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Temporal Analysis of Urban Land Use Change from 2010 to 2022: A Case Study of Kwasa Damansara, Sungai Buloh, Malaysia

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Abstract
Green spaces and agricultural lands have decreased, raising concerns about environmental sustainability. This study investigates the temporal changes in urban land use in Kwasa Damansara, Sungai Buloh from 2010 to 2022. Utilizing Landsat 7 ETM+ and iPlan Malaysia data, we employ supervised classification methods from ArcGIS 10.8 software to class the land use as built up area, water bodies, forest, and bare land. Significant changes in land use patterns at Kwasa Damansara, with developed area areas increasing by 22.77%, bare land increasing by 715.89%, forest decreasing by 51.26%, and water bodies increasing by 4106.66%. The analysis revealed significant urban expansion, particularly in built up areas, driven by population growth and economic development. Major infrastructure projects also contributed to the spatial reconfiguration of the region. The findings underscore the need for sustainable urban planning to balance development with environmental conservation. This study provides valuable insights for policymakers and urban planners to foster sustainable development and enhance urban resilience in Kwasa Damansara.
Keywords: Urban, Land Use, Temporal Analysis, Kwasa Damansara, Sustainable Urban Planning

Introduction

Urbanization is rapidly transforming the world's landscapes, with an estimated 50% of the global population currently residing in cities. By 2030, this figure is projected to rise to 60% (United Nations, 2002). This shift is driving significant changes in land use patterns and contributing to a global urbanization phenomenon. Urbanization refers to the transformation of rural areas into urban environments, which has profound impacts on ecosystems and their functions. One of the major consequences of urbanization is the formation of urban heat islands (Zhou et al., 2011), which exacerbate global warming (Chen et al., 2006). The rise in temperatures in urban areas not only makes cities uncomfortable for residents but also increases health risks (Poumadere et al., 2005), as it promotes the production of ground-level ozone, directly affecting human health (Akbari et al., 2001). Metropolitan regions face growing pressure to address challenges related to land use, transportation, environmental quality, sprawl, traffic congestion, affordable housing, and the loss of open spaces (Waddell, 2007). Furthermore, rapid population growth in urban areas has accelerated land and resource overuse (Cheruto et al., 2016), making sustainable urban planning and development essential for the future.

The urbanization process is particularly evident in rapidly developing regions such as Kwasa Damansara, Malaysia. Over the past few decades, Kwasa Damansara and its surrounding areas has undergone extensive urban growth, driven by economic development, population increase, and infrastructure expansion. This metropolitan area is experiencing remarkable urbanization due to the population growth. Its impact on the environmental quality and economic activities for the area. In Europe, urbanization causing illnesses spread throughout due to changing land use, air travel, intensive animal rearing, human population expansion, and worldwide commerce. The increased temperature throughout Europe impacted geographic distribution, abundance, and survival (Patz, 1996). The rising temperature also caused the recent emergence of vector-borne diseases (VBDs) like Chikungunya, West Nile Virus (WNV), Dengue (DENV-1), and Crimean-Congo hemorrhagic fever in Europe over the last few decades (Hotez, 2016).

The urbanization conflicts affect the sustainability of the land system and regional coordinated development due to rapid urbanization. Nowadays, the development of the environment is the focus of attention. To implement such a process, the identification of urbanization conflicts is so important in decision-making issues for the urban environment and sustainability for global urbanization (Ali et al., 2020). The land use conflict will cause an unbalanced relationship between humans and the environment, bad environmental quality, and ecosystem health which also raises ecological risk (Zhou & Peng, 2012). Urbanization is a dynamic process that significantly alters the landscape and land use patterns of a region. Kwasa Damansara, Sungai Buloh has experienced such a conflict.

Remote sensing and GIS approaches have been utilized extensively in many research in recent years to detect land use changes in a range of natural habitats (Nathalia et al. 2017). The availability of free satellite photos, which offer essential information to study the different types of land use and cover and remotely determine changes over time without having to physically touch the ground, has made such targeted investigations possible. However, finding cloud-free photos might be difficult in tropical areas, especially in Malaysia, specifically Kwasa Damansara. By using satellite images, many other developing nations worldwide have seen notable and extensive changes in land use and cover during the past three decades (Campbell et al. 2005).

Kwasa Damansara is a developed and densely populated region in Malaysia, serving as the nation's political, economic, and cultural hub. The rapid urbanization in this area has led to dramatic shifts in land use, necessitating a comprehensive analysis to guide future urban development. Previous studies have highlighted the critical need for sustainable urban planning to mitigate the environmental impacts of urban sprawl and to enhance the quality of life for residents (Rahman et al., 2017; Mustapha et al., 2020). Therefore, the purpose of this study is to investigate the temporal changes in urban land use in Kwasa Damansara, Malaysia in relation to urbanization, from 2010 to 2022. Despite the wealth of literature on land use change, there has been very little research investigating the phenomenon in Kwasa Damansara from 2010 to 2022. An urgent examination and understanding of the temporal changes in urban land use within this region. This is crucial to better understanding the phenomenon for great global relevance, particularly in Kwasa Damansara that are actively pursuing investments in urban planning and sustainable development. Our insights will be useful for policies in preventing the socioeconomic gaps in such infrastructure investments. In essence, our research offers perceptive perspectives and technological advancement to create a sustainable environment for the worldwide community by investigating the land use change on urban growth in Kwasa Damansara.

This study's goal was to illustrate and analyze the land use change and measure the change's magnitude spatially and temporally for the years 2010 to 2022. The findings from this research are crucial for effective planning and decision-making, which may guide the development of sensible land use policies, and rules governing, allocation, and monitoring of land resources in Kwasa Damansara. A wide range of stakeholders, including business executives, academics, government decision-makers, and development partners with an emphasis on the environment, urban planning, and agriculture, are expected to benefit from the findings.

Literature Review

Urban land use change is a complex process influenced by various socio-economic, political, and environmental factors. Understanding these changes requires a comprehensive examination of global, regional, and local studies that highlight the patterns, drivers, and impacts of urbanization. This literature review synthesizes key findings from previous research on urban land use change, with a focus on methodologies, case studies, and the specific context of Kwasa Damansara, Malaysia.

Global perspectives on urban land use change, urbanization is a dominant trend worldwide, with significant implications for land use patterns. Seto et al (2012) highlighted that urban land expansion is driven primarily by economic activities and population growth. Their global meta-analysis revealed that urban areas are growing faster than the population, leading to increased land consumption per capita. This expansion often comes at the expense of green areas and natural habitats, raising concerns about food security and biodiversity loss. Another global perspective is provided by Angel et al.,2011, who examined urban expansion patterns in 120 cities across the world. They found that urban land use change is characterized by the outward spread of urban areas, a process known as urban sprawl. This sprawl is often accompanied by increased automobile dependency, traffic congestion, and environmental degradation. These findings underscore the need for integrated urban planning strategies to manage urban growth sustainably.

In Southeast Asia, urbanization has been closely linked to economic policies and rapid industrialization. Yap (2010) discussed the urbanization process in Malaysia, emphasizing that economic liberalization and export-oriented industrialization have spurred urban growth. The study highlighted the role of government policies in facilitating urban expansion through infrastructure development and investment incentives. Shamsuddin (2016) focused on the environmental impacts of urbanization in Malaysia, noting that rapid urbanization has led to significant land use changes, including the conversion of agricultural and forest lands into urban areas. This transformation has contributed to environmental issues such as air and water pollution, increased flood risks, and loss of biodiversity. The study called for sustainable urban planning practices that integrate environmental conservation with development goals.

Urban Land Use Change and several studies have specifically examined urban land use change and the broader Selangor region. Abdullah and Nakagoshi (2006) used Landsat imagery to assess urban expansion in Selangor between 1972 and 2001. Their findings indicated a substantial reduction in green spaces, which were converted into residential, commercial, and industrial areas. This study underscored the importance of preserving green spaces to maintain environmental quality and urban resilience. Hussin et al, 2019, conducted a more recent analysis of urban land use change in Kuala Lumpur, focusing on the period from 2000 to 2015. Using remote sensing and GIS techniques, they identified significant urban growth, particularly in suburban areas. The study highlighted the role of infrastructure development, such as highways and public transportation projects, in shaping urban expansion. The authors emphasized the need for sustainable urban planning to balance development with environmental conservation. The papers by Man & Majid (2024), Man et al. (2024a), Man et al. (2024b), and Man et al. (2024c) examine the urban landscape changes and land use patterns in the Klang Valley, focusing on the impact of Mass Rapid Transit (MRT) system construction from 2010 to 2020. The studies highlight how MRT development has reshaped land use, driving urban expansion and influencing population density shifts, particularly around MRT stations. They offer insights into how the MRT infrastructure has contributed to the transformation of urban areas, including the case study of Damansara, Kuala Lumpur, demonstrating the system's role in facilitating urbanization and enhancing economic and social dynamics in the region.

Understanding the dynamics of urban land use change in Kwasa Damansara is vital for several reasons. Firstly, it provides insights into the region's urbanization trends and the factors driving these changes. Secondly, it highlights the environmental implications of urban growth, particularly the reduction in green spaces, which are essential for urban sustainability and resilience. Finally, the study's findings can inform policymakers and urban planners in developing strategies to promote sustainable development, ensuring that economic growth is balanced with environmental conservation and improved quality of life for residents.

By analyzing the temporal changes in urban land use in Kwasa Damansara from 2010 to 2022, this study aims to contribute to the broader discourse on sustainable urban planning and development in rapidly urbanizing regions. The literature on urban land use change provides a comprehensive understanding of the patterns, drivers, and impacts of urbanization. In the context of Kwasa Damansara, the studies reviewed highlight the significant changes in land use over recent decades, driven by population growth, economic development, and infrastructure projects. These changes have important implications for urban planning and sustainability, underscoring the need for integrated, community-driven, and adaptive planning approaches. By building on these insights, this study aims to contribute to the ongoing discourse on sustainable urban development in rapidly urbanizing regions.

Remote sensing and GIS technologies are widely used to analyze urban land use change. Jensen (2005) described the application of remote sensing in urban studies, noting that high-resolution satellite imagery allows for detailed mapping of land use patterns. Supervised classification and object-based image analysis (OBIA) are common techniques for categorizing land use into distinct classes. These methods enable researchers to monitor changes over time and identify trends in urban development. Temporal change detection techniques are crucial for assessing land use changes over specific periods. Singh (1989) discussed various change detection methods, including post-classification comparison, multi-temporal image differencing, and change vector analysis. These techniques help quantify the extent of land use changes and identify areas of significant transformation. Ground truth data and high-resolution aerial photographs are often used to validate the results, ensuring the accuracy of the analysis.

Study Area
Kwasa Damansara is part of Selangor. It is the most developed and densely populated region in Malaysia, serving as the political, economic, and cultural hub of the country. The region's rapid urbanization has led to significant changes in land use patterns, necessitating a comprehensive analysis to inform future urban planning initiatives. Figure 1 illustrates the study area, Kwasa Damansara in Peninsular Malaysia.

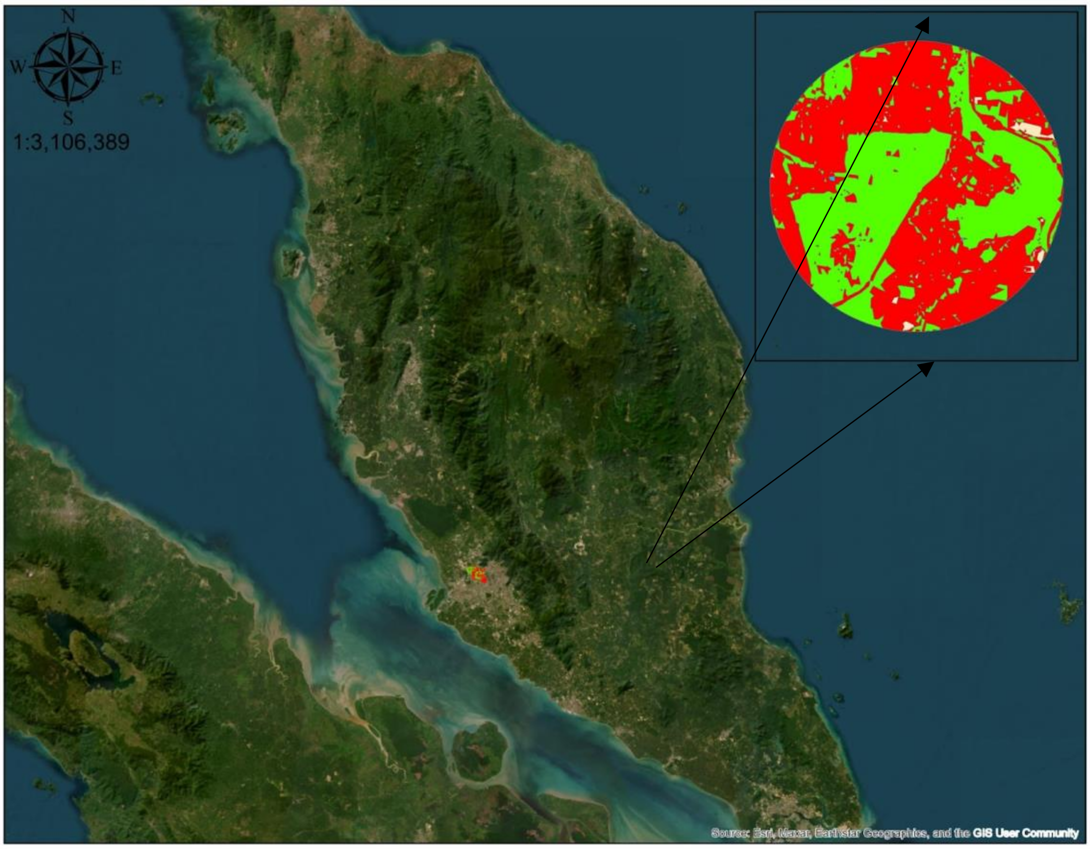

Figure 1. The study area (Kwasa Damansara, Malaysia)

Methodology
Data Collection
The study utilized the high-resolution satellite imagery for 2010 data. The imagery was obtained from reliable sources Landsat 7 ETM+. Data was downloaded from the website United State Geological Services (USGS) website at (http:// earthexplorer.usgs.gov/). While data 2022 was obtained from iPlan Malaysia. Additionally, auxiliary data, including

demographic statistics, urban development plans, and infrastructure maps, were integrated to provide systematic and enhanced land use changes analysis.

Image Pre-Processing
ArcGIS 10.8 software was utilized for the image pre-processing. The satellite images were pre-processed to correct atmospheric distortions and geometric inaccuracies caused by the internal and external conditions of the sensors during image acquisition (Bruce & Hilbert 2006). According to Song et al. (2001), it is important to go through pre-processing to correct atmospheric effects before undertaking classification and detailed analysis of changes. Hence, a haze reduction procedure was used to eliminate haze in the 2010 Landsat 7 ETM+. After that, an image mosaic was completed to combine in a single seamless composited Landsat image 2010. Figure 2 shows a workflow chart for the study.

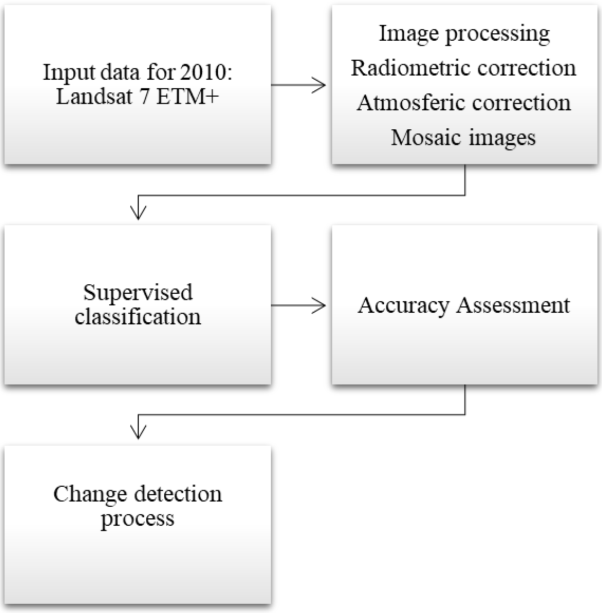

Figure 2 Workflow chart for the study

Image Classification
ArcGIS 10.8 software was utilized for the image classification process. All of the pixels in a pre-processed Landsat 7 ETM+ image are classified as developed area, forest, water bodies, bare land, and recreational (Song et al. 2001). Image classification techniques, including supervised classification and maximum likelihood algorithm, were employed to categorize land use into distinct classes. In order to classify the land use classes, polygons were drawn around the study area in the processed images of Landsat 7 ETM+. A minimum of 100 training sites were created. The Red-Green-Blue (RGB) bands enable visualization of the objects in the identification of the training sites. However, different land use classes had varying numbers of training sites. The pixels in the pre-processed Landsat 7 ETM+ image have been defined to determine the classes. The land use classes have been presented in Table 1. For 2022 data, data was obtained from iPlan Malaysia. The land use in the map was classified into four distinct classes such as forest, developed area, water bodies, and bare land.

Table 1
Land use classes

Land use class	Description
Forest	Includes regions with densely green area
Developed Area	Includes residential, industrial, commercial and transportation
Bare Land	A land without development and dominant vegetation cover
Water Bodies	Includes rivers, ponds, and water reservoirs

Accuracy Assessment
Accuracy assessment is a post-classification procedure carried out to verify the effectiveness of the classification process compared to real ground features. In this study, 376 random Ground Truth points were selected from the 2010 Landsat 7 ETM+ pre-processed image. The points were then compared with the points on the classified Landsat 7 ETM+ images. The comparison results were reported in a table. The results were then calculated using the formula to obtain the Kappa coefficient value, verifying the reliability of the land use map (Rosenfield & Fitzpatrick-Lins, 1986). The computation of producer accuracy, user accuracy, and overall accuracy was also determined to assess the classified land use map's accuracy. The Kappa coefficient value obtained was greater than 0.7, indicating that the land use maps were reasonably reliable for change detection (Lea & Curtis, 2010).

Change Detection
ArcGIS 10.8 software was used to do the temporal change detection techniques. The total area of every class for 2010 and 2022 was then calculated from the land use map 2010 and 2022. The area increment and reduction magnitude were calculated.

Result
From the accuracy assessment, the overall accuracy and Kappa coefficients value for the 2010 land use map is 91.03%. Table 3 describes the user accuracy and producer accuracy for the map. In 2010, the study area was majority covered by the developed area. As illustrated in Table 2, steady increment of developed area during the 12-year study period. Major changes were the increase of developed area areas by 22.77%, decrease of forest by 51.26 %, increment of water bodies by 4106.66 %, and increment of bare land by 715.89 %. The land use change detection map is illustrated in Figure 3 and Figure 4. Figure 5 shows the accuracy assessment points on the classified Landsat image.

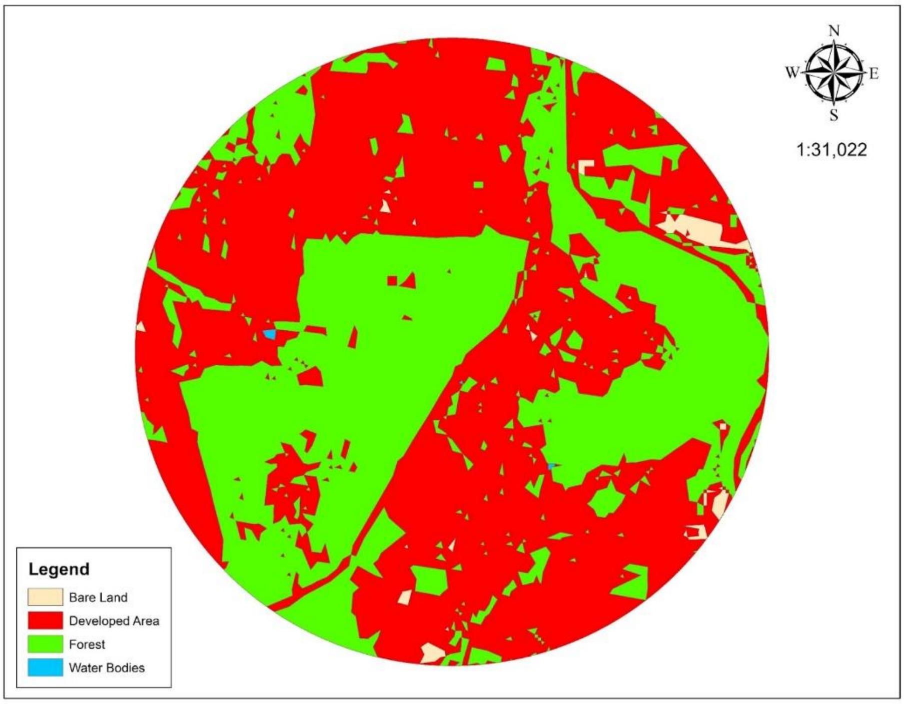

Figure 3 Land use map for 2010

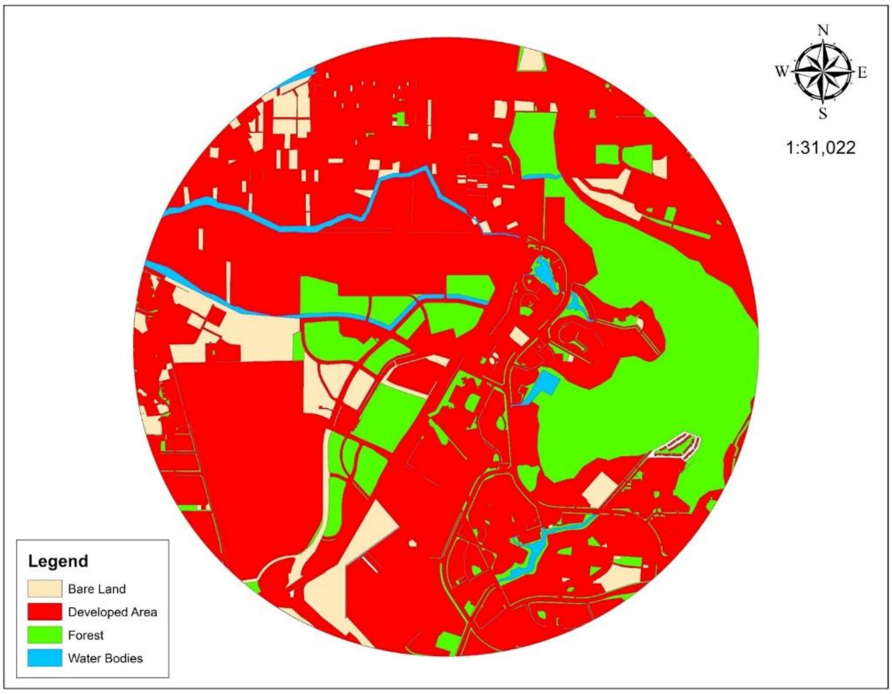

Figure 4 Land use map for 2022

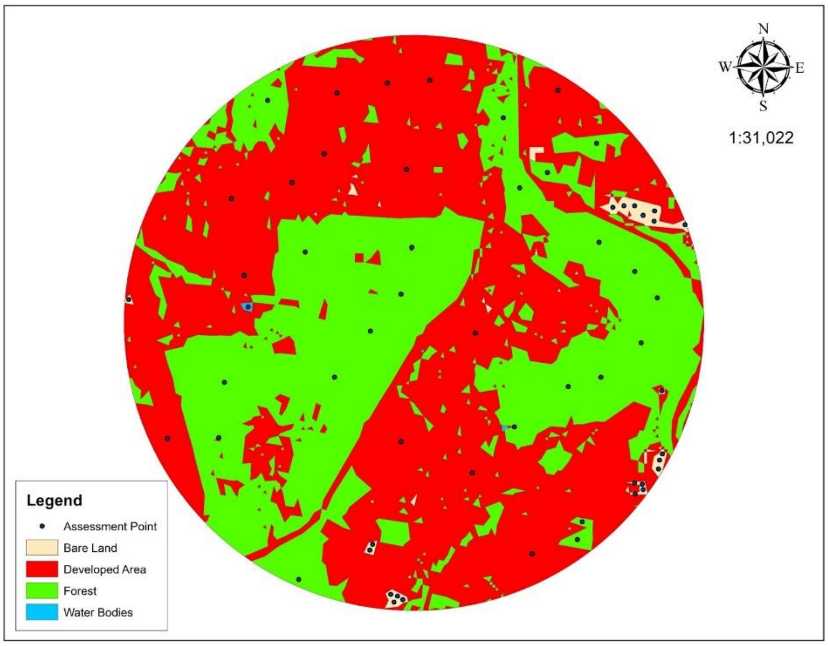

Figure 5 Land use map for 2022

Tabel 2
Land use class area comparison

No	Land Use	2010		2022		Land Use Changes	
		Area (Ha)	Percentage	Area (Ha)	Percentage	Area (Ha)	Percentage
1	Developed Area	1588.5	56.67	1958.11	69.85	369.61	13.18
2	Water Bodies	1.2	0.04	50.48	1.80	49.28	1.76
3	Forest	1187.12	42.35	578.59	20.64	-608.53	21.71
4	Bare Land	26.49	0.94	216.13	7.71	189.64	6.76
	Total	2803.31	100	2803.31	100	1217.06	43.42

Table 2 shows the statistical transition of land use change in 2010 and 2022. Between 2010 to 2022, around 608.53 ha (21.71%) of forest was converted into other land uses. Much of the forest was converted into bare land. The forest area also converted to a developed area in 2022. While the water bodies percentage increased by 1.76% due to some of the rivers in 2010 Landsat ETM+ image was not classified as water bodies during the classification process. During the accuracy assessment process, we found that most rivers were not classified as water bodies for 2010 due to a deficiency and constraints in processing the Landsat ETM+. The area of water bodies in 2010 was supposed to be higher compared to the area obtained from the classification process. The accuracy assessment results in Table 3 indicated that the 2010 classified Landsat image was accurate. The Kappa coefficient obtained from the classification process is 82.93%.

Table 3
Accuracy Assessment

	Developed Area	Water Body	Forest	Bare Land	Total User	User Accuracy
Developed Area	14	0	0	0	14	100
Water Body	0	1	8	0	9	11.1
Forest	0	0	22	0	22	100
Bare Land	0	0	0	22	22	22
Producer Accuracy	100	100	73.3	100		

Overall accuracy = 88.06%, Kappa coefficient = 82.93%

Discussion

The analysis revealed substantial changes in land use in Kwasa Damansara over the 12-year period especially in the residential expansion. There was a significant increase in residential areas, particularly in the suburbs of Kwasa Damansara. This expansion was driven by population growth and the demand for housing and facilities. Additionally, there are increments in the commercial and industrial growth due to the population demand. The region saw a notable rise in commercial and industrial areas, reflecting economic development and increased investment in business infrastructure. Besides that, this study also finds a significant reduction in green spaces. Green spaces have decreased as they were converted into urban areas. Therefore, this has implications for environmental sustainability and urban resilience. Major infrastructure projects and infrastructure development, including highways and public transportation systems, contributed to the spatial reconfiguration of the region.

The spatial analysis highlighted several urban growth corridors in the Kwasa Damansara, particularly along the major transportation routes. The expansion of urban areas in Kwasa Damansara was found to be spatially autocorrelated with the development of the transportation routes. The high-density of developments in the Kwasa Damansara clustering around the key infrastructure nodes. Infrastructure development, such as transportation networks and public utilities, plays a critical role in shaping urban growth patterns (Hussin et al., 2019). This study also revealed the primary drivers of land use change in Kwasa Damansara is the population growth. This is due to the increments in urban populations' demand for more residential and commercial spaces (Seto et al., 2012). Economic development is another major factor to Kwasa Damansara urbanization, with industrialization and commercial activities spurring the urban expansion (Yap, 2010). This is due to the economic policies in Malaysia promoting the enhancement of industrialization and commercial activities. Besides that, the construction of new transportation and other utility infrastructure also facilitated the urban expansion.

In the context of Malaysia, government policies and planning frameworks significantly influence urban land use changes. The National Physical Plan and various state-level development plans provide guidelines for urban development, aiming to promote balanced and sustainable growth. However, enforcement and implementation of these plans remain challenging, leading to unplanned and haphazard urban expansion in some areas (Shamsuddin, 2016). The reduction in green spaces highlights the importance of integrating green infrastructure and preserving natural areas within urban landscapes. It underscores the need for sustainable urban planning to balance development with environmental conservation. Additionally, the spatial patterns of growth suggest that future urban development should be guided by strategic planning to optimize land use and minimize negative impacts.

The literature underscores several key implications for urban planning and sustainability. First, integrated planning approaches that address the economic, social, and environmental dimensions are essential. This includes the preservation of green spaces and natural habitats, promoting compact and mixed-use developments, and improving public transportation systems (Angel et al., 2011). Second, community involvement is crucial for sustainable urban planning. Engaging local communities in the planning process ensures that their needs are addressed and fosters a sense of ownership over urban development initiatives (Shamsuddin, 2016). This participatory approach leads to more inclusive and effective urban policies. Finally, continuous monitoring and evaluation of urban land use changes are vital for adaptive planning. Remote sensing and GIS technologies offer valuable tools for tracking urban growth and assessing the impact of urban policies, enabling robust monitoring frameworks. These tools can help policymakers make informed decisions and adjust strategies as necessary to promote sustainable development (Jensen, 2005).

Conclusion

In conclusion, the analysis of land use changes in Kwasa Damansara over a 12-year period highlights significant shifts in both the magnitude and trend of urbanization, providing valuable insights into the driving forces behind these changes. Understanding these dynamics is crucial for policymakers and urban planners to make informed decisions that promote sustainable development, improve quality of life, and strengthen the resilience of urban areas amid ongoing growth. However, limited actions have been taken thus far to address these changes. To move forward, it is recommended that the Malaysian government implement policies that prioritize sustainable land-use practices, such as preserving green spaces and developing green infrastructure. Additionally, fostering community involvement in the planning process is essential to address local needs and encourage a sense of ownership over urban development. Coordinating infrastructure projects with urban planning will help achieve balanced growth and efficient land use. Furthermore, establishing a robust monitoring and evaluation framework will facilitate the tracking of land use changes and the assessment of urban policies over time. By addressing these strategies, Kwasa Damansara can achieve a sustainable balance between urban development and environmental preservation, ensuring a vibrant, livable region for future generations.

This research makes both theoretical and contextual contributions to the understanding of urban land-use dynamics and sustainable development. The spatio-temporal analysis of Kwasa Damansara enriches theoretical knowledge by integrating temporal and spatial methodologies to uncover urbanization trends and their underlying drivers, adding to the discourse on urban transformation in rapidly developing regions. Contextually, the study provides actionable insights specific to Malaysia, highlighting the need for sustainable land-use practices such as green space preservation, community engagement, and coordinated infrastructure planning. It emphasizes the importance of participatory governance and robust monitoring frameworks to ensure adaptive policy-making. Bridging the gap between theoretical urban planning concepts and practical applications, this research serves as a crucial resource for policymakers and planners in Malaysia, offering a roadmap for balancing urban growth with environmental sustainability while ensuring a vibrant, livable future for Kwasa Damansara and similar urbanizing areas.

Declaration of Competing Interest

All other authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data availability

No data was used for the research described in the article.

Credit Authorship Contribution Statement

Majid, N.A. Conceptualization, Methodology, Supervision, Funding acquisition, Writing – original draft, Writing – review & editing. Zaki, N.Z., Software, Data curation, Visualization, Investigation, Writing – review & editing.

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