

Assessing urban land use change and MRT impact: A case study of Cheras, Kuala Lumpur

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Received: 13 November 2024; Accepted: 28 April 2025; Published: 25 February 2026

Abstract

Understanding the spatial variability in the relationship between land use patterns and the impact of MRT infrastructure is essential for selecting effective strategies to manage and sustain urban development. Urbanization significantly influences land use configurations and environmental sustainability. This study applies Geographically Weighted Regression (GWR) to examine urban land use changes within Cheras, Kuala Lumpur, emphasizing spatial variation in the factors driving these changes. By utilizing spatially explicit datasets and GWR modelling, the research identifies localized determinants of land use dynamics and explores their implications for environmentally sustainable urban planning. The analysis was conducted using GWR 4.0 software, while ArcGIS 10.8 was employed for spatial mapping and further analysis. GWR, a local statistical technique, is capable of capturing the spatial variation of non-stationary variables and their corresponding regression coefficients, thereby modelling spatially differentiated relationships. The model's performance was assessed using various goodness-of-fit indicators. The corrected Akaike Information Criterion (AICc) improved significantly, decreasing from 1990.12 to -1602.32, while the Bayesian Information Criterion (BIC) rose from 2006.89 to 6036.47. Furthermore, the R-squared value increased from 0.01 to 0.86 and the adjusted R-squared rose from 0.009 to 1.22. These improvements indicate that GWR provides a superior local fit compared to global models. The analysis of local parameter estimates revealed that proximity to MRT stations significantly influences land use changes in the study area. These findings highlight the necessity for localized and spatially sensitive planning approaches to effectively address the diverse challenges of urbanization and to foster sustainable urban growth.

Keywords: Geographical Weighted Regression (GWR), land use change, land use patterns, Mass Rapid Transit (MRT), urban, urban planning

Introduction

In recent decades, global urbanization has accelerated significantly, leading to profound changes in urban lifestyles, social structures and employment patterns. This rapid transformation has been driven by population growth, economic advancement and technological innovation. As urban areas continue to expand, the need for reliable and efficient infrastructure becomes increasingly critical. In particular, well-designed urban transportation systems play a central role in fostering sustainable

development, easing traffic congestion and enhancing residents' quality of life (Ramlan et al., 2021). A key milestone in Malaysia's urban transportation landscape is the development of the Mass Rapid Transit (MRT) system in Kuala Lumpur. As a modern response to the city's growing mobility challenges, the MRT initiative was launched by former Prime Minister Dato' Seri Najib Razak in June 2010 and received official government approval in December of the same year (Berita Harian, 2016). Construction of the inaugural MRT line commenced on July 8, 2011 and full operations began on July 17, 2017 (Khoo & Ooi, 2023). By 2020, daily travel demand in the Klang Valley was projected to reach 18 million trips, highlighting the urgent necessity for an effective public transport network.

One of the significant components of this infrastructure development is the construction of MRT stations in Cheras, which is part of the MRT Sungai Buloh–Kajang line. These stations connect suburban areas to the central business district of Kuala Lumpur, easing road congestion and supporting more sustainable modes of urban mobility (Zulkiflee et al., 2024). Moreover, the establishment of MRT stations in rapidly urbanizing regions such as Cheras has accelerated land use transformation, encouraging higher-density, mixed-use developments in the surrounding areas. Globally, MRT systems have played a transformative role in shaping urban growth. Cities like Singapore, Hong Kong and Tokyo stand as prominent examples of how well-planned public transportation networks can drive economic development, improve mobility and support sustainable urbanization. In Singapore, the MRT has significantly influenced land use by promoting compact, high-density developments near transit hubs (Ramlan et al., 2021). Similarly, Hong Kong's MTR system has been central to the evolution of integrated, mixed-use urban neighbourhoods. These systems have proven effective in reducing congestion, cutting emissions and improving urban accessibility. Although Kuala Lumpur's MRT network is still in its developmental phase, its impact on land use and urban form is already evident. Over the past decade, MRT-related infrastructure has become a key driver of urban change in Cheras, reinforcing its status as one of the city's dynamic residential and commercial zones.

The Geographically Weighted Regression (GWR) model has been widely applied in the analysis of spatial factors influencing various land-related phenomena. For instance, Luo Ganghui et al. (2007) employed the GWR model to investigate how land parcel characteristics affect urban residential land prices, using GIS techniques to visualize their findings. Their study revealed that the influence of parcel area on land value varies significantly across space. Similarly, Li Zhi et al. (2009) applied the GWR model to examine the spatial distribution of factors affecting residential land prices in Nanjing, demonstrating that GWR effectively captures regional variations in land price determinants.

Building upon these foundational studies, the present research adopts the GWR model to explore the spatially varying impacts of the Mass Rapid Transit (MRT) system on urban land use patterns in Kuala Lumpur. While numerous previous studies have relied on conventional statistical methods such as Ordinary Least Squares (OLS) regression to analyse the relationship between land use types and their influencing factors, OLS assumes spatial homogeneity and thus overlooks localized variations (Ding, 2022). This study incorporates GWR and global regression models to address this limitation and compare their effectiveness. The application of GWR enables a more nuanced understanding of spatial relationships, making it a powerful tool for evaluating how infrastructure developments like the MRT influence land use at the local level. Traditional analyses of urban land use change have primarily relied on global regression models, which often assume spatial uniformity and thus fail to capture the inherent heterogeneity of urban systems. This oversimplification has driven a shift toward spatially explicit methods, notably Geographically

Weighted Regression, which allows researchers to investigate how relationships between land use change and its determinants vary spatially. Increasingly adopted in urban studies, GWR offers a more nuanced and context-sensitive understanding of the spatial dynamics shaping urban land use transformation (Fotheringham, 2002).

Cheras, a developed and densely populated region, is the political, economic and cultural hub of Southeast Malaysia. A great deal of research is needed to guide future urban development because of the significant changes in land use brought about by the area's fast urbanization. Sustainable urban design is crucial for lowering the harmful environmental impacts of growing cities and raising the standard of living for residents, per earlier research (Rahman et al., 2017). Unlike conventional global models, Geographically Weighted Regression (GWR) detects spatial non-stationarity, providing localized insights into how proximity to MRT infrastructure influences land use dynamics, thereby addressing the limitations of traditional regression approaches (Liu, 2019). This localized approach enhances the understanding of spatial variability, which has often been overlooked in previous studies using global regression techniques. Our insights will be valuable for informing policies that aim to reduce social disparities in infrastructure costs, while also offering meaningful perspectives and technological innovations to support the development of a sustainable environment.

Study area

Cheras is situated in the middle of Kuala Lumpur, Malaysia. It is one of Malaysia's most important cultural and economic areas. Cheras is Malaysia's most populated and economically active area, is home to a diversified population and acts as the main center of the country's trade, business and financial sector. Cheras' location is in the Peninsular of Malaysia, within the Klang Valley area as illustrated in Figure 1. Over the past few decades, the area has seen substantial demographic changes brought on by internal migration, economic opportunity and fast urbanization. The current urban transportation networks are under a lot of strain as a result of the infrastructure, housing and public services that have increased due to population development.

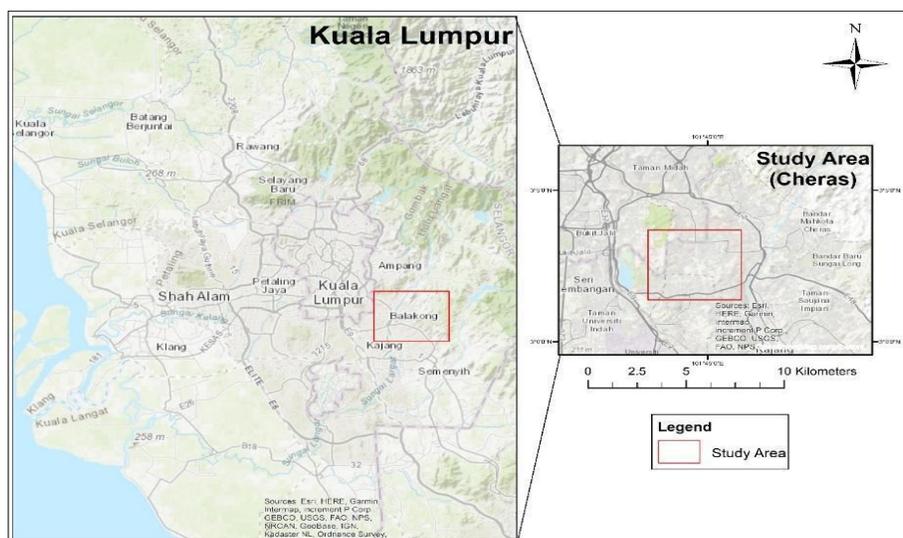


Figure 1. Study area, Cheras, Kuala Lumpur

Methodology

The general linear regression model serves as the foundation for the Geographically Weighted Regression (GWR) model. The multiple linear regression model's regression parameters incorporate the data's spatial location, resulting in a geographically weighted regression model:

$$y_i = \beta_0(u_i + v_i) + \sum_{k=1}^p \beta_k(u_i + v_i)x_{ik} + \varepsilon_i \quad i = 1, 2, \dots, n$$

The spatial coordinate of the i -th data sample in the equation is denoted by $(u_i + v_i)$. The k -th regression coefficient of the i -th data sample is represented by the continuous function $\beta_k(u_i + v_i)$, which describes the sample's spatial location. If $\beta_k(u_i + v_i)$ stays constant, the geographically weighted regression model becomes a general global regression model, which is a specific variant of the geographically weighted regression model. As a result, the GWR model is used to characterize the object's spatial instability, or how the position function $\beta_k(u_i + v_i)$ changes depending on the data sample's location. The geographically weighted regression model's fundamental component is the spatial weight matrix, whose spatial weight function is used to depict the data's spatial relationship. The weight function in this study is determined using the Gaussian function.

Building the GWR model

Let x_{ik} be the distance from the land sample to a particular influencing factor and let y_i be the land use of the i -th sample. The equation below can be used to construct the GWR model, which indicates the factor regression coefficient:

$$\begin{aligned} y_i &= \beta_0(u_i + v_i) + \beta_{iDIST}(u_i + v_i)x_{i1} + \varepsilon_i \\ &= \beta_0(u_i + v_i) + \sum_{k=1}^6 \beta_{ik}(u_i + v_i)x_{ik} + \varepsilon_i \end{aligned}$$

The regression coefficient of the distance to the station influences the degree. i is represented by the following equation: β_{iDIST} . To make the equation simpler, the coefficient has been combined β_{ik} . Regional difference maps illustrating the effects of the influencing factors on land use patterns are created and examined in ArcGIS 10.8.2. Land use data for the year 2022 were sourced from iPlan Malaysia. The dataset categorized land use into ten integrated classes, including residential, transportation, industrial, agricultural, forest, water bodies, recreational areas and others. These land use categories were mapped and visualized using ArcGIS software. The distance from each location to the Bandar Tun Hussein Onn MRT station was calculated to examine the spatial relationship between land use patterns and proximity to the MRT station. The results from the Geographically Weighted Regression (GWR) model generated in ArcGIS were then utilized for further analysis.

Geographically Weighted Regression (GWR) has proven effective in analysing spatially varying relationships, it is important to acknowledge other spatial analysis techniques that can also be applied in urban studies. Each method has its strengths and limitations and a comparative perspective can help contextualize the suitability of GWR in this research.

a. Ordinary Least Squares (OLS):

OLS is a traditional global regression technique that estimates a single equation to describe the relationship between dependent and independent variables across the entire study area. While it is widely used due to its simplicity and interpretability, OLS assumes spatial stationarity, that the relationship between variables does not vary across space (Liu et al., 2019). This assumption often fails in urban contexts, where spatial heterogeneity is common. As such, OLS may overlook local variations and provide misleading results in studies dealing with geographically diverse urban settings.

b. Spatial Autoregressive models (SAR):

SAR models address some of the limitations of OLS by incorporating spatial dependence into the regression framework. This means that SAR takes into account the influence that neighbouring locations have on each other, making it more suitable for data where spatial autocorrelation is present (Kobylińska, 2021). However, SAR still applies a global structure and does not allow for localized variations in parameter estimates. Thus, while SAR improves upon OLS by handling spatial dependencies, it may still fall short in capturing local nuances in land use change.

c. Machine learning approaches (e.g., Random Forest, Neural Networks):

Machine learning methods are increasingly used in spatial analysis due to their ability to model complex and nonlinear relationships. Algorithms such as Random Forest and Neural Networks can handle large datasets with high-dimensional features and uncover intricate patterns that traditional models might miss (Verma, 2023). However, these models typically require extensive training data and are often considered "black boxes" due to limited interpretability. For urban planning and policy-making, the lack of clear explanations for how variables influence outcomes can be a drawback.

Compared to the methods mentioned above, GWR offers a unique advantage by allowing parameter estimates to vary across space. This is particularly beneficial for urban studies in rapidly developing areas like Kuala Lumpur, where socio-economic and environmental factors influencing land use may differ between neighbourhoods. GWR provides local coefficients, making it possible to identify spatial clusters, variations and hot spots of influence. Moreover, GWR's capacity to integrate spatial heterogeneity makes it a powerful tool for planning interventions that are geographically targeted. For instance, in this study, GWR revealed spatially varying relationships between distance from the MRT station and land use patterns, allowing for a more nuanced understanding that global models could not provide.

A comparison with studies from other countries can further validate the choice of GWR for urban land use analysis in Kuala Lumpur. For example, GWR has been used effectively in Beijing to examine the impact of transport infrastructure on property values (Tu & Xia, 2008) and in Shanghai to study the relationship between land use and air quality (Hu et al., 2019). These

international examples highlight the model's adaptability in diverse urban settings, reinforcing its applicability in the Malaysian context.

Geographically Weighted Regression (GWR) is particularly suitable for analyzing land use changes in Cheras due to the area's complex urban structure and spatial heterogeneity. As a rapidly developing suburban area in Kuala Lumpur, Cheras comprises diverse land use types including residential, commercial, industrial and green spaces that are unevenly distributed across its landscape. This spatial variability makes traditional global models, such as Ordinary Least Squares (OLS), insufficient for capturing localized relationships between variables such as land use patterns and proximity to transit infrastructure.

GWR addresses this limitation by allowing regression coefficients to vary geographically, thus enabling the detection of location-specific relationships within the study area. For instance, the influence of the Bandar Tun Hussein Onn MRT station on surrounding land use may differ substantially between high-density residential zones and peripheral green areas. GWR is capable of modeling these localized effects, providing a more nuanced understanding of how urban infrastructure impacts land development in different parts of Cheras.

Moreover, the spatially-referenced nature of the data such as land use types and their distances from MRT stations makes GWR an ideal analytical tool. The model produces local coefficient and R^2 maps that not only quantify the strength of spatial relationships but also visually highlight areas with the most significant changes. These outputs offer valuable insights for urban planners and policymakers aiming to develop targeted, evidence-based interventions.

In conclusion, Geographically Weighted Regression (GWR) proves to be an ideal method for analyzing land use dynamics in Cheras due to its capacity to capture spatially varying relationships. This technique effectively accounts for the uneven impacts of MRT infrastructure across diverse land use zones, allowing for a more accurate representation of localized variations. By utilizing spatial data to examine these variations, GWR supports context-sensitive urban planning decisions, ensuring that interventions are tailored to the unique characteristics of each area. Therefore, GWR provides a robust and adaptable framework for assessing and managing urban land use changes in complex, heterogeneous environments like Cheras.

Results and discussion

The study area was classified into ten distinct categories according to the predominant land use types, including residential, industrial, recreational, forested areas, commercial, infrastructure and utilities, agricultural land, transportation networks, institutional and public facilities and water bodies (refer to Figure 2). The proximity of each location to the MRT station was measured and spatially integrated using ArcGIS software. The resulting spatial data were subsequently analyzed using the GWR 4.0 software for further interpretation.

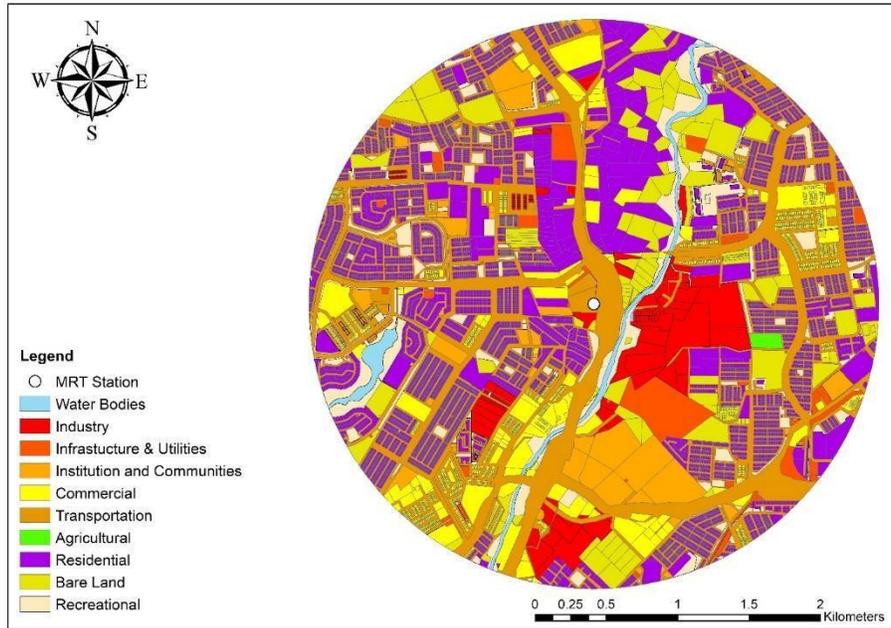


Figure 2. Land use distribution surrounding Bandar Tun Hussein Onn MRT station

Geographically Weighted Regression (GWR) was employed to examine the relationship between land use change and the explanatory variable “Distance from the Station” within the study area. This approach allows for the estimation of spatially varying regression coefficients, which adapt based on the proximity and influence of surrounding explanatory variables. To ensure the robustness of the analysis and identify key spatial clusters influencing land use change, model diagnostics such as spatial autocorrelation and coefficient mapping were utilized.

The evaluations were performed using the GWR 4.0 software, which provides four key goodness-of-fit indicators. Based on the results, the corrected Akaike Information Criterion (AICc) improved significantly, decreasing from 1990.117198 to -1602.316164, while the Bayesian Information Criterion (BIC) rose from 2006.894823 to 6036.473787. Furthermore, the R-squared value increased from 0.014525 to 0.861759 and the adjusted R-squared rose from 0.008564 to 1.222217. These improvements highlight the superior performance of the GWR model. As noted by Hurvich et al. (1998), the AICc and local R^2 values are essential for evaluating model fit. A higher local R^2 reflects stronger explanatory power of the independent variable on the dependent variable (Ding, 2022), while a lower AICc indicates enhanced predictive accuracy with optimal model complexity.

This study demonstrates that GWR significantly outperforms the Ordinary Least Squares (OLS) model. The consistently higher local R^2 values observed in the GWR results underscore its greater capability in capturing spatial variation across the study area. AICc remains a critical metric for assessing the balance between model accuracy and complexity, supporting the conclusion that GWR offers a more reliable and precise framework for modeling spatial relationships in urban land use studies.

Table 1. Comparison of OLS model and GWR model diagnostics

Criteria	OLS	GWR	Difference
AICc	1990.117198	-1602.316164	3592.433362
BIC/MDL	2006.894823	6036.473787	4029.578964
R Square	0.014525	0.861759	0.847234
Adjusted R Square	0.008564	1.222217	1.213653

Table 1 presents a comparison between the global regression model and the Geographically Weighted Regression (GWR) model, highlighting the latter’s superior ability to capture spatial variability within the dataset. The corrected Akaike Information Criterion (AICc) demonstrates a marked improvement in model fit, with the GWR model recording a significantly lower value of -1602.316164, compared to 1990.117198 for the global model a reduction of 3592.433362 points. Similarly, the Bayesian Information Criterion/Minimum Description Length (BIC/MDL) for the GWR model rose dramatically to 6036.473787 from 2006.894823 in the global model, indicating a substantial improvement of 4029.578964 points. These reductions confirm that the GWR model offers a more optimal balance between complexity and fit.

In terms of explanatory power, the GWR model also outperforms the global model. The R-squared (R^2) value increases from 0.014525 to 0.861759, reflecting an enhanced ability to explain variability in land use. Likewise, the Adjusted R-squared shows a significant rise from 0.008564 to 1.222217, an improvement of 1.213653, demonstrating that the GWR model more effectively accounts for variance while controlling for the number of predictors. Evaluations using AICc and local R^2 strongly affirm the GWR model’s advantage over the ordinary least squares (OLS) approach, particularly in terms of accuracy and spatial sensitivity.

Land use indicators across the study area exhibit both positive and negative correlations with the “Distance from MRT station” variable. Locations with positive parameter values suggest that proximity to the MRT station positively influences land use characteristics. Conversely, areas with negative values indicate a diminishing land use intensity as distance from the station increases. As shown in Table 2, these spatial variations reveal the non-stationary nature of the relationship between land use distribution and MRT proximity. The GWR model effectively captures these spatial inconsistencies, emphasizing the importance of localized analysis in understanding the dynamics of transit-oriented urban development.

Table 2. Values of coefficients for the 'distance to the station' variable

Variable	Coefficient			
	Mean	STD	Min	Max
Distance from MRT station	0.000084	0.0018	-0.006	0.008

Table 2 presents the local coefficient statistics for the variable “Distance to the Station,” demonstrating how this factor influences land use patterns within the study area. The range of coefficient values spans from -0.006 to 0.008, with an average value of 0.000084. This average suggests that, overall, distance to the MRT station has a very slight positive influence on land use. However, the presence of spatial heterogeneity is evident, as this effect is not uniform across the region. The standard deviation of 0.0018 indicates substantial variation in the relationship between distance and land use, depending on location. Specifically, the lowest recorded coefficient is 0.006,

signifying that in certain areas, increased distance from the station negatively impacts land use intensity. Conversely, the highest coefficient of 0.008 implies that, in other zones, a greater distance from the MRT station corresponds with a positive effect on land use. These disparities emphasize the importance of applying spatially sensitive models, such as Geographically Weighted Regression (GWR) to uncover localized dynamics. The GWR model successfully captures this spatial variability, offering a more detailed and context-specific understanding of how proximity to transit infrastructure shapes land use patterns.

Discussion

Figure 3 displays the coefficient map illustrating how different factors influence land use changes across the study area. The results reveal clear spatial variability in the relationship between land use patterns and the contributing factors of land use change. As land use change is a multifaceted process driven by numerous interrelated elements, identifying the variables that shape these patterns is essential. The coefficient values were derived using ArcGIS software, where negative values suggest a diminishing effect on the dependent variable, while positive values indicate a strengthening influence. The variable “Distance to the Station” exhibits a range of coefficient values from 0.0057 to 0.0079, with both positive and negative impacts distributed throughout the study area. This spatial dispersion underscores that the influence of proximity to the MRT station on land use patterns varies by location. As depicted in Figure 3, certain areas are more affected by distance to the station than others, highlighting the importance of localized analysis in understanding urban land use dynamics.

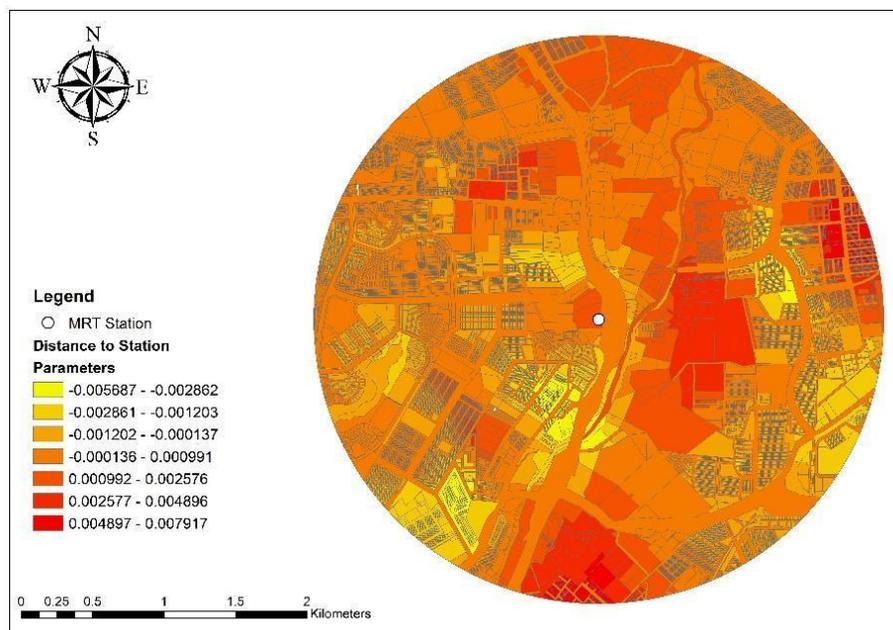


Figure 3. Estimated parameter values for land use change factor: Distance from the station

The local R^2 value represents the degree to which an independent variable aligns with and explains the variation in a dependent variable within a localized context. A higher local R^2

indicates a stronger explanatory relationship. However, in spatial-environmental studies, the interpretive value of the relationship often takes precedence over purely statistical strength. Even when the model fit is modest, GWR can yield valuable insights if the relationships it identifies are contextually meaningful.

In this study, the local R^2 values generated by the GWR model exhibit considerable spatial variation, ranging from 0 to 0.64. Areas situated closer to the MRT station demonstrated stronger correlations and higher local R^2 values, while peripheral zones displayed lower values. The average local R^2 across the study area was 0.23, suggesting that the variable “distance to the MRT station” accounts for approximately 23% of the observed land use patterns. This variation underscores that land use is not solely shaped by demographic factors such as population density and income levels, but is also significantly influenced by spatial proximity to transportation infrastructure. GWR models are particularly effective in capturing such geographically dependent relationships by providing localized parameter estimates and revealing the spatial dynamics of variable influence.

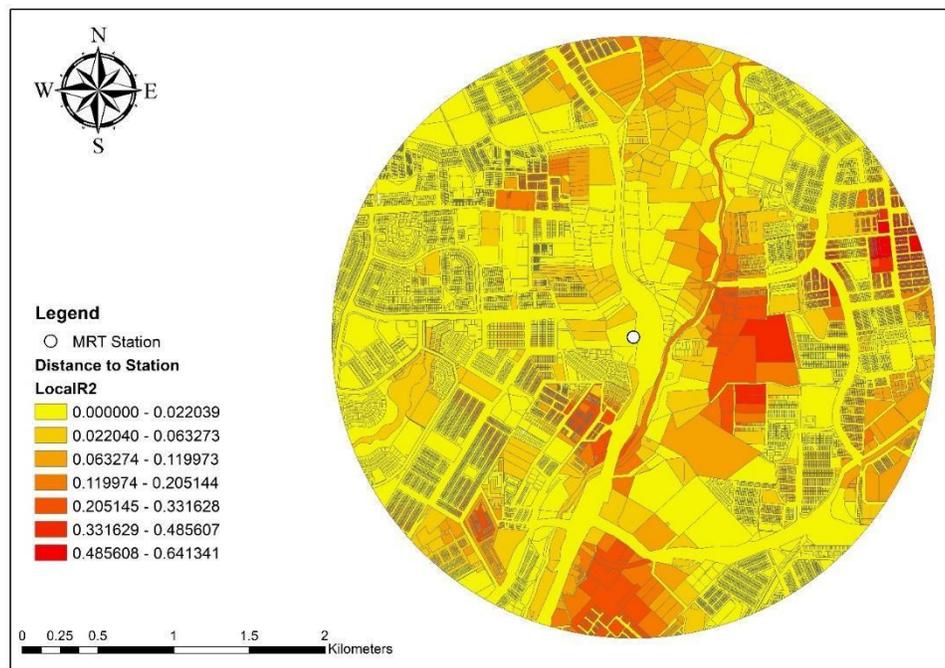


Figure 4. Spatial distribution of GWR-estimated parameters: Local R2

Insights derived from Geographically Weighted Regression (GWR) analyses hold significant value for promoting sustainable environmental planning. The spatial heterogeneity captured by GWR highlights the limitations of uniform, one-size-fits-all planning approaches, underscoring the necessity for context-sensitive strategies that reflect localized land use dynamics. Such spatially nuanced methodologies are crucial for managing the complex and evolving patterns of urban transformation effectively (Miller & Wentz, 2003).

In the Malaysian context, the application of GWR to urban land use change offers critical guidance for policymakers and urban planners. By pinpointing areas undergoing rapid or sensitive transformations and understanding the underlying driving factors, planners can design more precise and effective interventions. For instance, in Kuala Lumpur, zones identified as particularly vulnerable to urban expansion could be prioritized for green space conservation, improved

mobility infrastructure and sustainable development initiatives (Lim & Nor, 2020). Embedding GWR-based insights into policy frameworks enhances alignment between on-the-ground spatial realities and planning responses, supporting a more refined understanding of the environmental impacts of urbanization. This approach complements the goals of sustainable development, advocating for place-based solutions that integrate economic growth with ecological stewardship (UN-Habitat, 2022).

Transit-Oriented Development (TOD) is one such sustainable planning strategy that promotes compact, high-density, mixed-use development within walkable proximity to public transportation hubs such as MRT stations (Zulkiflee, 2024). In rapidly urbanizing regions like Cheras, where transit infrastructure is significantly reshaping the built environment, understanding the spatial interplay between MRT stations and land use change becomes critical for effective planning and implementation of TOD principles.

Geographically Weighted Regression offers a powerful analytical tool for exploring these relationships. Unlike traditional global regression models, GWR enables the estimation of regression coefficients that vary across space, capturing the localized differences in how land use responds to proximity to transit infrastructure. This spatial specificity is particularly relevant to TOD, where the impact of MRT development is not homogenous but varies depending on existing urban forms, population distribution and land use regulations. Through the application of GWR, this research identifies areas where the influence of MRT development on land use change is particularly strong or weak. For example, some locations may exhibit marked increases in residential or commercial density near MRT stations, while others demonstrate minimal response due to constraints such as land zoning or infrastructure limitations. These spatially explicit insights are essential for evaluating the success of TOD strategies and guiding more informed decisions regarding zoning, infrastructure investment and growth management.

Therefore, GWR serves not only as a robust spatial analysis method but also as a decision-support tool that enhances TOD planning. It allows urban planners to assess whether current development patterns align with TOD objectives and supports the formulation of targeted, data-driven interventions that promote compact, transit-accessible and sustainable urban environments. While this study primarily focused on the influence of “distance to MRT station” as a single explanatory variable in land use change, future research can expand and enrich this framework by incorporating a broader range of variables. These may include population density, land value, accessibility to public amenities, historical land use trends and socioeconomic characteristics. The inclusion of such variables would enhance the explanatory power of the GWR model and provide a more holistic understanding of the multiple factors shaping land use transformation. Expanding the scope of analysis in this manner will enable researchers and policymakers to develop more accurate, context-aware strategies for managing urban growth and promoting sustainable development across diverse spatial settings.

Conclusion

The Geographically Weighted Regression (GWR) model demonstrates superior performance over the Ordinary Least Squares (OLS) model across multiple statistical metrics, including R^2 , adjusted R^2 and Akaike Information Criterion corrected (AICc). Notably, the AICc score for the GWR model is significantly lower than that of the OLS model, indicating a better model fit. These

findings underscore the GWR model's capacity to effectively capture the spatial heterogeneity inherent in land use patterns and their driving factors.

By applying GWR to assess urban land use transformation, this study provides nuanced insights into the spatial configuration of urban growth and its implications for sustainable environmental planning. In particular, the variable "Distance to the MRT" emerges as a key determinant influencing land use configurations around transit nodes. These fine-grained spatial distinctions offer practical value for policymakers and urban planners in crafting geographically sensitive interventions. The results emphasize the importance of developing urban strategies that account for local spatial differences in land use drivers, thereby enhancing the effectiveness of development policies and fostering resilient, sustainable urban environments.

Despite the significant insights derived from this study, it is essential to acknowledge its limitations. The analysis focuses primarily on a single explanatory variable, proximity to the MRT station, specifically the Bandar Tun Hussein Onn station in Cheras. While this variable provides meaningful insight into the influence of transit infrastructure on land use, urban development is shaped by a broader constellation of factors that were not incorporated into the current model.

Future research can expand and refine the GWR framework by integrating additional explanatory variables such as population density, land value, income levels, employment trends, accessibility to public amenities, and environmental constraints. These variables can offer a more comprehensive understanding of the socio-economic forces driving land use change. For instance, population growth may spur demand for various land uses, while income levels can reshape neighborhood dynamics, with wealthier areas potentially transitioning into higher-density or mixed-use developments. Including such factors in the GWR model would enable the identification of more complex spatial relationships and further strengthen the model's explanatory power.

Moreover, broadening the temporal scope of the analysis would enrich the understanding of urban land use dynamics over time. Rather than focusing on a single time point or a narrow window, future studies could examine land use changes across multiple decades. This temporal expansion would help capture long-term trends and transitions, revealing how the influence of MRT development evolves across space and time. Such spatial-temporal analysis would provide deeper insight into how Transit-Oriented Development (TOD) unfolds and impacts urban areas over the long term.

Expanding the geographical scope of the study also presents an opportunity for broader insights. Instead of confining the analysis to Bandar Tun Hussein Onn MRT, future research could include an entire mukim in Cheras or extend to the Greater Kuala Lumpur region. A larger spatial frame would allow for the inclusion of multiple districts with MRT connectivity, offering a more holistic view of land use patterns across a diverse urban landscape. Analyzing several areas affected by MRT infrastructure would also facilitate comparative insights into how TOD influences different neighborhoods, depending on their unique spatial, economic and planning contexts. This broader perspective would support urban planners and policymakers in making more equitable and comprehensive decisions, ensuring the benefits of transit infrastructure extend across the metropolitan region.

Ultimately, enhancing the GWR approach through the incorporation of additional variables, a longer time horizon and a wider study area would offer a more nuanced and powerful framework for understanding how urban dynamics, especially those linked to MRT development, interact with diverse socio-economic and spatial factors. These advancements would not only improve the robustness of spatial analysis but also contribute to more effective and inclusive urban

planning strategies, helping cities like Kuala Lumpur navigate the challenges of rapid urbanization while promoting sustainable growth.

Acknowledgment

This work was supported by the Geran Universiti Penyelidikan (GUP) grant number GUP-2023-025. The authors acknowledge the collaboration and co-research, as well as the materials provided by PlanMalaysia and the UKM Library for this project.

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