Urban Land Value Estimation Model based on Income Capitalization Method

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Abstract. Land valuation is a critical component of the cadastral system, closely linked to land use and management. The value of land is typically assessed based on the benefits it offers. The high land prices often observed in urban areas result from increased demand, whereas the availability of land remains fixed. Several methods can be employed for land valuation, including the market comparison method, the income capitalization method, and the cost method. This study focuses on the income capitalization approach for determining land value. According to this method, higher income generated from a property leads to a higher property value. For residential properties, income is derived from net rent, calculated as rental income minus operational expenses, using the income approach. This research employs geostatistical analysis to model land values. The mathematical model developed through geostatistical analysis aims to represent actual land values accurately and facilitate the establishment of land value zones.

1 Introduction

The cadastral system is fundamentally structured around three key components, with land appraisal being a significant aspect interconnected with land control and land use. The valuation of land is determined by the benefits it offers. The variation in land value, whether high or low, is influenced by several factors. These factors include economic, social, governmental, and physical elements, all of which play a role in shaping land value. [1].

The phenomenon of high land prices in urban areas is caused by high level of need for land, while total land area is fixed. The price of land is an illustration in land appraisal. There are still issues with land assessment, such as the following: (1) the process is labour-intensive, time-consuming, and costly because there are so many land parcels; and (2) the outcomes of the appraisement do not accurately represent the value of the land. For statistical analysis of land value models, basic regression is still typically used. The impact of location is not considered in this analysis (X, Y). New techniques of assessment are being sought through this research to potentially address the issues that arise.

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Land can be valued based on several methods, namely: market price comparison method, income capitalization method, and cost method. This research will focus on land valuation according to the revenue of capitalization method. The income capitalization method is a property valuation technique that relies based on the yearly net income generated from managing the property. This net income is subsequently converted into the property's fair market value by applying a specific capitalization rate matrix. [2], [3]. According to the income approach, the value of a property is determined by its potential to generate income; the more income the property can produce, the higher its value. Because the value of a property is determined by capitalizing the net operating revenue annually with a specific capitalization level, this method is known as the capitalization method. This income approach is suitable for assessing income producing property [4], [5].

Geostatistics is the use of statistics and mathematics to the measurement of spatial distribution of events. The term "spatial" in this context refers to variables that are present on the surface of the earth, such as topography, flora, waterways, etc. Numerous models of geostatistics are used in the domains of geology and mining. Geostatistics was enlarged to assess issues associated to geological phenomena in mines, from retain estimation to classify control drawbacks[6].

Spatial trends and spatial correlation in the middle of various measured samples can be modelled using the interpolation technique known as geostatistics. The First Law of Geography states that there are spatial tendencies and correlations since everything that is closer together has an adjacent connection/interrelation than everything that is in the distance. Throughout geostatistical analysis, estimates of parameter values can be produced in preference to where the data is unspecified. Besides being able to make predicted areas, the geostatistical interpolation method can also include several error measures in the prediction results [7].

Spatial autocorrelation is a term used in geostatistics. A spatial autocorrelation plot displays how similar items are to one another. A consistent pattern in a variable's distribution indicates the presence of spatial autocorrelation. Estimated values in a given area are expected to align with the values of nearby areas. [8]. This study utilizes geostatistical methods to analyze data, which will be applied to model land values. It is anticipated that the land value mathematical model derived from geostatistical analysis will accurately represent the true value, which can subsequently be applied to the establishment of Land Value Zones.

2 Data

The spatial data utilized in this study include: (1) the administrative line boundaries of the Yogyakarta region obtained from the Geospatial Information Agency and (2) property sale listings and building/land lease data provided by Yogyakarta realtors. The data analyzed in this research were collected using the Purposive Sampling method, where samples were selected based on specific attributes or criteria aligned with the research objectives. The primary criterion for selection was that the analyzed data pertain to property leases.

This study examines 60 property rental records distributed throughout Yogyakarta City. The data comprise spatial inputs, including latitude and longitude coordinates, and attribute data in tabular form, such as property rental prices, building sizes, and land areas. These attributes collectively contribute to determining property rental prices. Property valuation is conducted using the income capitalization approach. Additionally, data on building or land capitalization rates were derived from the Indonesian Valuation Standards.

Table 1. Revenue Capitalization Rate.

Property Type	Capitalization Rate
Vacant land	0,5% – 2%
Rental house	3% – 5%
Commercial space and office	6% – 9%
Stall and store	5% – 10%
Flats and condominiums	7% – 12%

In this research, there are 9 data on apartment rental prices, 21 data on shophouse rental prices, 11 data on house rental prices, 12 data on kiosk rentals, and 7 data on vacant land rentals.

3 Method

In this investigation, an income capitalization approach is utilized. Building charter information have compelled to considered numerically and get the land price per meter square. The price of land per meter square can be expected to be the value of land per meter square. Computation of land price gotten by building charter information. The building or price can be estimated using Equation 1 below.

$$\text{Property price} = \frac{\text{Net operating income for 1 year}}{\text{Capitalization rate}} \quad (1)$$

Calculation of land value gotten from property rental information requires building price information per meter square. In Yogyakarta City, the building price per meter square is IDR 2000.000. The taking after (Equation 2) is the computation of land value gotten out of property rental information.

$$\text{Land value} = \frac{\text{Property price} - (\text{Building price x building area})}{\text{Surface area}} \quad (2)$$

The land value is obtained from the salary financed proceed toward, and will turn out to be modelled utilizing geostatistical examination. The geostatistical examination hypothesis built on haphazardness show that permits the determination of ideal gauges at irregular focuses within the ponder range. Preferably, require under consideration the spatial relationship. The supremacy of geostatistics is the utilize of a calculable degree of spatial relationship, in particular that more often than not spoken to by variogram [9]. There are different sorts of variogram models, counting circular, k-Bessel, gaussian, spherical, tetrasperichal, Penta spherical, exponential, hole effect, judicious quadratic, j-Bessel, and stable [10]. Fact-finding, exponential, gaussian, and spherical models are being used. The geostatistical strategies utilized to foresee information at unsampled areas is performed by Kriging, which is communicated within the taking after condition equation [11]:

$$Z(s)=\mu(s)+\varepsilon(s) \quad (3)$$

Z(s) = The variable value

μ(s) = Inevitable trend
ε(s) = Random noise in the system
s = Position

The appraisal strategies or method in geostatistics that is regularly utilized is the Kriging Method. Kriging method comprises of three sorts, to be specific ordinary, simple, and universal. The Ordinary Kriging is one of the most common and easy methods to use or implement.

This strategy is recognized by average and variance. The Kriging method influences the absenteeism and existence of variance and mean. On the off chance that the fluctuation(variance) is consistent, at that point the simple kriging is utilized. For precaution, on condition that the average is consistent and the information or data is halted (no slant), at that point the Ordinary Kriging strategy is utilized. On the off chance that the average is well known and the data carrying a drift (non-stationary), at that point the Universal Kriging strategy is performed. In this research, we will assess utilizing the Ordinary Kriging method since the information does not repress tendency, and contains a consistent average.

The variogram is a crucial tool for making estimates based on spatial data. In situations where two spatial values are in close proximity, their values are likely to be more similar compared to those that are farther apart[12]. The value of the semi-variogram is half of the variogram's value, as represented by the following mathematical equation. [11]:

$$\gamma(h) = \frac{1}{2\mathrm{N}(h)} . [z_i - z_j]^2 \quad (4)$$

γ(h) = Semi-variance; deliberated to depict the anticipated value of the distinction in sample values
zi,zj = Sample value at position-i and sample value at position-j
N(h) = Total of data
h = Length between the points of data (lag distance)

Nugget, sill, and range characterize the feature of semi-variogram and visualized using the graph in Figure 1.[13].

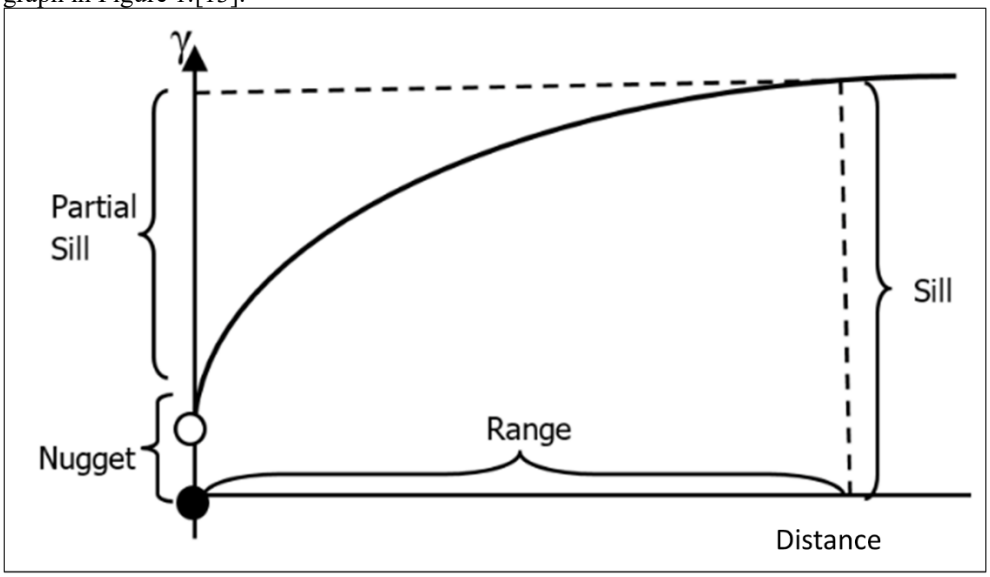

Fig. 1. Schematisation of Semi-variogram model. The curve speaks to the demonstrate work utilized (observational of the model function performed) and range established for the extend looked for.

Nugget is the changeability at zero extend, reflecting the testing mistake and the explanatory blunder. Meanwhile, range is within the realm of the spatial slant, boundary remove, exterior the test is dimensionally autonomous. And sill is the changeability of the spatially free tests (most extreme constrain of variogram esteem).

The Ordinary kriging method was chosen in this evaluation, since the mean value of the obscure test information is accepted to be static. Geostatistics expect that a few watched spatial varieties in normal marvels could be modelled in an irregular prepare with auto spatial relationship, and a can be modelled unequivocally [14]. A demonstrate can be said to be great on the off chance that the assessed blunder show meets a few prerequisites, to be specific the Root-Mean-Square Standardized is near to 1; Standardized value is near to 0; and the Average Standard Error is nearly the same as the Root-Mean-Square [11].

4 Results and Discussion

The income capitalization and land value blue-print proceed toward four semi-variogram representation. The variogram model error estimates are conferred in Table 2.

Table 2. Error estimation in modelling using Semi-variogram Model Error is assessed based on Root-Mean-Square, Mean Standardized, Root-Mean-Square Standardized and Average Standard Error in some form of variogram models.

Estimation Error	Stable	Gaussian	Spherical	Exponential
Root-Mean-Square	3443234	3426625	3418791	3472509,623
Mean Standardized	0,012889	0,014838	0,022036	0,00812752
Root-Mean-Square Standardized	0,980219	0,973388	0,957589	0,985556302
Average Standard Error	3531879	3551215	3570958	3536776,228

Constructed on the ambiences for selecting the most excellent demonstrate, the exponential semi-variogram show all the necessities. Another pace is to determine the standard deviation to approve the comes about of this sort of demonstrate. Tabel 3 shows the standard deviation of the semi-variogram.

Table 3. Semi-variogram Model with Standard Deviation Value based on Exponential, Spherical, Gaussian, and Stable variogram models.

	Stable	Gaussian	Spherical	Exponential
Standard Deviation	Rp 2.748.520	Rp 2.975.522	Rp 2.663.263	Rp 2.287.497

Acquired from Table 3, it is acknowledged that the ascending demonstrate has the least standard deviation, it is fair to say that the income capitalization approach is demonstrate excellently with the exponential semi-variogram model. Figure 2 displays the land value of Yogyakarta as the outcome of the semi-variogram modelling.

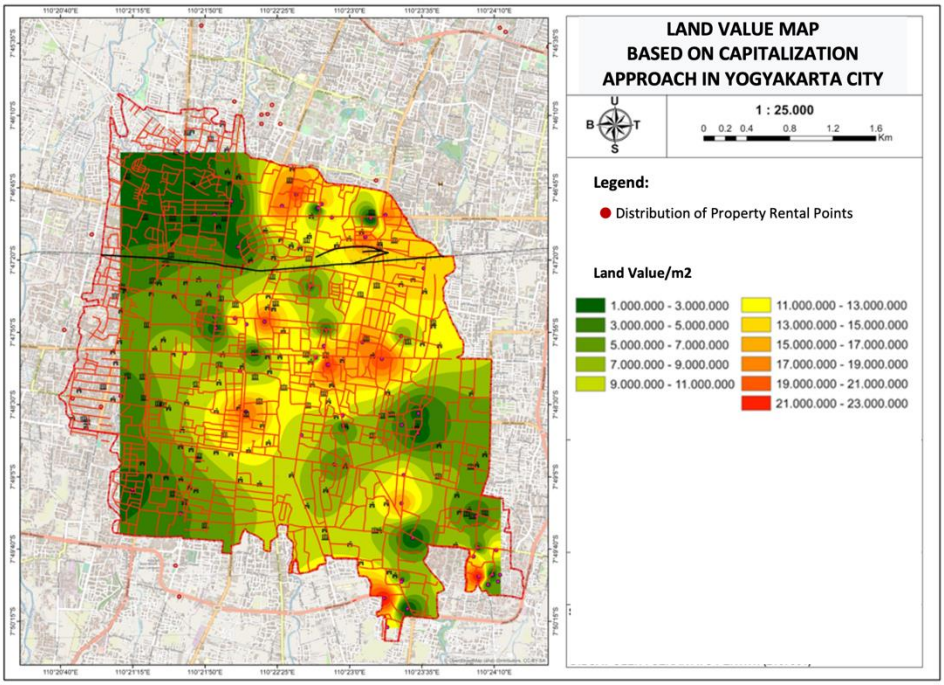

Fig. 2. Land Value Modelling in Yogyakarta City, Dependent on Income Capitalization Approach. The red colour represents the highest land value on Yogyakarta, spread across various areas of central Yogyakarta, while suburban areas tend to be green which represents relatively low land prices.

Found on the earnings financed proceed toward, best land value representation is the Exponential semi-variogram model. The centre of Yogyakarta become the highest land values, this is allegedly caused by the existence of several main sectors, there are educational centres, cultural centres and tourist destinations.

5 Conclusion

Elicited from the outcome of the examination that has been accomplish It is possible to be achieved that the geostatistics proceed toward utilizing the Kriging can be utilized to show urban land costs, since this modelling employments an introduction handle, the precision of the displaying comes about is exceptionally subordinate on the information test utilized. Land value approximation models are delivered from Exponential, Spherical, Stable, and Gaussian semi-variogram models. The exactness of the land value guesstimate demonstrating comes about, is affected by the determination of the semi-variogram model. The assessed mistake value or approximation error value from the wage financed proceed toward appears that the exponential semi-variogram demonstrate can be said to be a great demonstrate for evaluating land value. The evaluated land value outturn that the Exponential semi-variogram can at that point be utilized As a land valuation area outline map data and information.

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