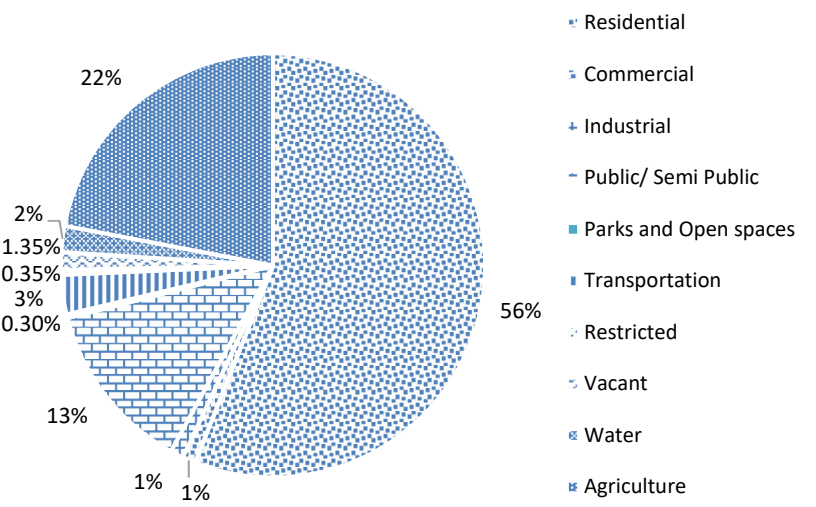


**Figure 6** **Demarcated CBD of Thiruvananthapuram Municipal Corporation**

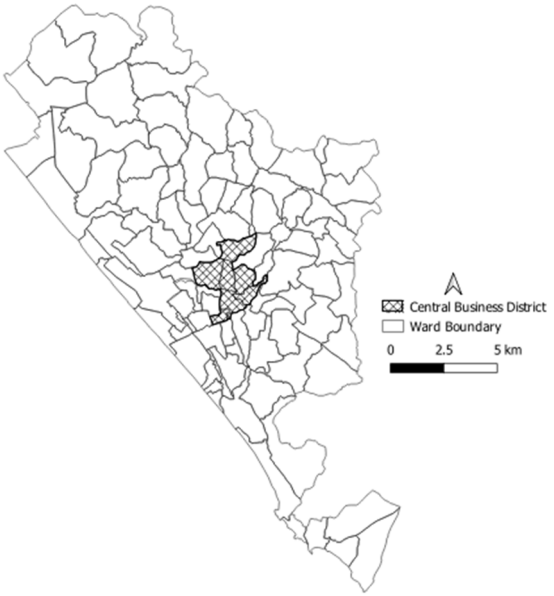



**Figure 7** **Land Price by Zone**

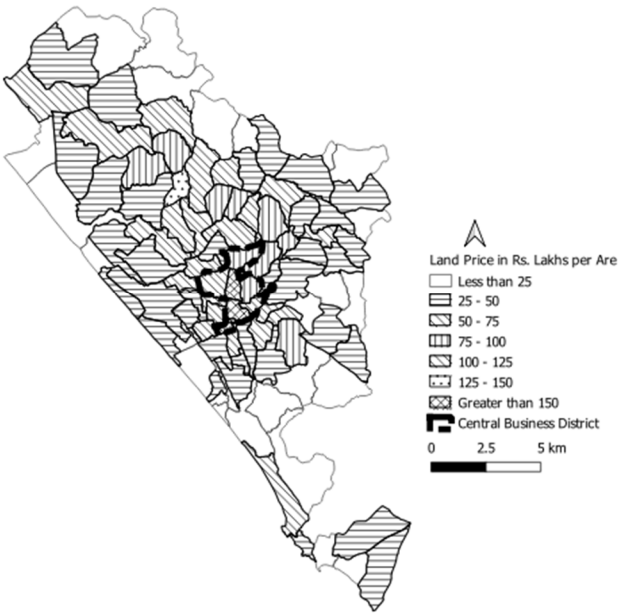


**Figure 8 Road Network Map**

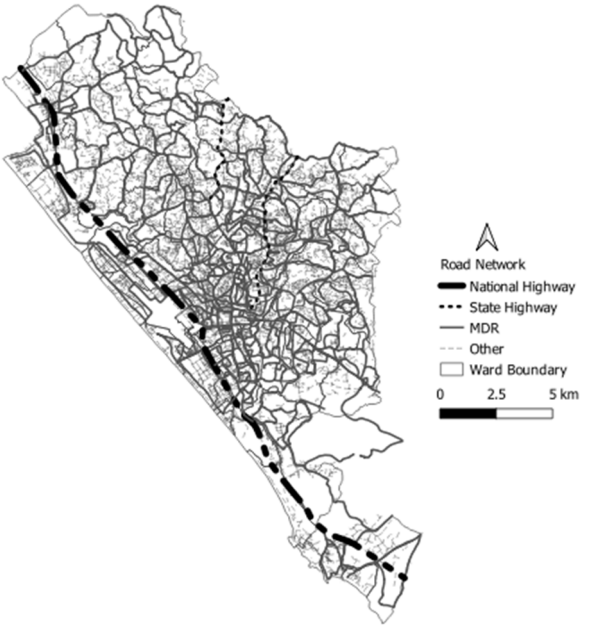



**Figure 9 Land Use Map**

# 5. Development of Land Price Model

## 5.1 Database

The parameters used in the model are summarized in Table 3.

**Table 3 Summary of Parameters**

| Parameter | Unit | Lowest Value | Average Value | Highest Value |
|---|---|---|---|---|
| Land price as of 2021 | Million USD per are | 0.01 | 0.03 | 0.52 |
| Distance to CBD | km | 0.05 | 5.30 | 27.32 |
| Road density | km per sq km | 0.10 | 3 | 6 |
| Access road width | m | 1.5 | 8.5 | 25 |
| Number of educational institutions | number | 1 | 8 | 30 |
| Number of employment opportunities | number | 1400 | 6500 | 20,000 |
| Residential land use | sq km | 0.30 | 0.20 | 0.50 |
| Commercial land use | sq km | 0 | 0.05 | 0.50 |
| Industrial land use | sq km | 0 | 0.02 | 0.32 |
| Public/semi-public land use | sq km | 0 | 0.03 | 0.20 |
| Agricultural land use | sq km | 0 | 0.04 | 0.76 |
| Water bodies | sq km | 0 | 0.03 | 0.40 |
| Transportation land use | sq km | 0 | 0.06 | 0.30 |

## 5.2 Determination of Independent Parameters

The parameters for developing the land price model are determined through a correlation analysis. Distance to the CBD, road density, access road width, number of educational institutions and employment opportunities, and residential and commercial land use areas have a significant correlation with land price as shown in **Error! Reference source not found.**.

For the distance to the CBD, a negative correlation is observed, which shows that the variables move in the opposite direction - as the distance to the CBD increases, the land price decreases. Road density, educational facilities, employment opportunities, commercial and residential land use, and road width have a positive correlation with land price.

**Table 4 Correlation Analysis**

| | a | b | c | d | e | f | g | h | i | j | k | l | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **a. Land Price** | 1 | | | | | | | | | | | | |
| **b. Distance to CBD** | -0.394** | 1 | | | | | | | | | | | |
| **c. Road Density** | 0.487** | -0.693** | 1 | | | | | | | | | | |
| **d. Access Road Width** | 0.517** | -0.341** | 0.294* | 1 | | | | | | | | | |
| **e. Educational institution** | 0.575** | -0.630** | 0.718** | 0.407** | 1 | | | | | | | | |
| **f. Employment Opportunities** | 0.526** | -0.311** | 0.419** | 0.392** | 0.748** | 1 | | | | | | | |
| **g. Residential Area** | 0.151** | -0.474** | 0.535** | 0.091* | 0.304** | 0.061 | 1 | | | | | | |

*(Continued…)*

**(Table 4 Continued)**

| | a | b | c | d | e | f | g | h | i | j | k | l | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **h. Commercial Area** | 0.600** | -0.338** | 0.549** | 0.395** | 0.564** | 0.443** | 0.106** | 1 | | | | | |
| **i. Industrial Land Use** | -0.057 | 0.084* | 0-.057 | -0.048 | 0-.098* | -0.120** | -0.142** | -0.039 | 1 | | | | |
| **j. Public/Semi-Public Area** | -0.014 | -0.022 | 0.063 | 0.030 | -0.004 | -0.037 | -0.003 | 0.078* | 0.116** | 1 | | | |
| **k. Agricultural Use** | -0.046 | 0 | 0.024 | 0-.055 | -0.064 | -0.114** | 0.021 | 0.022 | 0.104** | 0.120** | 1 | | |
| **l. Waterbodies** | -0.074 | 0.002 | -0.001 | -0.093* | -0.092* | -0.135** | -0.104** | -0.072 | 0.292** | 0.387** | 0.304** | 1 | |
| **m. Transportation Area** | -0.088* | -0.034 | -0.16** | -0.008 | -0.144** | -0.179** | -0.306** | -0.049 | 0.094* | -0.016 | 0.301** | -0.016 | 1 |

***Notes:*** Total 690 data points

### 5.3 Land Price Model

A nonlinear land price model is developed by using the selected parameters and the parameter estimates are shown in **Error! Reference source not found.**. By using the observed data, the analysis models the relationship between the variables. This statistical method creates a relationship between the dependent and independent variables. Here, land price is taken as the dependent variable, and distance to the CBD, road density, number of educational facilities and employment opportunities, commercial and residential land use, and road width are considered the independent variables. Of the total data points, 80% of the data points are randomly selected and considered for the model development, and the remaining 20% of the data points are kept aside for the model validation.

**Table 5 Land Price Model**

| Parameter Estimates | | | | |
|---|---|---|---|---|
| **Parameter** | **Estimate** | **Std. Error** | **95% Confidence Interval** | |
| | | | **Lower Bound** | **Upper Bound** |
| a | -7.945 | 8.993 | -25.612 | 9.722 |
| b | 6.239 | 1.031 | 4.213 | 8.265 |
| c | 0.463 | 0.027 | 0.410 | 0.516 |
| d | 0.095 | 0.013 | 0.070 | 0.120 |
| e | 3.474 | 0.818 | 1.868 | 5.080 |
| f | 17.274 | 1.648 | 14.036 | 20.512 |
| g | 0.183 | 0.061 | 0.062 | 0.303 |
| h | 0.033 | 0.045 | -0.056 | 0.122 |

$$L = -7.945 - 6.239\,ln\,D + 0.463Rd^2 + 0.095NEF^2 + 3.474\,ln\,NEO + 17.274C + 0.183exp(R) + 0.033W \quad (1)$$

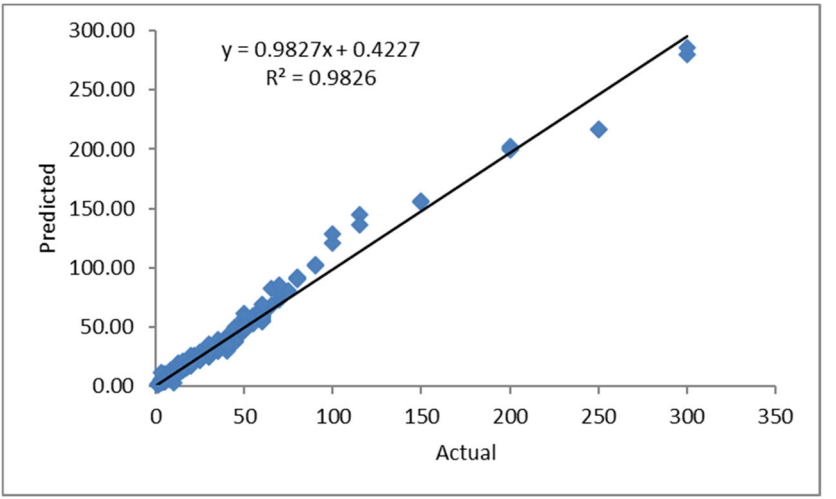
where,

L: Land price Rs. in Lakhs (100,000) per Are (market price as of 2021)
D: Distance to CBD in km
Rd: Road density in km per sq km
NEF: Number of educational facilities
NEO: Number of employment opportunities
C: Commercial land use in sq km
R: Residential land use in sq km
W: Width of the road in m

The model also assesses the strength between the variables and their future relationship with each other as well as land price.

The plot of actual versus predicted land prices shows how the model performs against the null model. To ensure a good fit, the points should be close to the fitted line. Outliers are the points that are vertically distant from the line. An adverse effect can be caused by both types of points. In **Error! Reference source not found.**, it is clearly shown that all of the points are closer to the line with an R2 value of 0.98. This shows the model is statistically significant and 98% of the model represents the observed data.

**Figure 10 Predicted v/s Actual Land Price**




## 5.4 Performance Evaluation of Model

### 5.4.1 Error Metrics

A non-linear model is found to be the best-fitting one for the land price model of the study region. The model validation is done with the use of the root mean square error (RMSE) and mean absolute percentage error (MAPE). RMSE is the residual error between the actual and predicted values, and the MAPE is a measure of the prediction accuracy of a forecasting method in statistics.

$$RMSE = \sqrt{\frac{\sum_1^N (Actual - Predicted)^2}{N}}$$

$$MAPE = \frac{\sum_1^N \left| \frac{Actual - Predicted}{Actual} \right|}{N} X\ 100$$

where N is the number of land parcels considered.

The RMSE and MAPE values obtained to validate the data fall under a good fit and very good range, respectively, whereas the RMSE and MAPE values of the calibration data fall under an adequate fit and good range, respectively, as shown in **Error! Reference source not found.**.

**Table 6 RMSE and MAPE Values of Model**

| | Validation Data | Calibration Data | Range | | Reference |
|---|---|---|---|---|---|
| **RMSE** | 0.081 | 0.054 | RMSE<0.05 | Good fit | Schermelleh-Engel et al., 2003) |
| | | | 0.05<RMSE<0.08 | Adequate fit | |
| | | | 0.08<RMSE<0.1 | Moderate fit | |
| | | | RMSE>0.1 | Not acceptable | |
| **MAPE** | 8.05% | 11.14% | MAPE< 10% | Very good | Swanson, 2015 |
| | | | 10%<MAPE<20% | Good | |
| | | | 20%<MAPE<50% | Ok | |
| | | | MAPE>50% | Not good | |

## 6. Discussion

The study focuses on the Thiruvananthapuram Municipal Corporation, in the Thiruvananthapuram District of Kerala state, India. The center of the study area, which houses the state government, major financial institutions, cultural landmarks, and commercial hub, is the centralized core that attracts the majority of economic investments and job opportunities, and thereby has the highest concentration of economic activities in a limited space. Furthermore, the transportation infrastructure of the city, such as bus terminals, railway stations, and major road networks converge in this central area. Residents and commuters predominantly converge in this core for work, education, and leisure purposes. As a result, Thiruvananthapuram Municipal Corporation clearly shows the dominance of a single core that serves as the focal point for its functions, which defines the city as a classic example of a monocentric city.

The study has developed a model that can predict the land price of the region. The various attributes that contribute to the land value of the region are identified. These attributes include proximity to commercial areas and efficient public transportation hubs. Other significant parameters that affect land prices include distance to the CBD, road density, access road width, number of educational institutions and employment opportunities, and residential and commercial land use area. The relationships between the parameters and land prices in the study are quite interesting and can have significant implications for urban planning and real estate development.

Distance to CBD and Land Prices: The inverse relationship between distance to the CBD and land prices suggests that properties located closer to the CBD tend

to have higher land values i.e. for each unit increase in the distance to the CBD, the land price decreases by approximately Rs 0.6 million per are (equivalent to 7200 USD). This finding aligns with the concept of urban centrality and the bid-rent theory proposed by Alonso (1964), The bid-rent theory suggests that land closer to the city center commands higher prices due to its proximity to economic and commercial activities, which is consistent with the findings in this study.

Road Density and Land Prices: The positive correlation between road density and land prices indicates that regions with well-developed road networks tend to have higher land value; i.e. for every additional kilometer of road per square kilometer, the land price is increased by approximately 46,000 Rs per are (550 USD). This could be due to improved accessibility, ease of using transportation, and the potential for increased economic activity in areas with better road infrastructures. Well-developed road networks and efficient public transportation systems improve connectivity within a region. Areas with better accessibility tend to attract businesses, residents, and investors, thus increasing demand for real estate and contributing to higher land prices. This is in line with the various studies in the literature (Binoy et al., 2020, Derdouri and Murayama, 2020, Glumac et al., 2019, McGreal and de la Paz, 2012, Pa et al., 2001) which emphasizes the importance of accessibility and connectivity in urban planning and real estate development.

Educational Facilities and Land Prices: The positive relationship between the presence of educational institutions and land prices suggests that areas with a higher concentration of schools, colleges, and universities are more desirable for residents and investors, which result in higher land value. This finding is consistent with studies in the literature (McGreal and de la Paz, 2012, Saefuddin et al., 2012) that recognize a quality education as a valuable amenity. Real estate developers, city planners, and policymakers often recognize the importance of incorporating quality education options into their plans to create vibrant, attractive, and thriving communities. Additionally, educational institutions often contribute to the local economy, which can further influence land prices.

Employment Opportunities and Land Prices: The positive correlation between employment opportunities and land prices reflects the fact that areas with a diverse range of job prospects attract people and businesses, thus driving up the demand for real estate and consequently increasing the land price. This relationship is in agreement with those found in existing research works (Binoy et al., 2020, Pan et al., 2018) that find a correlation between economic opportunities and real estate demand.

Commercial Land Use and Land Prices: The study finds that commercial land use has the most substantial impact on land prices. The positive relationship between commercial land use and land prices highlights the economic significance of commercial activities; i.e. an increase in the commercial land

use area by one sq km is associated with an increase in land price of approximately 1.73 million Rs. per are (equivalent to 20,000 USD). Regions with thriving commercial sectors tend to have higher demand for space, thus resulting in increased land value. This reinforces the literature (Binoy et al., 2020; Cellmer et al., 2014; Ha et al., 2022; McGreal and de la Paz, 2012; Nakamura, 2019; Pa et al., 2001; Rakhmatulloh et al., 2018; Tamba et al., 2011; Wang and Hou, 2021); i.e., the economic importance of commercial activities within an area and their role in shaping land prices.

Land Use Diversity: The discussion of the role of residential and commercial land uses in this study reinforces the importance of a balanced mix of land use. Areas with both residential and commercial spaces create vibrant communities where people can live, work, and access amenities within proximity. The coexistence of these uses can stimulate economic activity and positively influence land prices.

Overall, the study findings align with well-established principles in urban economics and planning. Geographical and accessibility parameters, as well as the presence of key amenities such as educational institutions and job opportunities, all contribute to the desirability of a location, which in turn influences land value. Understanding these relationships is vital for making informed decisions in urban development, real estate investment, and policy-making to create thriving and sustainable communities.

The primary objective of this study is to develop a predictive model for land prices for a specific region. To achieve this, we analyze a range of parameters that could potentially influence land value. These parameters include geographical factors such as proximity to commercial areas and transportation hubs, as well as other variables like road density and the number of educational institutions and employment opportunities.

The findings are then compared and contrasted with existing research studies in a literature review. This comparative analysis serves to validate the results and provide a broader perspective on the factors that drive land prices. By highlighting both similarities and differences, the study contributes to the ongoing discourse on land price determinants and enhances the existing understanding of these factors.

One significant outcome of the study is the confirmation of the substantial impact of commercial land use on land prices. The analysis reveals a significantly positive correlation between commercial land use and land prices, which is supported by a notable coefficient value (17.274). This observation reinforces the economic importance of commercial activities within an area and their role in shaping land value.

## 7. Conclusion

The study has achieved its primary objective of uncovering the intricate relationship between land price and various geographical and accessibility parameters. Through a rigorous analysis, the study identifies the significance of factors like distance to the CBD, road density, access road width, number of educational institutions and employment opportunities, and land use in determining land prices within the study area.

The development of a land price model with a high coefficient of determination ($R^2$) of 0.98 shows the robustness of the model in fitting the observed data. The performance evaluation of the model, which uses metrics like RMSE and MAPE, lends credibility to its accuracy in predicting land prices based on the selected parameters.

The implications of the study extend to the realm of urban planning and development. The insights gained can empower city authorities and policymakers to make well-informed decisions regarding land use planning, infrastructure investments, and overall development strategies. By understanding the factors that influence land prices, cities can work toward creating sustainable and equitable urban environments that cater to the needs of their residents.

However, the study does acknowledge its limitations, such as the specificity of the study area and the potential influence of unmeasured variables on land prices. This calls for cautious interpretation and a nuanced approach when applying the findings to other regions. The study suggests that future research can address these limitations by conducting similar studies in different contexts, while also considering additional variables to further refine the predictive model.

In conclusion, the study makes a valuable contribution to the understanding of land price determinants and provides a reliable model for predicting land prices based on geographical and accessibility parameters. The insights garnered from this research can serve as a guiding compass for urban planners and policymakers, which can help them in making informed decisions that foster sustainable and well-balanced urban development.

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# Appendix

KSCSTE - National Transportation Planning and Research Centre
Development of Integrated Land Use Transport Model for Thiruvananthapuram
Land Value Survey

**Ward Name:** **Date:**

| Plot area | Price of plot | Land value (per cent) | Type of access* | Purpose of plot # | Filled up/wetland Y/N | Please enter the distance in km to | | | | | | Locality | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Shopping area | Public transport facility | Medical facility | Educational facility | Recreational facility | Other facility (Specify) | | |
| | | | | | | | | | | | | | |
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***Type of access:** NH[1] SH[2] PWD Road[3] Corp/Mun/Panch[4] Private Road[5] 3W access[7] 2W access[6]

**#Purpose of plot:** Residential[1] Commercial[2] Industrial[3] Religious[4] Public[5]