

Land Value Changes Analysis in Sub-Urban Area of Surabaya-Gresik using Spatial Modelling of Anselin Local Moran's I

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Abstract

Land value changes in suburban areas are a complex phenomenon influenced by land use dynamics, population growth, and infrastructure development. In metropolitan regions like Surabaya, urbanization pressure has led to land conversion, especially from agricultural land to residential and industrial zones. This suburbanization process triggers uneven changes in land value, depending on external factors such as accessibility and regional connectivity. This study aims to analyze the relationship between land use change from non-urban to urban and the changes in land value in the Surabaya–Gresik area in 2019 and 2023. The analysis utilizes GIS-based and spatial modelling with Sentinel-1 imagery, Land Value Zone (ZNT) maps, and the Anselin Local Moran's I method to identify spatial clustering patterns of land value changes. The results indicate that most areas undergoing urbanization also experienced an increase in land value, classified as High-High (HH) clusters, particularly in the districts of Sambikerep, Lakarsantri, and Menganti. However, exceptions were found in areas such as the southwestern parts of Lakarsantri and Pakal, which, despite urbanization, remained in the Low-Low (LL) cluster, reflecting persistently low land values. These findings highlight that urbanization does not automatically raise land value without supporting infrastructure and adequate accessibility. This spatial-temporal approach provides crucial insights for regional planning that is responsive to the dynamic growth of suburban areas.

Keywords: Land Value Change, Remote Sensing, Spatial Clustering Patterns, Suburban, Transformation

1. Introduction

Land value is land's ability to be exchanged for other commodities in a sale and purchase transaction. The market value of land reflects the price agreed upon by the seller and buyer in the form of money [1]. Economically, land value describes the potential of a land to generate profits through its utilization and management [2]. Based on its use, land value can be divided into two, namely improved land, which includes the price of land and buildings on it, and unimproved land, which only takes into account the price of land without buildings [3]. Two main factors influence land value, namely external and internal factors. External factors include external elements that affect land value, such as environmental conditions, transportation accessibility, and the

presence of new community centers, as well as internal factors related to the physical condition of the land itself, such as topography and soil properties [4]. Land values are highly dynamic, especially in areas that are strategic locations to fulfill land needs due to rapid development and population growth [5] and [6]. Land scarcity in urban centers drives expansion, increasing demand and causing significant changes in land values, influenced by accessibility, infrastructure, and land conversion to support various needs [7].

Suburbanization is one of the factors causing changes in land values in suburban areas. This process involves the formation of new settlements and industrial areas in the periphery, driven by the

movement of people from the city center to meet the needs of housing and economic activities [8][9] and [10]. Changes in the function of agricultural land in sub-urban areas have resulted in a shift in the livelihood structure of the community, from relying on the agricultural sector to other sectors outside agriculture [11] and [12]. The reduction of agricultural land area and the increasingly urgent economic needs encourage people to find solutions through new businesses outside the agricultural sector [13]. One such case is the Surabaya Metropolitan Area (SMAs). This can be seen from changes in settlement patterns in the peripheral areas of Surabaya City, especially in Sidoarjo Regency and Gresik Regency, which are directly adjacent to the city. The rapid urbanization process in these areas has led to a decline in the population growth rate of the central city of Surabaya, while the surrounding areas, particularly Gerbangkertosusila, have experienced a significant increase in population growth rate [14] and [15].

The second feature of suburbanization is characterized by a significant reduction in the area of paddy fields due to the increase in population and the expansion of urban areas, especially for large-scale residential development such as real-estate types and industrial areas [16] and [17]. Research by [18] showed that Gresik Regency experienced the largest shrinkage of paddy fields in 2017, amounting to 2,273 hectares in 6 years (2012 - 2017). Another study by [19] noted the conversion of 17.8 hectares of protected paddy fields into built-up areas in Driyorejo District. These changes not only affect local ecosystems but also have an impact on land value patterns that continue to increase in sub-urban areas due to the increasing need for residential and industrial space.

The analysis of land value changes in sub-urban areas, especially in relation to land cover changes, is important because these areas are often the main locations of land cover changes due to urbanization pressures [20] and [21]. Research by [22] with a case study of Denpasar City, analyzing the 2007 and 2011 land value zone maps with land use changes showed that the biggest change occurred in residential complexes into buildings. Another study by [23] in Banyudono Subdistrict, Boyolali Regency, analyzed the impact of public and social facilities development on land value zones. The results showed that areas near new facilities experienced a significant increase in the Average Indication Value of land values. Another study by [24] conducted a study in Boyolali Subdistrict to see the impact of terminal displacement and the construction of the Semarang-Solo toll road on land use change and land value zones. The study showed a significant increase in

land value in the area near the new facility. Another study by [25] conducted a study in Sleman Regency analyzing the impact of land cover change on the value of ecosystem services, which although focused on ecosystem services, provided insight into the relationship between built-up land change and economic value.

Several studies related to land value change analysis [26][27] and [28] used spatial analysis methods to identify changes in land use and land value that occurred. From some of these previous studies, no research observes spatial and temporal patterns of land value change. Observing patterns of land value change related to land cover change is very important for future land management. Thus, in this study, a spatial and temporal analysis of land value changes related to land cover changes, especially in sub-urban areas, was conducted. The analysis is using GIS-based and spatial modelling. The resulting spatial analysis and modelling are expected to make an important contribution to understanding the dynamics of land use and the preparation of regional planning strategies that are more adaptive to the development needs of sub-urban areas, both from the economic and environmental sustainability aspects.

2. Methodology

The research is located in the border area between Surabaya City and Gresik Regency, East Java Province, Indonesia as shown in Figure 1. Surabaya is the second-largest city in Indonesia and serves as the main economic and administrative center of East Java Province. Directly adjacent to Surabaya on its western side, Gresik Regency is characterized by a mix of industrial, residential, and agricultural land uses and functions as an important supporting region within the metropolitan system.

There are 9 sub-districts located on that area, which are divided into 5 sub-districts in Surabaya (Benowo, Pakal, Sambikerep, Lakarsantri, and Karang Pilang) and 4 sub-districts in Gresik (Kebomas, Cerme, Menganti, and Driyorejo). The total area of the study region is approximately 312.48 km², consisting of 90.67 km² within Surabaya City and 221.81 km² within Gresik Regency. Based on 2023 statistical data, the total population of the study area is approximately 773,042 inhabitants, with around 343,598 inhabitants in the Surabaya part and 429,444 inhabitants in the Gresik part. This cross-boundary area forms part of the western fringe of the Surabaya Metropolitan Area and represents a transitional urban–peri-urban zone characterized by rapid land use change and increasing development pressure.

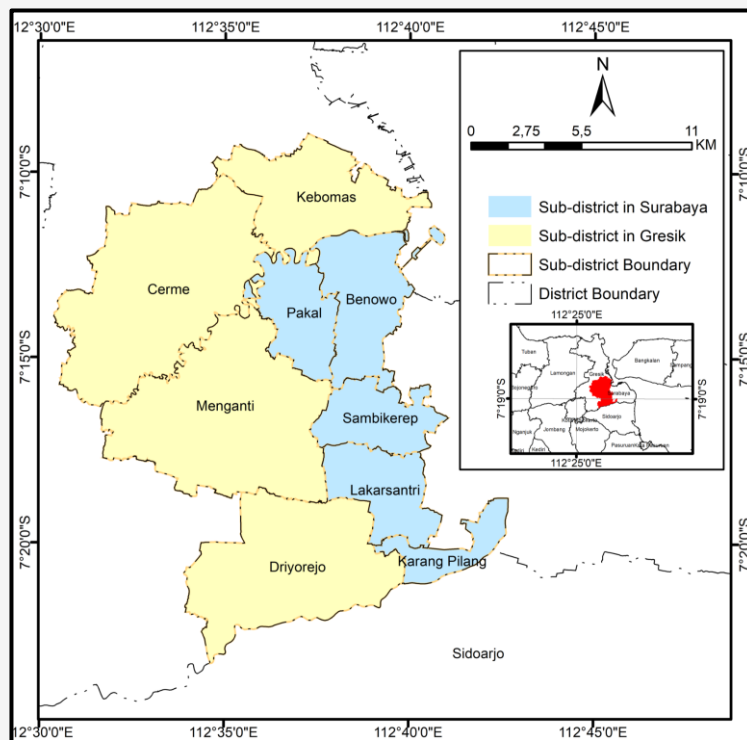


Figure 1: Study area in Surabaya-Gresik, East Java, Indonesia

The methodological flowchart was presented in Figure 2. Sentinel-2 satellite imagery was used to produce land cover maps. Image preprocessing and supervised classification using the Random Forest algorithm were conducted on the Google Earth Engine (GEE) platform. The classification of Sentinel-2A imagery resulted in five land cover classes, i.e., water bodies, bareland, built-up land, vegetation, and agriculture. Land cover data of Surabaya City and Gresik Regency from the East Java Provincial Public Housing, Settlement Area, and Cipta Karya Office were used as reference data to determine the accuracy of the Sentinel-2 land cover classification results. The results of image classification are tested for accuracy using a confusion matrix. The accuracy was determined by overall accuracy and the kappa coefficient resulted from the confusion matrix. Geospatial data analysis software was used for post-classification processing, spatial analysis, visualization, and map layout generation.

Land value zones were obtained from the National Land Agency. Land value data of 2019 and 2023 were overlaid. The process was carried out in order to obtain land value change information. The difference in land value is calculated using the subtraction method, land value on 2023 subtracted by land value on 2019. If the difference result obtained is positive, then the land value in the area has increased, and otherwise, if the difference result

obtained is a negative result, then the land value in the area has decreased, and if the difference result is zero then the land value in the area remains unchanged.

Subsequently, land value changes from non-urban to urban areas were performed. This process involves analyzing changes in land value within land cover areas which have transformed from non-urban to urban. To better capture the intensity of land value change, the study identifies increases across land value classes, ranging from class 1 to class 8. Classes 1–2 represent very low to low land value areas, generally corresponding to peripheral zones with limited development pressure. Classes 3–4 indicate moderate land values, reflecting transitional areas influenced by emerging urban activities. Classes 5–6 correspond to high land value areas, typically associated with established or rapidly developing urban zones. Classes 7–8 represent very high land value areas, commonly located in strategic urban centers with strong accessibility and high economic demand. Transitions between these classes, such as from class 1 to 2, 3 to 4, 5 to 6, and up to class 7 to 8, are used to observe patterns of significant land value growth and to assess the progressive stages of urbanization and land market intensification. In order to enhance the comprehension of the spatial patterns of value changes, a cluster distribution analysis was conducted using the Anselin Local Moran's I method [29].

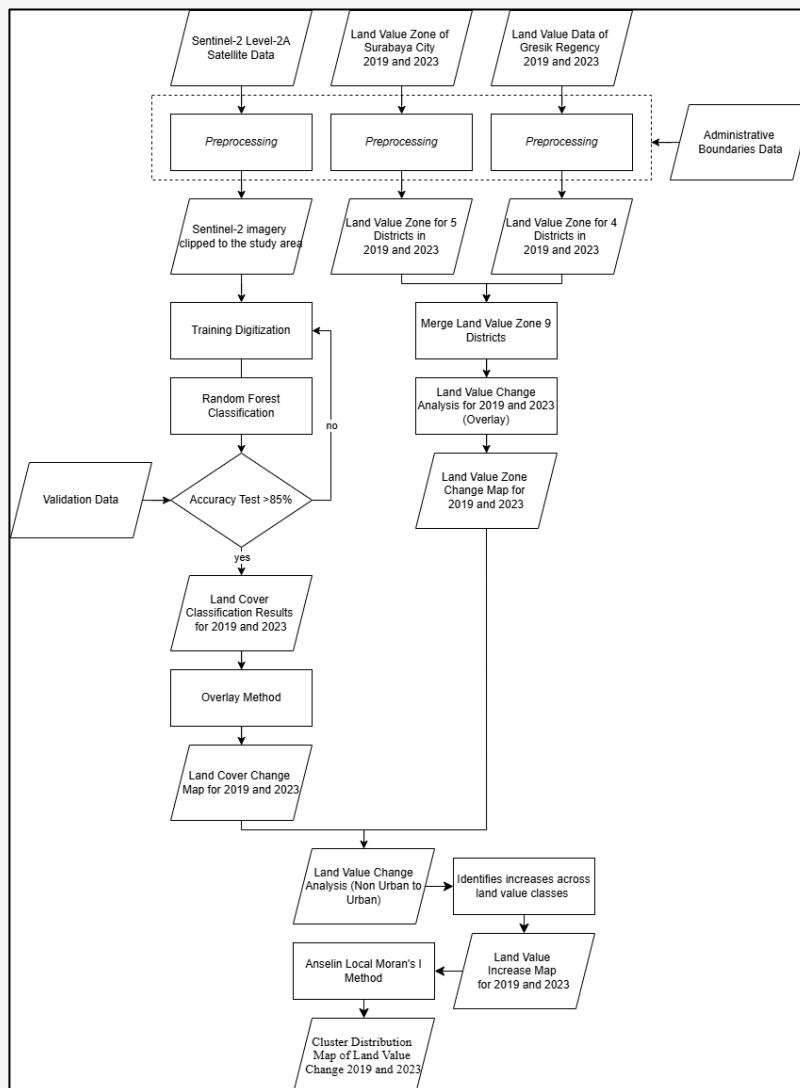


Figure 2: Methodological Flowchart for Land Value Change Analysis

The objective of this method is to identify locations that demonstrate statistically significant High-High (HH), Low-Low (LL), High-Low (HL), and Low-High (LH) value clustering patterns [30]. This approach enables the identification of areas that have shown substantial concentrations of change within a geographical context. High - High (HH) signifies a location with a high value that is surrounded by neighbors also having high values. This pattern indicates a hotspot or a cluster of elevated values, suggesting a localized area of intense activity or change. Low - Low (LL) represents a location with a low value that is surrounded by neighbors also having low values. This indicates a coldspot or a region with consistently low values, reflecting an area with minimal or no change. High - Low (HL) refers to a high value location surrounded by low value neighbors. This is an outlier potentially

signaling an anomalous increase in an otherwise stable or low change region. Low - High (LH) indicates a low-value location surrounded by high-value neighbors [31]. This outlier may reflect a pocket of resistance to change or an area under a different influence compared to its surroundings [32].

3. Result

3.1 Land Cover Classification

During the land cover classification process, the results obtained must meet the standard technical guidelines for the accuracy of basic maps in Indonesia. The standard overall accuracy set for land cover is 85%. Overall accuracy is the accuracy value calculated by summing the number of correctly classified values and dividing it by the total number of values, while the kappa coefficient shows the level

of conformity between the classification results and the truth value. Using the confusion matrix, the overall accuracy and kappa coefficient values of the classification results can be calculated. Table 1 showed good kappa coefficient value of land cover map results in 2019 and 2023 (0.81 and 0.88). It can be said that the land cover map from Sentinel-2 imagery in those two years can be used for this research. Figure 3 presents the land cover classification maps for the years 2019 and 2023, displaying five land cover classes represented by five distinct colours. Both maps are predominantly colored dark green, indicating that agriculture is the most extensive land cover in the study area. The second most dominant class is built-up land, which is shown in red. Additionally, water bodies, represented in light blue, are primarily located in the northern part of the study area. The bareland class is not visually visible on the map, while the vegetation class appears to be spread out on the eastern side of the area. The

comparison of land cover in 2019 and 2023 (Figure 4) shows a significant increase in built-up land, from 82.63 km² to 93.26 km², indicating ongoing urban expansion. Meanwhile, agricultural land decreased from 192.64 km² to 186.12 km², suggesting land conversion due to development. Vegetation cover increased in 2023 due to urban greening initiatives, secondary vegetation regeneration on previously unused or abandoned land, and better vegetation conditions during the image acquisition period. Additionally, seasonal variability may have influenced classification results, leading to higher vegetation detection. Meanwhile, the reduction in water bodies may be related to land reclamation activities, changes in surface water extent during the dry season, or increased water extraction, which can reduce the areal extent of detectable surface water. These changes reflect urban growth and shifting land use patterns that require attention in spatial planning and environmental management.

Table 1: Accuracy Assessment of Land Cover Classification

Accuracy	2019	2023
Overall Accuracy	88.00%	91.07%
Kappa Coefficient	0.81	0.88

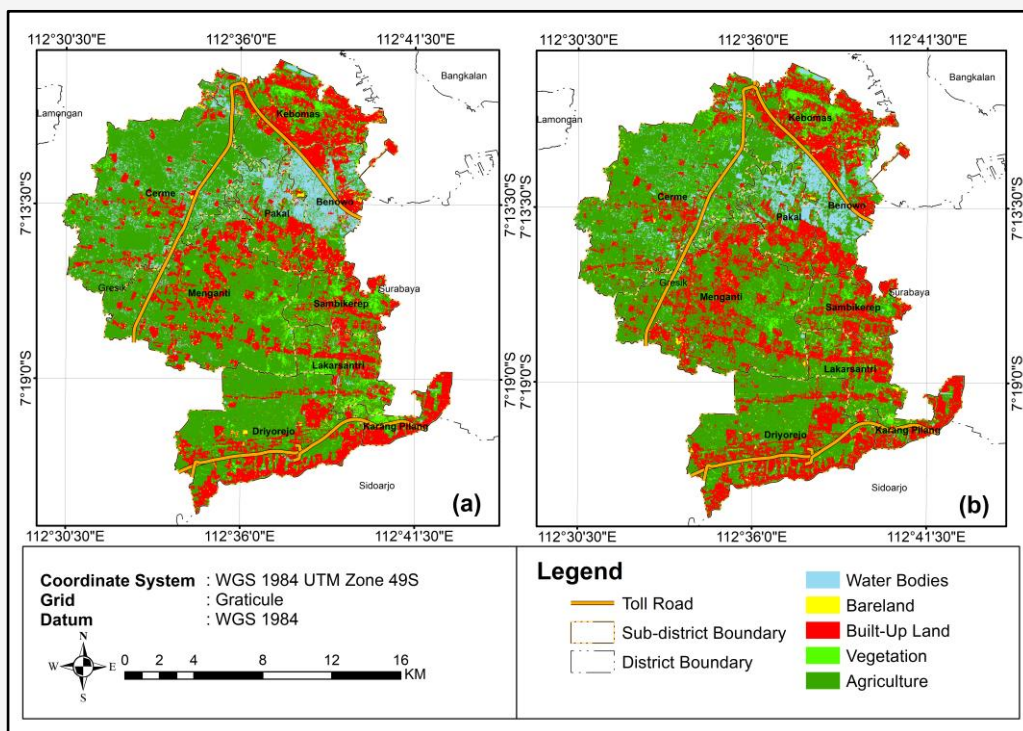


Figure 3: Land Cover Classification (a) 2019 and (b) 2023

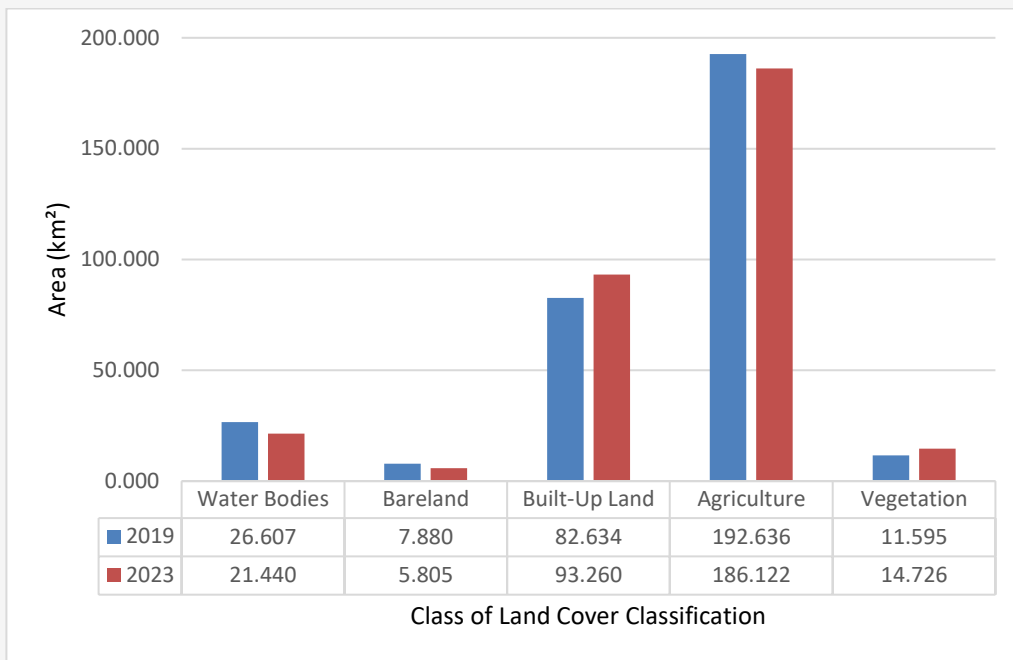


Figure 4: Histogram of Land Cover Area

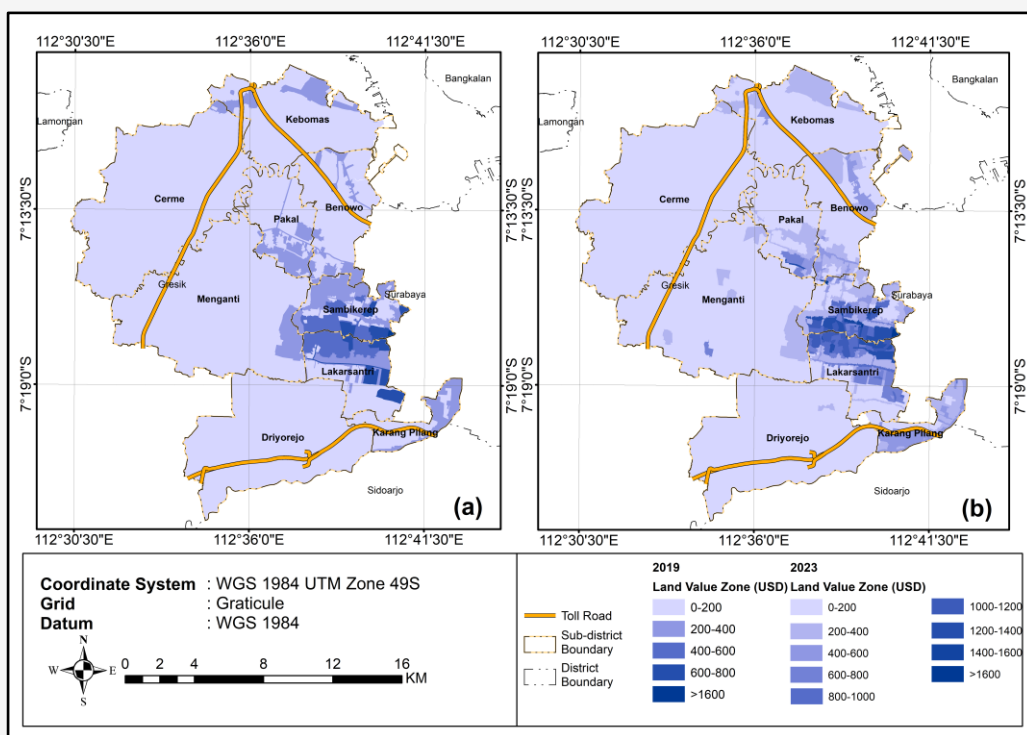


Figure 5: Land Value Zone Map (a) 2019 and (b) 2023

3.2 Land Value Zone

Based on the 2019 and 2023 land value zone maps (Figure 5), it can be seen that the border area between Surabaya (especially Sambikerep and Lakarsantri sub-districts) and Gresik (especially Menganti) experienced a significant increase in land value. In

2019, most of the land value zones in this area were within the range of 400-800 USD/m². However, by 2023, zones with higher values began to dominate, and new zones with land values reaching 1000-1200 USD/m² emerged around Lakarsantri and parts of Sambikerep. This change indicates a rapid

urbanisation process in these border areas. Increasing land values are also seen in the Menganti and Benowo areas, which were previously dominated by low land values (200-400 USD/m²), but are now showing a trend towards medium values. These areas are experiencing development pressure due to the expansion of Surabaya to the west and southwest. The availability of large tracts of land and easy access to the city centre have encouraged the growth of new settlements in these areas, which has had a direct impact on increasing land prices. This suggests that the Surabaya-Gresik border is a strategic area for future urban development.

3.3 Land Value Changes in Areas that Transform from Non-Urban to Urban in 2019 and 2023

The spatial analysis of land value changes shown on both maps supports the assessment of areas undergoing transformation from non-urban to urban land cover between 2019 and 2023. Figure 6 shows the changes in land value between 2019 and 2023, classified into three categories: increasing value (red), decreasing value (green), and fixed value (yellow). The spatial distribution shows that most areas in Sambikerep Sub-district and its surroundings experienced a significant increase in land value, as

seen from the dominance of red colour in the area. This indicates development pressure or high demand for land, which generally occurs in developing suburban areas. In addition, there are areas that experienced a decrease in land values, mainly scattered in the western and southern parts of the study area, although the number is smaller. The yellow colour, indicating no change in value, is spread more evenly across the various sub-districts, indicating that most areas remain stable in land value. Locations crossed by toll roads also seem to be associated with increased land values, which corroborates the influence of infrastructure on land value dynamics.

In the subsequent analysis (Figure 7), areas experiencing increases in land value were examined in greater detail by analysing the range of land value increase classes within the urbanised area. The spatial distribution shows that the most notable increases are scattered across Sambikerep, Lakarsantri, and parts of Menganti, which are located along the administrative border between Surabaya City and Gresik Regency. In these transitional zones, land value increases are predominantly observed in the 1–2 and 3–4 class ranges.

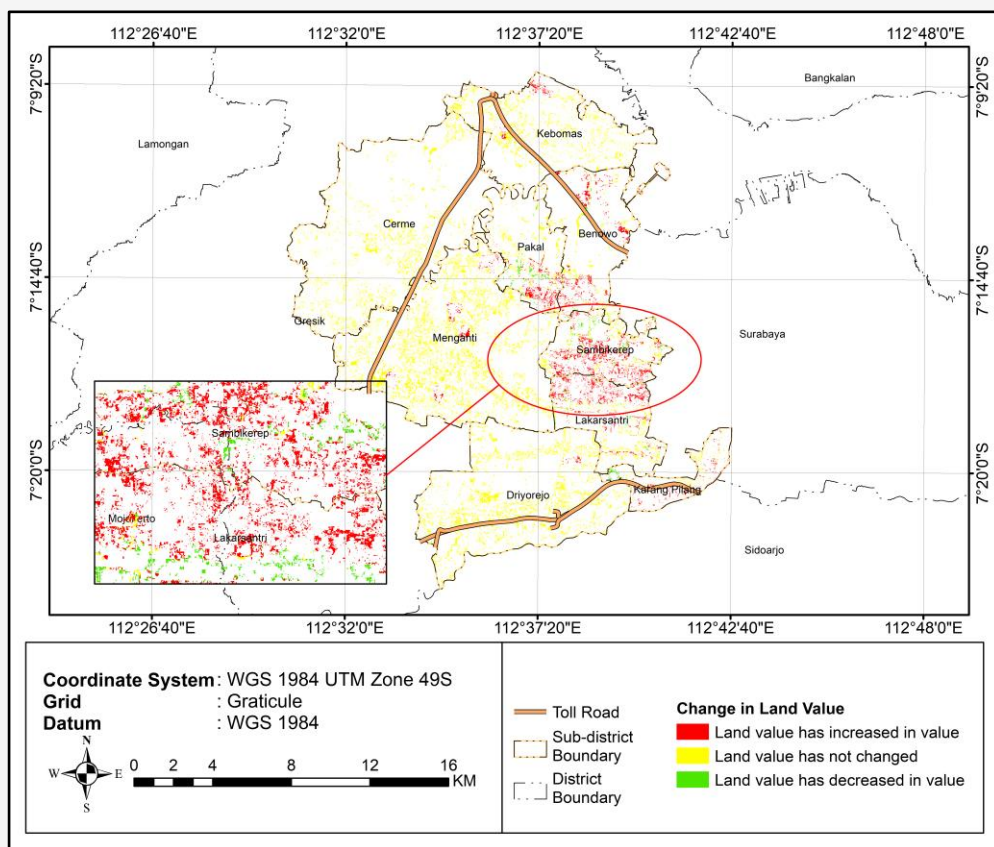


Figure 6: Land value change map

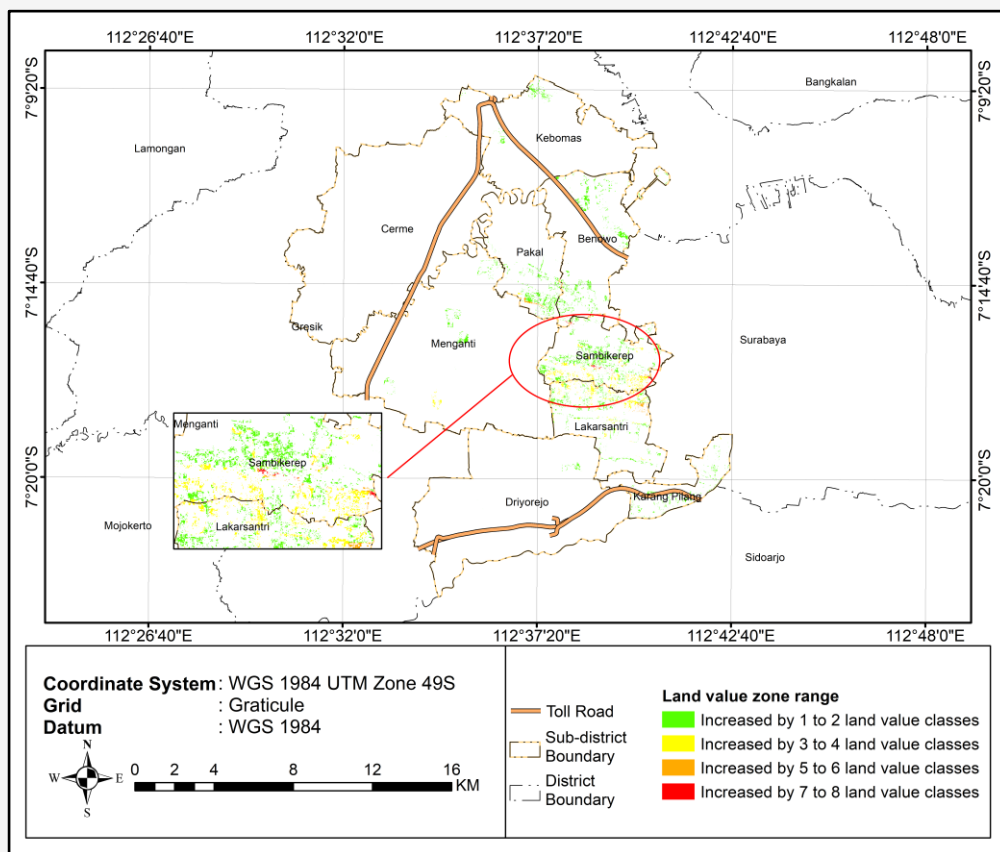


Figure 7: Land value increase map

The 1–2 class increase represents areas with relatively modest land value growth, indicating early-stage urban influence where non-urban land begins to be affected by nearby development. The 3–4 class increase reflects a moderate to high rise in land value, suggesting a more advanced phase of urban transformation driven by increasing accessibility, infrastructure development, and growing demand for residential and commercial land. Higher land value increase classes are more limited in spatial extent and tend to be concentrated closer to established urban centres, while lower classes dominate the peripheral areas. Overall, the gradual shift in land value increase from lower to higher classes illustrates the progressive expansion of Surabaya City's urban development toward the western fringe, leading to incremental land value escalation in the surrounding suburban areas.

In addition, there are also areas that experienced a spike in land value with a range of 5–6 even up to 7–8 classes. The locations with the highest spikes are generally located in the Surabaya-Gresik border zone, between Sambikerep and Lakarsantri. This significant increase in land value indicates a very

high development pressure in the area. In the area, there are many elite settlement complexes with a smart city concept which has caused a surge in changes in land values. This suggests that the factor of land use change from non-urban to urban in the border area has a major role in driving land value escalation, mainly due to the increasing demand for built space and the expansion of settlements in the suburbs.

After identifying the pattern of land value increase in the Surabaya-Gresik area between 2019 and 2023, spatial modelling using Anselin Local Moran's I was applied to examine the spatial pattern of change (Figure 8). The results indicate a clear spatial differentiation in land value dynamics across the study area. In 2019, two High–High (HH) cluster zones were identified in Lakarsantri and Sambikerep, representing spatially significant concentrations of high land values that are reinforced by similarly high-value neighboring areas. These HH clusters indicate emerging and established urban growth centers, where land value increases are driven by strong development pressure, improved accessibility, and proximity to Surabaya's urban core.

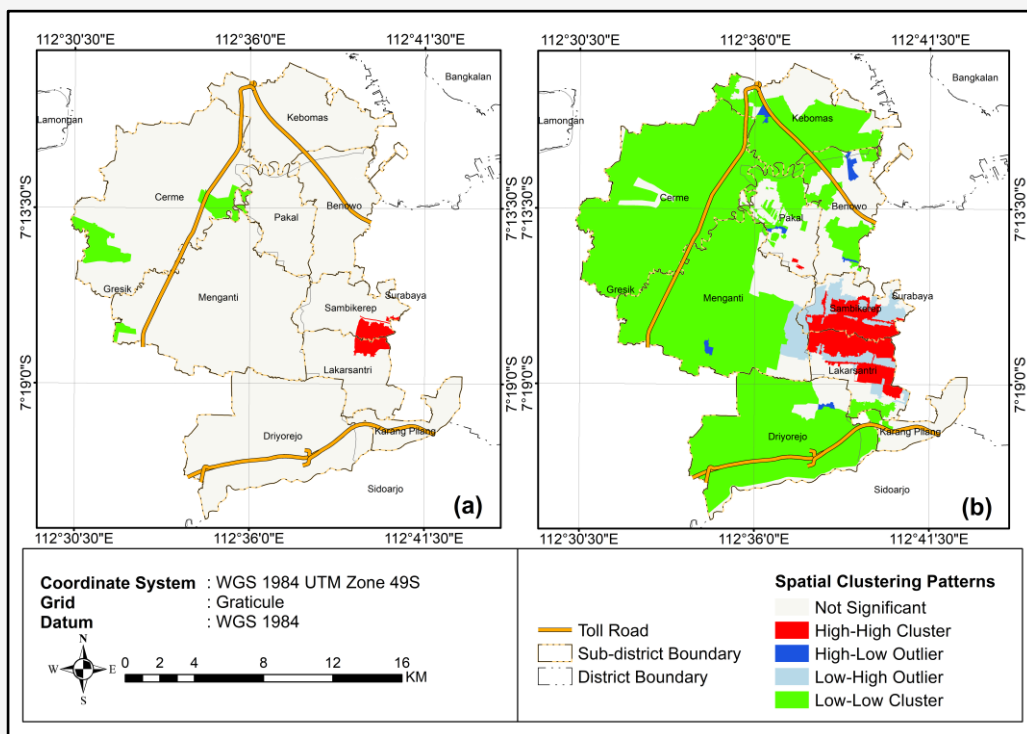


Figure 8: Cluster Distribution Map of Land Value Change (a) 2019 and (b) 2023

Conversely, Low–Low (LL) cluster zones were predominantly observed in Gresik areas such as Cerme and Menganti, as well as in a small portion of southwestern Surabaya. These LL clusters reflect peripheral zones characterized by consistently low land values and limited interaction with high-value areas, indicating weaker development intensity and lower urban influence.

By 2023, the spatial pattern of land values shows a notable expansion of the HH cluster zones. High–High clusters persist in Lakarsantri and Sambikerep and extend westward to Pakal and into Menganti (Gresik). This spatial expansion of HH clusters suggests the outward diffusion of urban development from Surabaya into adjacent areas of Gresik, strengthening economic connectivity and land use transformation along the administrative boundary. In contrast, LL cluster zones become increasingly concentrated in the western and southern parts of Gresik, including Benowo, Driyorejo, Cerme, Menganti, and Kebomas, as well as several areas in southwestern Surabaya such as Karangpilang, Lakarsantri, and Pakal. The persistence and spatial concentration of these LL clusters indicate areas that remain less affected by urban growth, highlighting a widening spatial disparity in land value change between rapidly urbanizing zones and peripheral regions experiencing slower development.

Land transformation from non-urban to urban is usually associated with an increase in land value due

to increased land functions and increased demand. Based on the overlay map between land cover change to urbanised areas and land value zones, it can be seen that most areas that transitioned from non-urban to urbanised between 2019 and 2023 experienced a significant increase in land value. This is most striking in the western region of Surabaya, particularly in the sub-districts of Lakarsantri, Sambikerep and parts of Pakal, which show a shift from medium to high land value classes, indicating a strong urban dynamic.

Further spatial analysis using Anselin Local Moran's I shows a spatial cluster pattern of land value change. In the context of land value in the Surabaya–Gresik area between 2019 and 2023, HH clusters are typically found in the core urban zones such as central Surabaya and key commercial corridors. These areas experienced consistent increases in land value, driven by concentrated economic activities, dense infrastructure networks, and high investor interest. HH patterns reflect sustained urban growth and development consolidation. In the Surabaya–Gresik area, LL clusters are often located in rural areas, particularly in parts of northern or western Gresik where infrastructure development and urbanization have remained limited. These areas may be characterized by low development demand and slower land market dynamics. In this study area, HL clusters might appear around newly developed infrastructure projects or industrial estates that

caused local spikes in land value, even though surrounding areas remain less developed. These clusters often indicate early signs of urban expansion or speculative land investments on the urban fringe.

In the Surabaya–Gresik case, LH clusters may occur in zones with development constraints, such as areas with environmental protections, zoning limitations, or land tenure issues that prevent land values from rising in step with nearby urbanized regions. In 2019, high land value clusters (High-High/HH) appeared only in Lakarsantri and Sambikerep, while other areas, especially in Gresik, were dominated by low land value clusters (Low-Low/LL). By 2023, however, there is an expansion of the HH cluster to parts of Menganti in Gresik, along with the expansion of the LL cluster in peripheral areas such as Benowo, Driyorejo, and parts of Karangpilang. This shift shows that land value increases are not only occurring in the city centre, but are also starting to spread to suburban areas.

Although most of the areas that turned urban experienced an increase in land value, there are exceptions. Some urbanised areas, especially in the southwestern parts of Lakarsantri and Pakal, are actually included in the LL (Low-Low) cluster, indicating that land values remain low despite land use change. This indicates that a change in land use status from non-urban to urban does not necessarily increase land value if it is not accompanied by infrastructure development, road connectivity, or other market forces. Therefore, factors such as accessibility to toll roads, public facilities, and integration with the city centre also determine the direction of land value change.

Overall, the analysis confirms a strong relationship between urbanisation and increasing land values, although this relationship is not spatially uniform. Local spatial analysis indicates that land value dynamics in the Surabaya–Gresik area are influenced by factors beyond land use change, including proximity to major transportation corridors, distance to urban and industrial centers, and the availability of infrastructure and public services. In addition, administrative boundaries and zoning regulations contribute to spatial disparities, particularly in border areas where development pressure from Surabaya extends into Gresik. Consequently, the Anselin Local Moran's I results demonstrate that land value changes are spatially uneven and shaped by multiple interacting spatial factors rather than urbanisation alone.

4. Conclusion

This study shows that land value changes in the Surabaya-Gresik sub-urban area are strongly

influenced by the dynamics of land cover change and other spatial factors such as accessibility to infrastructure, especially toll roads and proximity to the city centre. Most areas that experience changes from non-urban to urban tend to show an increase in land value and form a High-High (HH) cluster, which means that they experience a significant increase in land value, especially in the Sambikerep, Lakarsantri, and Menganti areas. However, there are also areas that have experienced urbanisation but remain in the Low-Low (LL) cluster, such as in parts of Lakarsantri and Pakal, which indicates that urbanisation does not necessarily increase land values if it is not supported by infrastructure development and connectivity.

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