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A Vision of Kuala Lumpur 2040

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ABSTRACT

In November 2023, Kuala Lumpur Structure Plan (KLSP) 2040 was launched, emphasizing a vision of a green, healthy, and vibrant city - a city that promotes an active lifestyle through natural environments like forests and parks and revitalizing urban spaces with cultural activities reflecting Kuala Lumpur's identity. However, with unconnected public infrastructure, overdeveloped skyscrapers, and limited green areas, this paper aims to discuss the city's sustainable development to accommodate the growing 2.1 million to 2.35 million population by 2040 to achieve its goals.

1. Introduction

This research paper explores Kuala Lumpur's journey towards sustainability by 2040, examining various dimensions of urban development, population dynamics, and innovative strategies of sustainable growth from micro–High Rise Development to macro–Sustainable Urban Planning. As the world's population grows, urban areas experience increased density, impacting infrastructure and quality of life. Kuala Lumpur, a major urban centre, faces similar challenges due to rapid urbanization. Sustainable cities balance economic, social, and environmental aspects to meet present and future needs. They prioritize resource efficiency, economic sustainability, and social equity, in urban development.

High-rise buildings have historically addressed urban density and land scarcity. Proper planning ensures high-rise developments contribute positively without increasing density excessively. However, overhang and vacant units pose challenges in Kuala Lumpur's real estate market. So do greenhouse gas emissions from high-rise buildings that harm the environment. Effective urban planning and management promote liveability and resilience, utilizing density for amenities and social interaction while avoiding overcrowding. Improving transportation and last-mile connectivity encourages sustainable modes of travel. By improving Urban Transportation and repurposing car park infrastructure reduces urban heat island effects, enhances air quality, and improves food security. This paper will analyse these aspects, identifying challenges and proposing strategies to achieve a sustainable Kuala Lumpur by 2040.

2. Methodology

This research paper employs a mixed-methods approach to analyse Kuala Lumpur's journey towards sustainability by 2040, focusing on various dimensions of urban development, population dynamics, and innovative strategies for sustainable growth. The methodology encompasses both qualitative and quantitative techniques to provide a comprehensive understanding of the subject matter.

2.1. Literature Review

An extensive review of existing literature on urban sustainability, high-rise development, urban planning, transportation, and related topics forms the theoretical framework. Scholarly articles, reports, policy documents, and case studies provide insights into theoretical underpinnings and practical implications.

2.2 Data Collection

Quantitative data from government databases, statistical reports, and academic studies is collected. Key indicators such as population growth, economic development, greenhouse gas emissions, land use patterns, and transportation infrastructure are analysed. Qualitative data is gathered through interviews and surveys with key stakeholders involved in urban planning, development, and sustainability initiatives in Kuala Lumpur.

2.3 Analysis

Quantitative analysis includes statistical techniques to identify trends, correlations, and patterns. Descriptive statistics, regression analysis, and spatial analysis are used. Qualitative analysis involves thematic coding of interviews and content analysis of policy documents. The analysis aims to uncover insights into current urban sustainability challenges and opportunities in Kuala Lumpur.

2.4 Synthesis and Discussion

Findings from the literature review and data analysis are synthesized to provide a comprehensive understanding of Kuala Lumpur's sustainability journey. The discussion explores challenges related to high-rise development, transportation, environmental sustainability, and social equity. It also highlights innovative strategies and best practices from other cities.

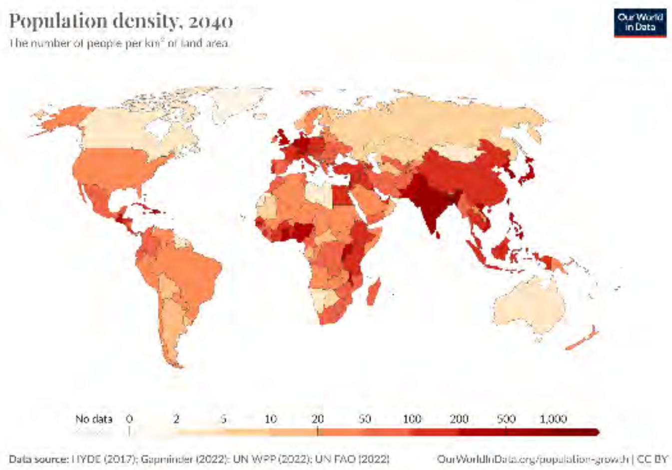
2.5 Recommendations

Based on the analysis, recommendations for achieving sustainable development in Kuala Lumpur by 2040 are provided. These encompass policy interventions, urban planning strategies, infrastructure investments, and community engagement initiatives aimed at promoting economic prosperity, social inclusion, and environmental sustainability

3. A Vision of Sustainable Kuala Lumpur 2040

3.1 The World Population Today
3.1.1 Population Density

Population density refers to the number of individuals per unit of area, typically expressed as "per square kilometre" or square mile. The global population is estimated to be around 8 billion, and the Earth's total area, including both land and water, is approximately 510 million square kilometres. Therefore, the worldwide population density can be calculated as approximately 8 billion divided by 510 million, which equals 16 people per square kilometre. However, if we consider only the Earth's land area, which is about 150 million square kilometres, the human population density becomes 53 per square kilometre (Central Intelligence Agency, 2024) This figure includes all continental and island landmasses, including Antarctica. Figure 1. shows List of Countries by Population 2024.



	Country	2024
1.	Macao	21,608.7
2.	Monaco	17,360.4
3.	Singapore	8,430.0
4.	Hong Kong	7,139.7
5.	Gibraltar	3,274.3
6.	Bahrain	1,897.1
7.	Maldives	1,726.3
8.	Malta	1,677.3
9.	Bangladesh	1,342.1
10.	Sint Maarten	1,303.8

Fig. 1. (a) Population Density 2024 (b) List of Countries by Population (Our World in Data, 2024)

3.1.2 Urbanization

Throughout human history, the majority of people lived in small communities. However, there has been a significant shift in recent centuries, especially in the last few decades. There has been a large-scale movement of populations from rural to urban areas. By 1800, still, over 90% of the global population lived in rural areas. By 1950, this reduced to 65% of the population, and by 2000 1 in 8 people lived in urban areas (U.S. Census Bureau, 2020)

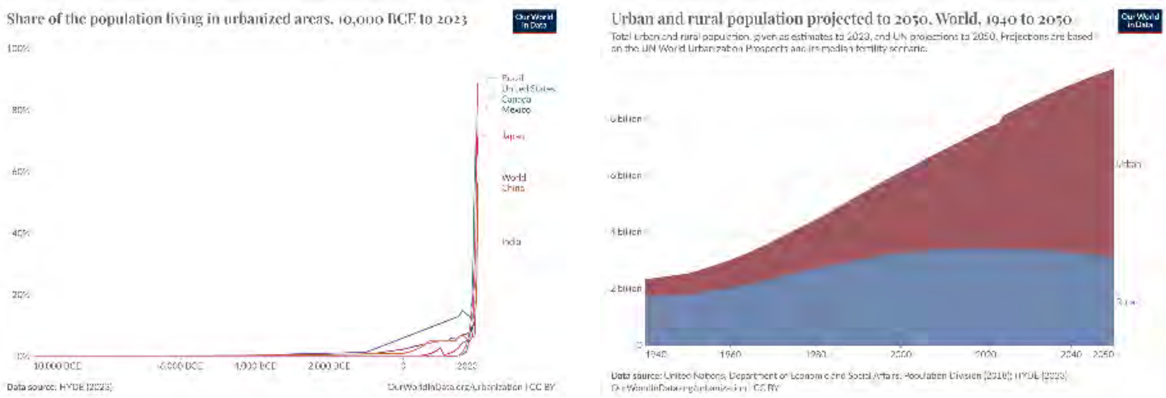


Fig. 2. (Left) Share of population living in urbanized area, 1400-2023 (HYDE,2023)
(Right) Urban Population projected to 1940-2050 (Our World in Data, 2024)

Figure 2. displays estimates of urban and rural populations in absolute terms, projected up to the year 2050. These projections are based on the UN's medium fertility scenario. According to this scenario, the global population is expected to rise to approximately 9.8 billion by 2050. It's projected that by this time, close to 7 billion people will reside in urban areas. This means that around 1 in 7 people globally will be living in urban settings. Moreover, it's estimated that more than twice as many people in the world will be living in urban areas compared to rural areas (Our World in Data, 2024).

3.1.3 Urban Density

Urban density, is a term used in urban planning and design, refers to the number of people living in a particular urban area, distinct from the measures of population density. It's often argued that higher-density cities are more sustainable compared to low-density ones. Urban density specifically measures the population of urbanized areas, excluding non-urban land uses like regional open spaces, agriculture, and water bodies. Other methods for measuring urban density include population density, median density, population-weighted density, residential density, floor area ratio, employment density, gross density, and net density. Each method provides a different perspective on urban population distribution and land use. Table 1. provides the urban density of cities worldwide.

	City		Density (km²)	Population	Area (km²)
1	Philippines	Manila	43,064	1,846,600	43
2	Philippines	Mandaluyong	38,495	425,758	11
3	Philippines	Caloocan	31,233	1,661,584	53
4	Israel	Bnei Brak	30,854	218,691	7
5	India	Kolkata	30,097	6,200,000	206
6	Nepal	Kathmandu	29,161	1,442,000	49
7	Bangladesh	Dhaka	29,069	8,906,136	306
8	Philippines	Makati	28,975	629,616	22
9	Haiti	Port-au-Prince	27,395	987,310	36
10	France	Levallois-Perret	26,713	64,379	2

Table 1: List of Cities by Urban Density

3.1.4 Kuala Lumpur Urban Population 2040:

In 2020, Kuala Lumpur experienced a significant increase in emigration, with more people leaving the city than arriving, resulting in a net migration figure of -16,100. This substantial outflow had a declining impact on the city's population growth. Of those leaving, 51.4 percent moved to neighbouring states, particularly Selangor. At the same time, international migrants accounted for 12.6 percent of the total immigrant population, contributing to Kuala Lumpur's overall population growth. It is projected that by 2040 (Table 2), non-citizens will represent 14.3 percent of the population, while citizens will comprise 85.7 percent, with the Bumiputera population expected to remain stable, while the Chinese and Indian populations are forecasted to see slight decreases (Kuala Lumpur City Hall [KLCH], 2023).

Kuala Lumpur is also expected to experience an aging population by 2040 (Table 3), with individuals aged 65 years and above making up 17.3 percent of the total population. Meanwhile, the younger and working-age groups are projected to decline, representing 13.3 percent and 69.4 percent of the population respectively by 2040 (KLCH, 2023).

Kuala Lumpur had a stable population growth rate of 2.2% from 1.59 million people in 2010 to 1.98 million people in 2020. Though there’s a change of population profile, Kuala Lumpur is still expected to have an average of 1.04% annual growth rate from 1.98 million people in 2020 to 2.35 million people in 2040 (KLCH, 2023).

Type of Ethnic	Percentage (%)			
	2025	2030	2035	2040
Bumiputera	41.7	41.6	41.5	41.5
Chinese	35.2	34.7	34.2	33.7
Indian	8.8	8.7	8.6	8.5
Others	1.3	1.5	1.7	2.0
Non-Citizens	13.0	13.5	14.0	14.3
Total	**100.0**	**100.0**	**100.0**	**100.0**

Table 2: Population Projection based on Ethnic Kuala Lumpur, 2025-2040 (KLCH, 2023)

Category	Percentage (%)			
	2025	2030	2035	2040
0-14 years	16.7	15.1	13.9	13.3
15-64 years	74.1	73.2	71.6	69.4
65 years and above	9.2	11.7	14.5	17.3
Total	**100.0**	**100.0**	**100.0**	**100.0**

Note:
Young Age Group (0-14 years)
Working Age Group (15-64 years)
Old Age Group (65 years and above)

Table 3: Age Structure Projection Kuala Lumpur, 2025-2040 (KLCH, 2023)

3.2 Sustainable Cities
3.2.1 Definition

The concepts of Sustainable development were developed in Europe during the 17th and 18th centuries in response to a growing awareness of the depletion of timber resources in England. In 1987, the United Nations published a Brundtland Report. The report included a definition of "sustainable development" which is now widely used -

Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains two key concepts within it:

- *The concept of 'needs', in particular, the essential needs of the world's poor, to which overriding priority should be given; and*
- *The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.*

—World Commission on Environment and Development, Our Common Future (1987)

In 2012, the United Nations Conference on Sustainable Development in Rio de Janeiro developed The Sustainable Development Goals (SDGs). UN Sustainable Development Goal 11 aims to make cities and human settlements inclusive, safe, resilient and sustainable. It in a way offers opportunities for all, with access to basic services, energy, housing, transportation and green public spaces, while reducing resource use and environmental impact.

Sustainable development focuses on finding a balance between economic development, environmental protection, and social well-being. A sustainable city, eco-city, or green city is designed to take into consideration the social, economic, and environmental impacts, creating a resilient habitat for existing populations while preserving the ability of future generations to benefit similarly. These cities prioritize inclusivity and sustainable economic development, reducing energy, water, and food consumption, and minimizing waste and pollution.

3.3 Skyscrapers

3.3.1 Definition of High-Rise

A tower block, high-rise, apartment tower, residential tower, or office tower is a tall building used for various purposes, including residential, office, hotel, retail, or mixed-use developments. High-rise apartment buildings have appeared since Ancient Rome and were prominent in medieval cities, serving defensive and symbolic roles. Modern high-rise buildings emerged with advancements in firefighting technology, which set height limits of 22 meters until the late 9th century. Building regulations usually maintain a height limit of around 30 meters for safety, despite modern firefighting capabilities. The invention of the elevator and the availability of materials like reinforced concrete and steel made high-rise construction feasible. While steel frames are common in North American skyscrapers, residential towers are typically made of concrete. A particularly tall high-rise is commonly referred to as a skyscraper.

3.3.2 Definition of Skyscraper

The term "skyscraper" emerged in the late 19th century to describe tall buildings with steel-framed construction and at least 10 stories. These structures are predominantly found in major American cities like New York City, Philadelphia, Boston, Chicago, Detroit, and St. Louis. Often regarded as the first steel-frame skyscraper, the Home Insurance Building in Chicago (completed in 1885) stood at 10 stories, reaching 42 meters (138 feet) in height. The development of steel skeleton construction paved the way for the towering skyscrapers seen today.

Architectural historians refined the definition of skyscrapers by highlighting engineering advancements in the 1880s that enabled the construction of tall multi-story buildings. This definition emphasized the use of steel skeleton construction, distinguishing skyscrapers from structures relying on load-bearing masonry, such as Chicago's Monadnock Building, which reached its practical height limit in 1891.While modern sources generally define skyscrapers as buildings at least 100 meters (330 feet) or 150 meters (490 feet) tall, there is no universally accepted definition other than being very tall high-rise buildings (Petruzzello, 2022).

3.3.2 The Skyscrapers Development

Skyscrapers, commonly found in downtown areas of major cities, are driven by economic factors by maximizing floor space to reduce cost of land per unit of floor space. This economic decision to build upwards is especially prevalent in large cities to cater great population densities where land prices are high. The feasibility of constructing skyscrapers is limited in smaller cities due to the high construction cost of skyscrapers. In modern cities, skyscrapers are becoming increasingly common as they offer a substantial amount of rentable floor space per square meter of land. Typically, only businesses like offices, commercial enterprises, and hotels can afford the high rents associated with skyscrapers. Table 6. shows the list of cities with the most completed skyscrapers that are taller than 150 m (492 ft) as of April 2024 (Cities by Number of 150m+ Buildings - The Skyscraper Center, n.d.).

	City		Number of skyscrapers
1	Hong Kong	Hong Kong	554
2	China	Shenzhen	410
3	United States	New York City	317
4	United Arab Emirates	Dubai	263
5	China	Guangzhou	191
6	China	Shanghai	189
7	Malaysia	Kuala Lumpur	173
8	Japan	Tokyo	173
9	China	Wuhan	168
10	China	Chongqing	145

Table 4: List of Cities with Most Skyscrapers
(Cities by Number of 150m+ Buildings - The Skyscraper Centre, n.d.)

3.3.3 Skyscrapers ≠ High Dense Country & City

When we examine the list of countries by population density alongside the list of cities by urban density and compare it with the list of cities with the most skyscrapers, we discover that a highly dense country or city does not correlate with the quantity of skyscrapers. For example, Macau, Hong Kong, and Singapore are among the top 10 most densely populated countries, but only Hong Kong is on the list of cities with the most skyscrapers. On the other hand, the top three cities in the Philippines with the highest urban density are not in the list of cities with the most skyscrapers. Meanwhile, although Kuala Lumpur is not among the most populated countries or cities, it ranks 7th in the list of cities with the most skyscrapers.

3.4 Sustainable Growth 1: Vacancy Tax for Overhang Units
3.4.1 Kuala Lumpur Overhang Units 2024

The term "overhang" in Malaysia's property market refers to newly completed units that remain unsold for over 9 months. As of 2023, Malaysia had 55,368 overhang units valued at RM41.67 billion, covering residential, commercial, serviced apartment, and SOHO units. Kuala Lumpur, ranked 7th globally in skyscrapers but not among the densest cities, faced significant overhang issues, with over 16.39% of Malaysia's overhang units (9,073 units, RM8.89 billion) located in the city (National Property Information Centre [NAPIC], 2023)

In the residential sector, Kuala Lumpur experienced robust activity with 5,927 new launches. However, 3,535 units remained unsold, valued at RM3.63 billion, indicating potential oversupply issues. Concerns were also raised with 6,128 units under construction and 2,714 planned but not yet built. The commercial sector appeared balanced, with only 23 unsold shop units. Serviced apartments faced challenges, with 4,806 unsold units and 8,974 under construction, indicating future oversupply. Similarly, SOHO properties had 709 overhang units, valued at RM 663.76 million (NAPIC, 2023)

The mismatch between supply and demand causes overhangs, stemming from misjudged market demand by developers or units not meeting buyer preferences. Affordable housing may be unsold due to unfavourable locations or limited amenities. The Sell-then-Build (STB) system exacerbates this, as units remain unsold if prices rise beyond affordability. This poses challenges in meeting the demand for affordable housing, especially as median house prices have nearly doubled in the past decade while household incomes have grown slower (Kunasekaran , 2023).

3.4.2 Kuala Lumpur Vacant Living Quarters

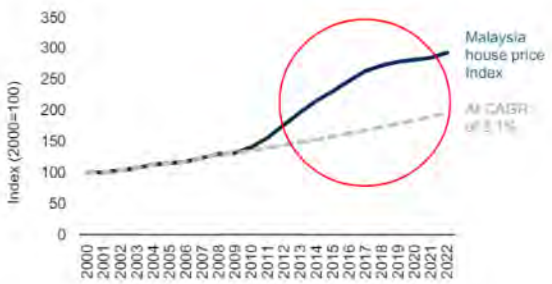
Living quarters are classified as vacant if they are not usually occupied and not used as a usual place of residence. The Department of Statistics Malaysia (DOSM) found that out of 9.5 million living quarters in Malaysia, approximately 7.7 million were occupied and the remaining 1.8 million were vacant. Of these vacant units, 22% were in Selangor, 13% in Johor, 8.5% in Perak, 8.2% in Sarawak, 8.1% in Sabah, 6.6% in Kuala Lumpur (DOSM, n.d.).

The primary reason for vacancies is due to units being either newly completed or awaiting rental or sale, followed by vacant units in holiday resorts or transit locations, and units undergoing repair or renovation. Approximately 704,935 units remain unoccupied, either due to being newly completed or intended for rental or sale. This suggests that these units were possibly acquired for speculative or investment purposes, with the intention of generating quick profits or rental income. However, it is important to acknowledge that the data lacks a detailed breakdown between newly completed units and those intended for rental, making it difficult to ascertain whether the units are primarily for long term rental or purchased for speculative purposes (Kunasekaran , 2023).

3.4.3 Khazanah Research Institutes: Implementing Vacancy Tax

To address the issues associated with unsold or unoccupied units, Khazanah Research Institute published a research paper on implementing a vacancy tax as a solution to curb speculation of the overhang and vacant units while fostering an affordable and sustainable housing market.

Typically, a vacancy tax is imposed on units that remain unused for a specified period, calculated by the percentage of their gross selling price. Higher-priced units incur a greater tax. This tax aims to prompt developers to conduct thorough market analysis and provide housing that meets diverse needs, preventing oversupply. It also discourages speculation by individuals aiming for quick profits. Countries like Canada (Vancouver and British Columbia) and Australia (Melbourne) have implemented such taxes to promote affordability and curb speculation, particularly among local and foreign buyers. Some argue that discounted prices disadvantage existing owners and affect secondary market values. Nevertheless, house prices in Malaysia have risen rapidly since 2010 due to innovative



	2022	2021
All-house price	RM 449,604	RM 434,758
All-house price at CAGR 3.1%	RM 300,550	RM 289,814

Source: NAPIC (various years(b)) and author's calculations

Fig. 3. House Price Index 2000-2022 (Kunasekaran , 2023)

financial schemes and speculative demand, leading to a housing bubble (Fig. 3.). Implementing a vacancy tax would prompt developers and individuals to sell or rent their overhang and vacant units to avoid the tax, providing home buyers with affordable options (Kunasekaran , 2023).

3.5 Sustainable Growth 2: Extending Lifespan of a High-Rise Development
3.5.1 Kuala Lumpur Land Development

The urban development area of Kuala Lumpur has expanded significantly after 2000. From 2000 to 2021, the built-up area increased by 2,112.3 hectares, six times higher compared to an increment of 355 hectares from 1984 to 2000. Built-up areas to date occupy 78.8% of Kuala Lumpur's total area, primarily residential buildings 25.5% and transportation 24.2%. Non-built-up areas covering 21.2%, including forest reserves, open spaces, and undeveloped land. Of the 2,121.14 hectares undeveloped land out of 5137.94 hectares non-built up area, 1,566.64 hectares are already committed to development, leaving 554.5 hectares for future development (Figure 4) (KLCH, 2023).

Source: Kuala Lumpur Structure Plan 2040
Fig. 4. Kuala Lumpur Existing Build Up and Non-Build Up 2021 (KLCH, 2023)

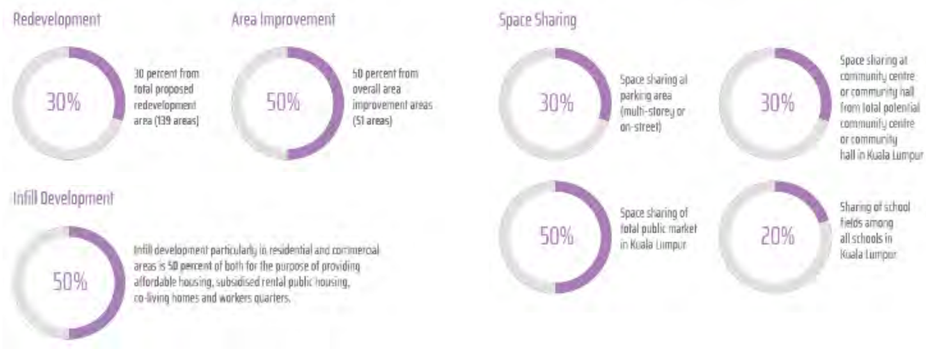


Fig. 5. Kuala Lumpur Sustainable Development Target by 2040 (KLCH, 2023)

To support Kuala Lumpur's integrated and sustainable development strategy by 2040, efficient land use planning targets are crucial. Kuala Lumpur Structure Plan 2040 targets focus on redevelopment, area improvement, infill development, and space sharing. By 2040, it's projected that 30% of redevelopment areas and 50% of renewal areas will be implemented. There will be a 50% infill development for affordable housing, subsidized rental public housing, co-living residences, and worker quarters. Limited land availability necessitates effective space sharing. This includes 30 percent sharing of parking spaces, community centers, and community halls; 50% share of space for public markets; and 20% space sharing for school fields (Figure 5) (KLCH, 2023).With limited land availability, this presents a challenge for future planning.

3.5.3 High Rise Development Greenhouse Gasses Emission

Edinburgh Napier University's research team assessed buildings' lifecycles (Table 5), finding high-rise structures have significantly higher embodied carbon, at 250 $kgCO_2e/m^2$, compared to 180 $kgCO_2e/m^2$ for low-rise and 90 $kgCO_2e/m^2$ for single-family homes. This is equivalent to a 500,000ft^2 high-rise emitting as much as 2,700 cars annually. Meanwhile, façade systems in high-rise commercial buildings contribute more due to materials like aluminium and glass. Assuming that the buildings would have a life cycle of 60 years, findings showed that operational carbon emissions still accounted for the majority, representing between 77% and 83% of total emissions. While there was a difference in operational energy use intensity between residential and non-residential buildings, no distinction was made between low-rise and high-rise buildings within the same occupancy category.

	Embodied Carbon of the structure, $KgCO_2e/m^2$ of floor area	Embodied Carbon of the facade, $KgCO_2e/m^2$ of envelope area	Operational emission over 60 years, $KgCO_2e/m^2$ of floor area	Total lifecycle GHG, $KgCO_2e/m^2$ of floor area	Operational carbon as a percentage of total lifecycle GHG emissions
Non-Residential Low Rise	180	72	2,460	2,953	83%
Non-Residential High Rise	250	168	2,460	3,120	79%
Residential Low Rise	180	76	1,898	2,426	78%
Residential High Rise	250	61	1,898	2,462	77%
Residential Houses (Row House, Town House)	90	84	1,491	1,925	77%

Source: https://usglassmag.com/insights/2021/12/is-high-rise-construction-the-sustainable-design-choice/

Table 5: Building Life Cycle Embodied Carbon and Operational Carbon emissions (Sanders, 2021)

The research further study on four different urban density and building height topologies High-density, low-rise (HDLR), High-density, high-rise (HDHR), Low-density, low-rise (LDLR), and Low-density, high-rise (LDHR) with each configuration real-world examples: HDLR to Central Paris, HDHR to Midtown Manhattan, LDLR to typical suburban sprawl, and LDHR to Empire State Plaza in Albany, New York.

The study, illustrated in Figure 6 (Left), evaluated the four urban types' average greenhouse gas (GHG) emissions per capita for a fixed land area. The results indicated that GHG emissions are primarily influenced by building height rather than urban density. HDLR had 2.8 times fewer carbon emissions over a 60-years life cycle than HDHR, despite similar population support and less per person carbon intensity. Additionally, HDLR outperformed both low-density scenarios.

In terms of scenarios with fixed population sizes shown in Figure 5 (Right), the study found that HDLR remained optimal for GHG emissions, with HDHR representing the worst. For a 50,000 population with minimal land use increase, HDLR emitted less than half the GHGs of HDHR. This led to the conclusion that dense, low-rise urban designs can accommodate similar populations as dense, high-rise areas with substantially lower carbon emissions and no significant land use increase, contrasting the notion that denser and taller buildings are more sustainable.

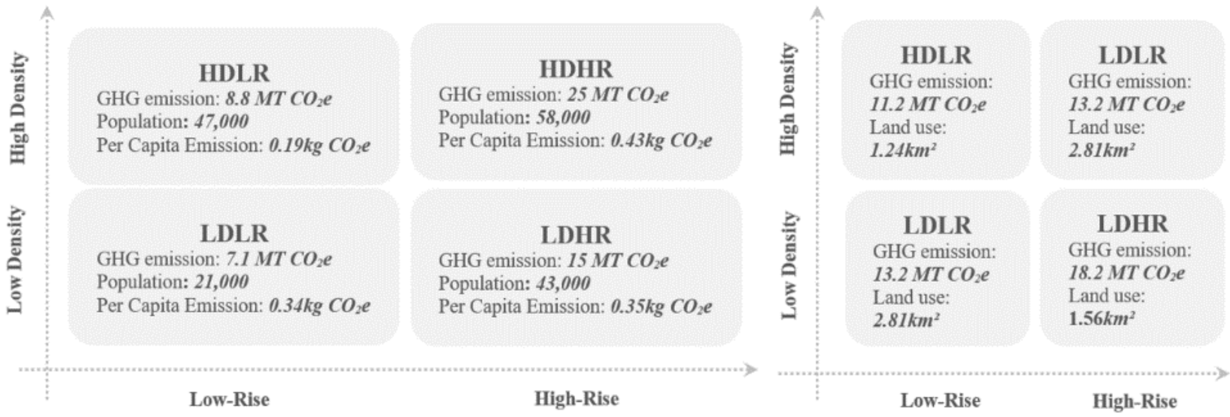


Fig. 6. (Left) Estimated GHG Emission with Fixed Land Area (KLCH, 2023)
(Right) Estimated GHG Emission with Fixed Population (KLCH, 2023)

With a population of 2.1 million and covering an area of 243km², Kuala Lumpur has an urban density of 8,900/km². In contrast, Manhattan, with a population of 1.6 million and an area of 58.69km², boasts a much higher urban density of 28,154/km². Albanya, with a population of 100,826 and an area of 55km², has a lowest urban density of 1,789.90/km². As Kuala Lumpur's urban population is projected to grow from 2.1 million to 2.35 million by 2040, covering an area of 243km², it is estimated to have an urban density of 9,700/km², categorizing Kuala Lumpur as Mid Dense High Rise category.

Corresponding with the studies mentioned above, a Mid Dense High Rise 2040 Kuala Lumpur high-rise structures will still have a significant amount of GHG emissions. As Carbon dioxide (CO^2) is the primary greenhouse gas and given that energy plays a significant role in CO^2 emissions, decreasing energy usage can ultimately reduce GHG emissions.

3.5.3 Construction and Demolition Waste

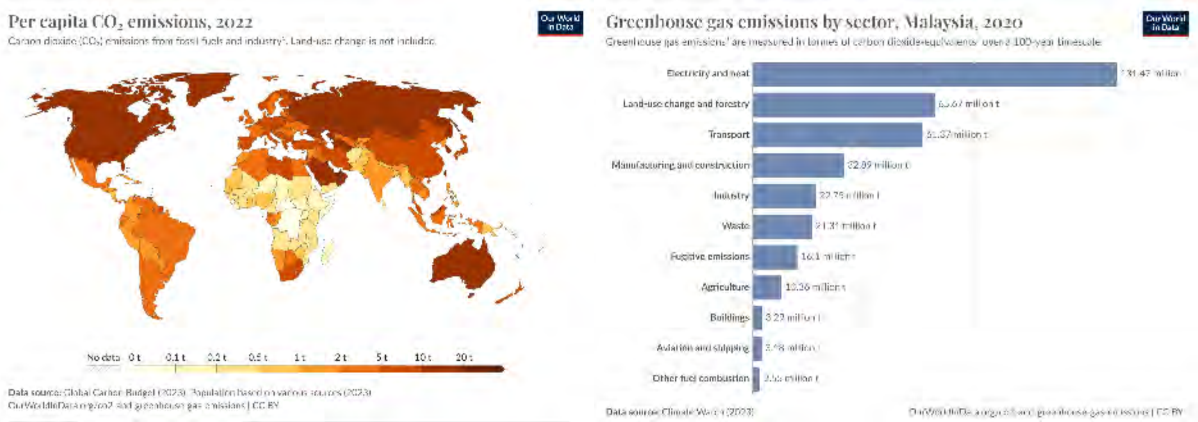


Fig. 7. (Left) Greenhouse Gas Emission per capita (Global Carbon Project, 2023)
(Right) Greenhouse Gas Emission by section (Climate Watch, 2023)

Malaysia produces 484.1 million tons of greenhouse gas (GHG) every year, approximately 14.3 tons per capita (Figure 7, Left), ranking the top 20 among 196 countries. Of this, waste contributes 17% to the total GHG emissions - highlighting a concerning trend of the construction industry that generates 30%-40% of the nation's total waste (Construction Waste Statistics, 2023). This underscores the urgent need to address waste management and sustainability issues within the construction sector.

Buildings are often designed for linear use. They typically undergo changes every 30 years as the lifespan of a building is largely determined by human work cycles. This results in shorter life spans for building types such as shops, businesses, educational facilities, and industrial buildings even when they have not reached their technical life expectancies. In fact, the majority of contemporary skyscrapers are constructed using steel beams that have a lifespan of around 100 years before requiring replacement. It's quite common for steel beams to be replaced gradually, piece by piece, in older skyscrapers, particularly in New York City. And most interestingly, residential buildings have a projected lifespan of 225 years (Soharu, Anil & Bp, Naveen & Sil, Arjun, 2022).

The building life cycle is commonly viewed as a linear process, beginning with material extraction, processing, manufacturing, occupancy, and disposal when no longer needed. At the end of their life, buildings are demolished, and much of the materials end up in landfills, even if they haven't reached their technical lifespan. This wastage increases energy consumption, leads to pollution, resource depletion, and habitat loss.

The term "zero waste" was first introduced by Paul Palmer in 1973. Zero waste construction aims to minimize waste generation and environmental impact by reducing, reusing, and recycling materials. It advocates for a closed-loop system where waste is eliminated or minimized, and materials are reused or recycled. Strategies for zero waste construction include designing buildings for easy disassembly, using sustainable materials like bamboo and reclaimed wood, adopting lean construction techniques, implementing waste reduction strategies, and considering the environmental impact of materials throughout their lifecycle (Civil Engineering, 2023).

To mitigate negative environmental impacts, designs should consider not only construction and service life but also the entire lifecycle of structures and components. This study focuses on key factors in the life cycle of buildings and their environmental impacts across lifecycle phases.

3.5.4 Refurbishment and Adaptive Reuse

The environmental impact of buildings is significant, especially in terms of energy consumption, materials, and waste. Even when materials are recycled, there are limitations. They might be down-cycled or unable to be reused in their original form, leading to lower practicality use of materials and inevitable waste. For new building uses, an impractical recycled material creates more demand for new materials to be extracted and produced. It's crucial to design buildings with proper life cycle solutions that facilitate material reuse and recycling, thereby minimizing waste. By addressing this issue during the design phase with appropriate technologies and materials, buildings can minimize construction and demolition waste achieving zero-waste construction.

There are less carbon-intensive material options available now in the market that's been widely used such as cross-laminated timber (CLT). *Stadthaus* in Hackney, London, and *Forte Living* in Melbourne, Australia, pioneered the use of CLT exclusively in tall buildings. *Ascent MKE* in Milwaukee, Wisconsin, set a new record in 2022 as the tallest high-rise integrating CLT components, standing at 25 stories and reaching 86.6 meters, primarily using CLT for floor slabs alongside concrete and steel (Think Wood, 2022).

However, with limited land availability for new development in Kuala Lumpur, by taking into consideration the context of building energy consumption, maximizing the use of embodied energy in building means prioritizing reuse over demolition, aligning with the materials zero waste concept. As Edinburgh Napier University's research above shows the operational energy of buildings contributes significantly to their environmental impact, refurbishing and adapting existing skyscrapers to meet current energy standards (Green Building) are essential. The Empire State Building, an iconic New York landmark completed in 1931 and standing at 443.2 meters tall, underwent refurbishment, resulting in annual energy cost savings of up to 38% and earning it a LEED certification (De la Garza, 2021).

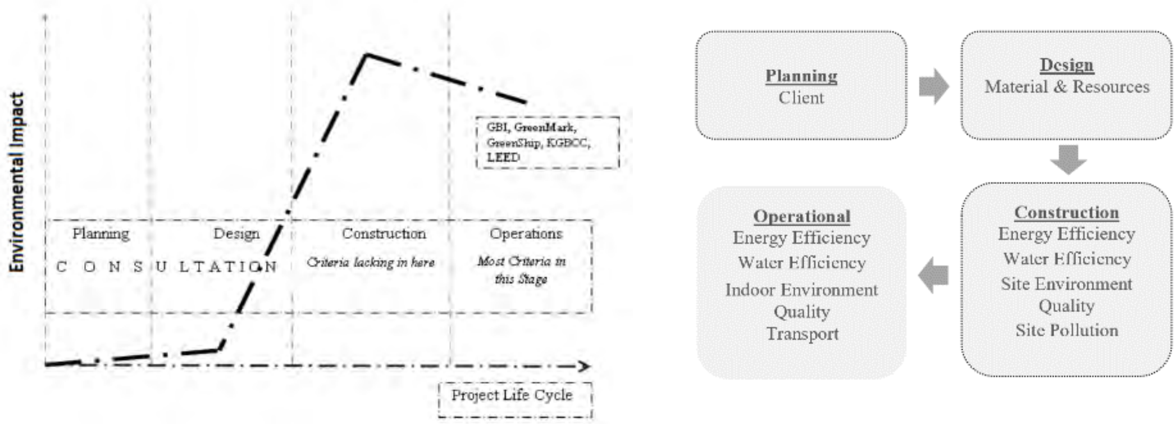
3.5.4 Malaysia Green Building Certification

Green building involves the implementation of environmentally responsible and resource-efficient practices across all stages of a building's life, including site selection, design, construction, operation, maintenance, renovation, and eventual deconstruction (Green Building, 2016). The aim of green buildings is to reduce their impact on the environment and human health by using sustainable materials, decreasing energy usage, managing waste, and optimizing water consumption. There are many Green Building Rating Systems in the world, LEED in the US, BREEAM in the UK, Green Star in Australia, Green Mark in Singapore, GBI and GreenRE in Malaysia.

Green Building Index (GBI) in Malaysia established in 2009 by the Malaysian Institute of Architects and the Association of Consulting Engineers Malaysia. It operates as an independent non-profit initiative, aiming to decrease urban carbon footprints and enhance the quality of our built environment. encompasses six key criteria: energy efficiency, indoor environment quality, sustainable site planning and management, materials and resources, water efficiency, and innovations.

In 2013, Green Real Estate (GreenRE) as an alternative green building rating system introduced by the Real Estate and Housing Development Association of Malaysia (REHDA), in collaboration with governmental bodies like the Ministry of Energy, Green Technology and Water, the Construction and Industry Development Board (CIDB), and the Institute of Engineers Malaysia. GreenRE evaluates a building's or development project's green features and design elements, focusing on energy and water efficiency, waste management, operations and management, and indoor environment quality, with the goal of reducing carbon emissions and providing a more comfortable living or working environment for occupants.

Bahaudin et al. (2013) 's research paper on comparing Green Buildings discusses that most of the Green Building Assessment - LEED, Green Mark, GBI mainly focuses on the completed building's operations and maintenance phase. However, it stresses the importance of considering the planning, design, and construction phases. As the construction phase contributes significantly to environmental impacts such as GHG emissions and waste, the paper suggests developing more criteria for the pollution control, value engineering, and waste management into planning, design, and construction stages of a building's life cycle by still maintaining the priority in the operational phase in a green building (Figure 7) (Bahaudin, 2013). In short, to implement zero waste construction as Green Building criteria.



Source: Comparison of Green Building Criteria *Source: Comparison of Green Building Criteria*

Fig. 8. (Left) Environment Impact during Project Life Cycle (Bahaudin, 2013)
(Right) Proposed Green Building Framework (Bahaudin, 2013)

3.5.5 Net-Zero Architecture

Other than Green Building, a net zero energy building is designed to generate as much energy as it consumes annually. It represents the highest level of energy performance for a build project. This is accomplished through energy-efficient design, onsite renewable energy, or off-site renewable energy sources. The objective is to minimize the building's carbon footprint by reducing energy consumption and utilizing renewable energy sources to offset any remaining energy needs.

The World Green Building Council, in collaboration with international experts, The Climate Group, and C40, advocates for a future where all buildings produce no carbon emissions by 2050—a future of net zero buildings. The Advancing Net Zero initiative aims for all new buildings to operate at net zero carbon by 2030 and for 100 percent of buildings to achieve this status by 2050. The Net Zero Carbon Buildings Commitment urges companies worldwide to commit to making their buildings net zero by 2030 (Wills & Madew, 2018).

For refurbishment or adaptive reuse projects to achieve net zero energy, this approach includes improving the building envelope, upgrading HVAC and lighting systems, installing renewable energy systems, and enhancing water efficiency through plumbing upgrades and low-flow fixtures. These upgrades result in reduced energy consumption, improved heating and cooling efficiency, clean energy generation, and enhanced water efficiency, ultimately leading to energy-efficient and environmentally friendly net-zero buildings (Stouhi, 2022).

3.6 Sustainable Urban Living
3.6.1 Urban Planning

There are nine urban planning theories still remain as the principal theories of planning today: the Rational-Comprehensive approach, the Incremental approach, the Transformative Incremental (TI) approach, the Transactive approach, the Communicative approach, the Advocacy approach, the Equity approach, the Radical approach, and the Humanist or Phenomenological approach.

In the 21st century, urban planners have increasingly focused on addressing the effects of growing congestion in urban areas and the negative impacts of induced demand from larger highway systems, especially in Western countries like the United States. New planning theories have emerged to tackle these challenges, incorporating non-traditional concepts such as Blue Zones and Innovation Districts. “Blue Zones" refer to specific geographic areas with low rates of chronic diseases that increase life expectancy (Sullivan, 2023). Meanwhile, an “Innovation District” is a focused zone where entrepreneurs, medical institutions, start-ups, and academia are clustered together in physical spaces (Innovation Quarter, n.d.).

3.6.2 Sustainable Urban Planning: 15-minutes city

The current climate crisis and the global COVID-19 pandemic have increased attention on the 15-minute city concept. In July 2020, the C40 Cities Climate Leadership Group outlined a framework for cities to "build back better" by implementing this concept especially in Milan, Madrid, Edinburgh, and Seattle in response to the pandemic.

Although the ideas behind this 15-minute cities have been around for some time, revealed first in 2015, refined in 2021, the French-Columbian urbanist Carlos Moreno defines the 15-minute city concept as the urban residents are able to access six essential functions—living, working, commerce, healthcare, education, and entertainment—within a 15-minute walk or bike ride from their homes. The model is structured around four components: density, proximity, diversity, and digitalization. This approach aims to reduce reliance on cars, promote sustainable and healthy living, and enhance the quality of life for urban residents (Moreno et al., 2021).

Implementing the 15-minute city concept requires a multidisciplinary approach involving transportation planning, urban design, and policymaking to create well-designed public spaces, pedestrian-friendly streets, and mixed-use developments. This shift in lifestyle may include remote work, reducing daily commuting, and is supported by advancements in information and communications technology.

3.5.3 Practicality of 15-minutes city

By factor in all essential facilities within a 15-minute walk, extended by bicycle use, an area of approximately 5 square kilometres will be covered within a 1.25-kilometer radius. A core population of 25,000 people is needed to support social, physical, and environmental infrastructure. This means that a population density of 5,000 people is required per square kilometre or 50 per hectare (Dublin Democratic Planning Alliance [DDPA], n.d.).

Recent studies indicate that regardless of occupancy rates and dwelling types/sizes, the gross population figures tend to match the net units per hectare (units/hectare) (DDPA, n.d.). Thus, an average dwelling density of 50 units/hectare would achieve the desired population density of 5,000 people per square kilometre for the 15-minute city concept. Considering lower existing densities in some areas and the capacity to accommodate predicted population growth, a net density of 65 to 100 units/hectare could potentially meet housing needs without compromising quality or community cohesion.

3.7 Sustainable Growth 3: Kuala Lumpur as a 15-minute city

According to Kuala Lumpur Structure Plan 2040, City Centre Development have a Plot Ratio 1:10, Residential Area with Kuala Lumpur Structure Plan 2020 highest residential density is 100 units per acre (Ngah Seron, 2022), equal to 247 units per hectare. Again, Kuala Lumpur has an urban density of 8,900/km², as Kuala Lumpur's urban population is projected to grow from 2.1 million to 2.35 million by 2040, it is estimated to have an urban density of 9,700/km², which is higher than a 15 min walk city 5000 people per square meter. However, Kuala Lumpur still highly depends on private car vehicles as main transportation compared to other global countries.

3.7.1 Transportation Mode Split

In Hong Kong, public transit, including the MTR, buses, trams, and ferries, accounts for approximately 90% of transportation, with private vehicles like cars and motorcycles making up only about 10% (Transport Department, 2023). Walking and cycling are minimal, often included in the public transit system. In Singapore, the public transit system, consisting of the MRT, buses, and LRT, covers approximately 65% of transportation, while private vehicles represent about 25%, and walking and cycling contribute approximately 10% (Land Transport Authority, 2023). In Kuala Lumpur, public transit, including the LRT, MRT, buses, and KTM Komuter, makes up about 40% of transportation, with private vehicles accounting for approximately 55%, and walking and cycling comprising around 5% (KLCH, 2023) .

3.7.2 The Last Mile

A transportation system comprises a combination of buses, trains, cars, bicycles, and footpaths. The fundamental effectiveness of a transportation system can be measured by its mobility and accessibility. KLSP 2040 Goal 5, Mobility City 1 focuses on Integrated Multimodal Public Transportation in Kuala Lumpur. To enhance Kuala Lumpur's transportation infrastructure, the aim is to expand the Rail Network, developing an Urban Commuter System in the city centre, prioritizing Public Bus Services, including expanding routes, integrating services, implementing priority lanes, and addressing Taxi and E-hailing Services. Meanwhile, Mobility City 2 aims to ensure a safe, accessible pedestrian network by implementing improved walkways in master plans, enhancing infrastructure for micro mobility vehicles, increasing public awareness through education and safety enforcement.

However, the last mile problem is essentially the challenge of public transport by not reaching the exact destinations. Since World War II, cities have prioritized vehicles over pedestrian access, resulting in residential areas being distant from central business districts (CBDs). This has led to difficulties in commuting efficiently, particularly in covering the last or first mile. While owning a car is a common solution, it exacerbates issues such as traffic congestion. Ride-sharing apps like Uber and Grab offer convenience but contribute to urban congestion. To address this issue, it is necessary to reconsider our urban environments and transportation choices. Solutions such as e-bikes, electric vehicles, improved bicycle infrastructure, bike-sharing programs, pedestrian-friendly planning, and smarter city design offer more sustainable options for the last mile problem, shifting the conversation towards more viable last mile travel choices (Stigo, 2017).

With the completion of various transportation projects such as MRT2 (currently under construction), MRT3 (planned), the High-Speed Rail (HSR) (planned), urban commuter systems like trams and BRT, and ongoing projects like LRT3 and the East Coast Rail Link (ECRL), the KLSP 2040 identified potential areas for future public transportation networks to achieve its goals. These areas include Kepong Lama - Jinjang, Penchala - Menjalara, Setapak, Bangsar, Alam Damai in Cheras, and OUG - Puchong (Figure 8).

Again, as stated in KLSP 2040 Mobility City 2.1B the implementation of the Kuala Lumpur Pedestrian and Cycling Master Plan 2019–2028, due to the impact of COVID-19, the progress of the master plan's implementation is questionable and will not be discussed in this paper. The Master Plan provides detailed pedestrian and cycling plans for city centre development but only indicates high potential demand for the rest of the Development Zones in Kuala Lumpur (Figure 9). It is strongly recommended that the cycling and walking master plan be designed in conjunction with the rail network.

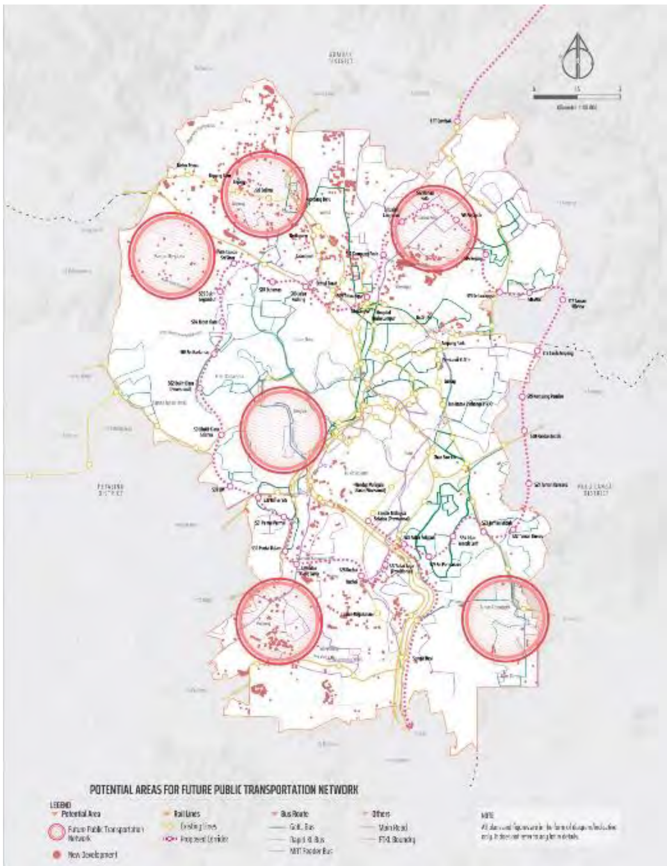


Fig. 9. Future Public Transportation Networks (KLCH, 2023)

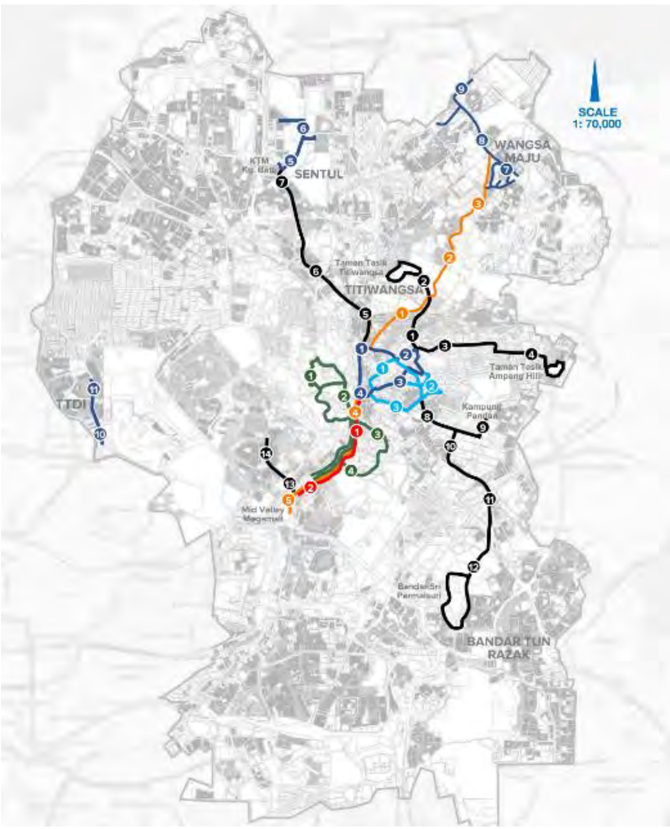


Fig. 10. Kuala Lumpur Existing & Proposed Cycling Lane (KLCH, 2019)

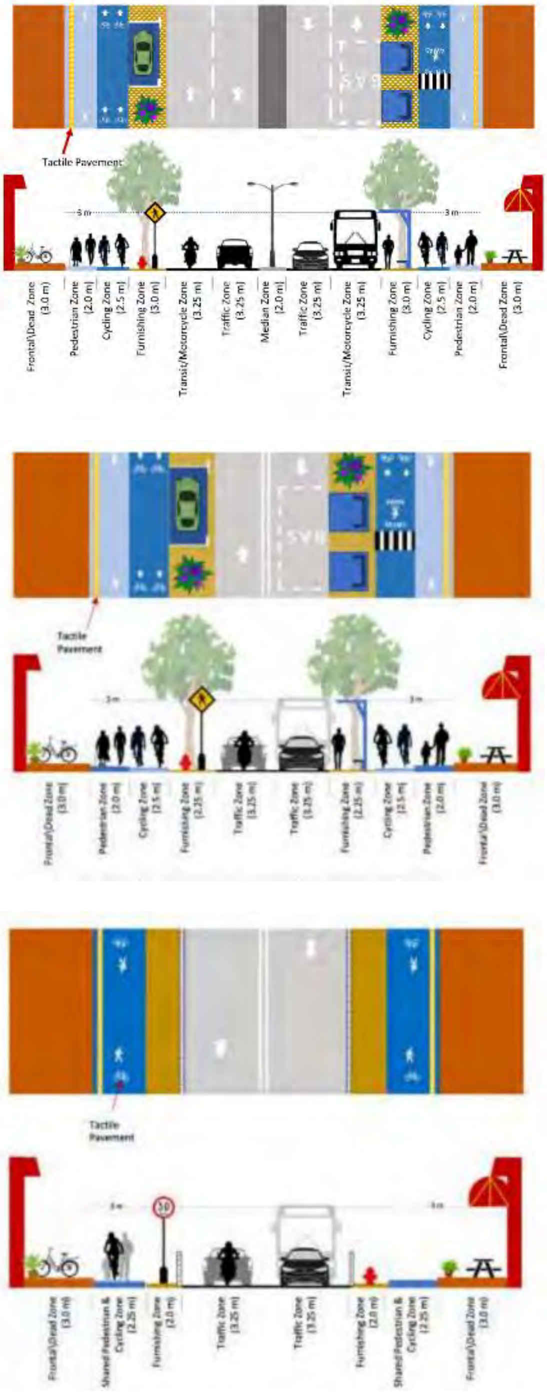


Fig. 11. (Top) Primary Road for Potential Demand Density Area (Middle) Secondary Road for Potential Demand Density Area

(Bottom) Local Road for Potential Demand Density Area

In terms of MC2.1E improving pedestrian linkages between buildings, continuity between buildings is highly encouraged especially buildings that allow access to the public. This is reflected in Draft Kuala Lumpur Local Plan 2040 as plot ratio incentive. This means that the plot ratio of the development could be increased by 3.5% to 40% if direct pedestrian walkway is provided to the nearby public transport.

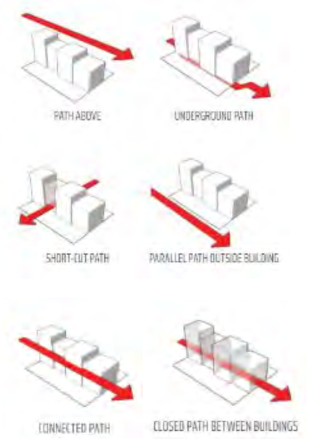


Fig. 12. Pedestrian Walkway between Building (KLCH, 2023)

Criteria	Compliance Criteria	Maximum Incentive Percentage by Category			
	400 meters	TPZ 1	TPZ 2	TPZ 3	TPZ 4
		30%	20%	10%	5%
	600 meters	TIZ 1	TIZ 2	TIZ 3	TIZ 4
		20%	15%	10%	5%
Main Criteria 1. Provision of development with direct connectivity to the station (station development)	Incentives are granted if the main criteria are complied	Up to 20%	Up to 15%	Up to 8%	Up to 3.5%
		Up to 15%	Up to 10%	Up to 7.5%	Up to 3%

Direct Connectivity can be provided in the form of connecting routes such as bridges, tunnels to stations, or transit vehicles such as sky train, cable car, or Autonomous Rail Rapid Transit (ART)
TPZ: Transit Planning Zone, TIZ: Transit Influence Zone
Source: Kuala Lumpur Local Plan 2040

Table 6. Kuala Lumpur Development Plot Ratio Incentive (KLCH, 2023)

3.8 Sustainable Growth 4: Improving Urban Transportation, Adaptive Reuse Car Park Infrastructure

3.8.1 Car Park Requirement

Current Parking Standards	
Type of Development	**Standard**
1. Public Housing – Private Car	
(a) Public Rental Estates, Home Ownership Schemes and Private Sector Participation Schemes (including Housing Society Estates) (b) Sandwich Class Housing	- **Public Rental Estates:** 1 car space per 13-16 flats - **HOS/PSPS/HS:** 1 car space per 5-8 flats - 1 car space per 4-7 flats
2. Public Housing – Goods Vehicle	
(a) Public Rental Estates, (these standards apply equally to Housing Society estates) and mixed Rental/HOS estates	**Light Goods Vehicle** - **Public Rental Estates:** 1 LGV space per 80 flats - **HOS (in mixed Rental/HOS estates only):** 1 LGV space per 200 flats. **Medium Goods Vehicle** No fixed standard. To utilize estate commercial centre loading/unloading bays for overnight parking in Rental or mixed Rental/ HOS estates.
3. Private Developments – Private Car	
- Zone 1 Areas - Zone 2 Areas - Zones 3 and 4 Areas	- 1 car space per 4-7 flats - 1 car space per flat or for every 100m^2 of gross floor area, whichever is the fewer - Minimum 1.5 car parking spaces for each dwelling
4. Village Housing	- Up to 1 car parking space for each standard NTEH (65m^2), with 10-15% of provision for overnight goods vehicles.

Recommended Parking Standards						
Type of Development	**Global Parking Standard**	**Adjustment Ratio**				
1. Subsidised Housing – Private Car	1 car space per 6-9 flats	**Type of Housing** Rental/Saleable 0.45				
2. Subsidised Housing – Goods Vehicle	**Light Goods Vehicle** 1 LGV space per 100-200 flats **Medium Goods Vehicle** No fixed standard. To utilize estate commercial centre loading/unloading bays for overnight parking in estates.					
3. Private Housing – Private Car	1 car space per 6-9 flats	**Average Flat Size (GFA)**				
		< 40m^2	40m^2 – 69.9m^2	70m^2 – 99.9m^2	100m^2 – 159.9m^2	> 159.9m^2
		0.6	1	2.5	5	9
4. Village Housing	No change					

Notes:
All Residential Developments
(1) The global parking standards for each district should be determined by Transport Department according to the demand/supply conditions in the respective districts. The global parking standards are subject to periodic review.
(2) A 15% discount should be applied to the provision of residential car parking spaces where over 50% of the site area of the development fall within a 500m radius of rail stations. The 500m-radius catchment area of a rail station should be drawn from the centre of the station disregard of topographic undulation.
Subsidised Housing
(3) An adjustment factor of 0.6 may be used instead if it is reasonably certain at the planning stage that the subsidised housing will be 100% for sale upon completion. However, should the project be transferred to public rental use at a later stage, the adjustment ratio could be reverted back to 0.45.
(4) Bachelor/single person flats should be excluded from the calculation of the overall parking provision of both car parking spaces and LGV spaces.
(5) The LGV parking requirements for each district should be determined by Transport Department according to the demand/supply conditions of subsidised housing in the respective districts. The requirements are subject to periodic review.
Private Housing
(6) The average flat size of a development should be calculated by dividing the total domestic gross floor area (GFA) by the total number of flats of the development.
(7) The standard for the developments of an average flat size greater than 159.9m^2 is a minimum requirement. Request for provision beyond the standard will be considered by Transport Department on a case-by-case basis.
(8) Visitor car parking for private residential developments with more than 75 units per block should include 5 visitor spaces per block in addition to the recommendations or as determined by the Authority. For other private residential developments, the visitor car parking provision is to be decided by Transport Department on a case-by-case basis.
(Refer to Statement of Intent for further guidance)

Fig. 13. Hong Kong Residential Development Parking Provision (Transport Department, 2009)

			Lower Bound			Upper Bound		
S/n	Uses	Lot Types	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
1	Residential	Car	1 lot per 2 dwelling units	1 lot per 1.25 dwelling units		1 lot per 1.25 dwelling units	1 lot per dwelling unit	
		M/cycle						
		Bicycle	1 lot per 4 dwelling units		1 lot per 6 dwelling units	No Upper Bound		
		HV						
2	Serviced apartments	Car	1 lot per 4.2 dwelling units		1 lot per 2.6 dwelling units	1 lot per 2.1 dwelling units		
		M/cycle	1 lot per 80 dwelling units		1 lot per 50 dwelling units	1 lot per 40 dwelling units		
		Bicycle	1 lot per 4 dwelling units		1 lot per 6 dwelling units	No Upper Bound		
		HV						

Fig. 14. Singapore Residential Development Parking Provision (Land Transport Authority, 2019)

Type of Housing Development	Car Park	Calculation Formula for Parking Space Requirement
Medium Cost Flats I (Not exceeding RM150,000 per unit)	All zones: 1 car park/1 unit + 10% visitor car parks (from the total number of house units)	All zones: (Number of house units x 1 car park) + 10% visitor car parks
Medium Cost Flats II (Exceeding RM150,000 - RM300,000 per unit)		
Affordable Housing / PPA1M designated by government / PRIMA Housing (unit price RM300,000 and below)		
PR1MA Housing (Exceeding RM300,000-RM400,000 per unit)	All zones: 1.2 car park/1 unit + 10% visitor car parks (from the total number of house units)	All zones: (Number of house units x 1.2 car park) + 10% visitor car parks
High-Cost Apartment I (Exceeding RM400,000 – RM750,000 per unit)	All Zones: 2 car parks/1 unit + 10% visitor car parks (from the total number of house units)	All Zones: (Number of house units x 2 car parks) + 10% visitor car parks
High-Cost Apartment II (Exceeding RM750,000 – RM2,000,000 per unit)	All Zones: 2.2car parks/1 unit + 10% visitor car parks (from the total number of house units)	All Zones: (Number of house units x 2.2 car parks) + 10% visitor car parks
High-Cost Apartment III (Exceeding RM2,000,000 per unit)	All Zones: 2.5car parks/1 unit + 10% visitor car parks (from the total number of house units)	All Zones: (Number of house units x 2.5 car parks) + 10% visitor car parks

Fig. 15. Kuala Lumpur Residential Development Parking Provision (KLCH, 2021)

By looking at Car Park requirements for Residential, Hong Kong's requires 1 car park space per 6-9 flats, parking requirements decrease significantly when they are located near rail stations. Similarly, Singapore needed to provide 1 car park per 1.2 lot. Also, as stated by the Singapore - Land Transport Authority in 2018, "*In recent years, significant improvements have been made to the public transport network, and first-and-last mile connectivity has been enhanced with better walking and cycling facilities, such as sheltered footpaths and cycling paths. In view of these initiatives, the vehicle growth rate for cars and motorcycles was reduced to zero*".

Drawing from these case studies, assuming that by 2040, if Kuala Lumpur achieves a successful transportation mode split, increasing public transportation usage from 20%(2020), 50%(2024) to 70%(2040) (Figure 12) (KLCH, 2023), the demand for car parks would decrease. Instead of demolishing existing car park structures, what potential alternative use could it be considered?

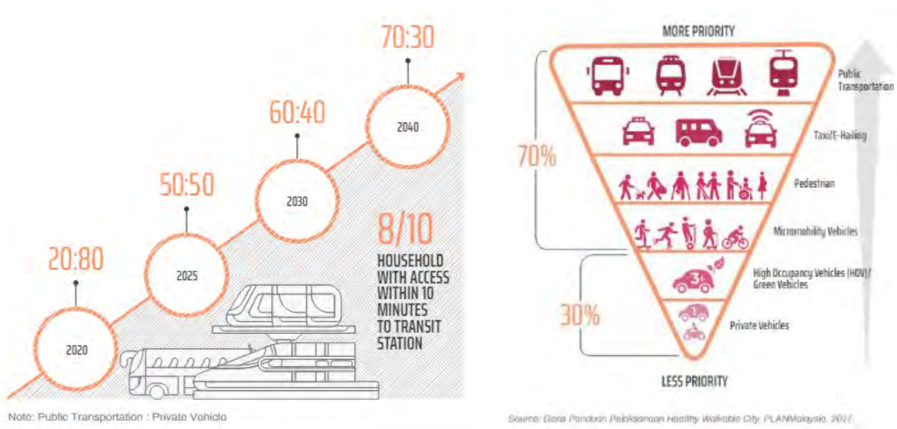


Fig. 12. (Left) Kuala Lumpur Public and Private Transportation Mode Split (KLCH, 2023)
(Right) Urban Mobility Mode (KLCH, 2023)

3.8.2 Adaptive Reuse Existing Car Park Infrastructure gr

The World Health Organization (WHO) recommended the availability of a minimum of 9m² of green space per individual (World Health Organization, 2012). London provides 27m² green space per person, Amsterdam In 2021, Kuala Lumpur provided 10.61m² green space per person, fulfilling WHO recommendation of green space yet falling below the National Urban Policy's 20m² target. To accommodate the 2.35 million populations by 2040, the city must secure an additional 4,700 hectares of open space.

Instead of demolishing the car park infrastructure, it could be adaptive reuse as a green open space. A new green plot ratio for each land based on KLSP research is calculated as follows:

The 20m² green area required for 2.35 million people is 47,000,000m² or 47km². This equates to 19% of the total 243km² area of Kuala Lumpur. As the urban planning requirement implemented now insists that every piece of land should have a minimum of 10% green, thus every land's green ratio will increase 9% to achieve National Urban Policy's 20m² target.

To adaptive reuse car park infrastructure, 100 car parks are required for every 100 units. To increase public transport usage from 20% to 70%, which represents a 250% increase in public transport users, for 2500 units, there would be 1000 car parks needed. By calculating the ratio, this means that from 1 unit to 1 car park, in 2040 for every 2.5 units only 1 car park is needed.

Each car park area is 5x2.5m = 12.5m². From 1 unit to 1 car park (12.5m²) to every 2.5 units 1 car park (2.5 x 12.5 = 31.25m²), this means that 60% of the car park area could be transformed into green open space. As the plinth area is 60% of a site development, 36% of each car park floor (of 100% site) in 2040 could be dedicated to green space.

Adding up 10% of the initial green area provided, it could be more than 20m² green space for an individual! Additionally, the transformation of multilevel car parks to green open space marks the historical development of a city.

3.8.3 Vertical Farming

Again, outlined in the KLSP2040, rooftop green and the expansion of green areas on building facades and balconies were stated to achieve the green space per capita 20m². To enhance and maximize greenery in urban areas, the existing car park structure proposed to adaptively reuse. There are already various types of vertical farming with soil-less green solutions been widely use:

1. Hydroponics: By using nutrient-enriched water, this method grows plants without soil, it is a popular technique with a floating raft system, where plants like lettuce, spinach, basil, cilantro, and parsley are grown in water with added nutrients (CropIn Technology, n.d.).
2. Aquaponics: Combining aquaculture and hydroponics, aquaponics utilizing fish waste as fertilizer for crops. It's known for its water efficiency, producing significantly more food per acre compared to traditional agriculture (CropIn Technology, n.d.).
3. Aeroponics: This advanced method uses nutrient-rich mists instead of water, allowing plants to grow without a medium. Inspired by NASA experiments, it promotes faster growth and is highly water-efficient (CropIn Technology, n.d.).

By implementing these strategies, not only can we increase green space, but we can also enhance sustainability and optimize land usage in Kuala Lumpur.

4. Conclusions

Developing sustainable cities involves both top-down leadership and bottom-up community engagement. This process requires collaboration among renewable energy engineers, urban planners, policies makers, with a great amount of public awareness. Effective sustainable urban planning encourage mixed-use and high-density development, improving green infrastructure public transit, constructing energy-efficient buildings, managing waste and water resources, and investing in renewable energy, all underpinned by active participations of local communities, sustainable business practices, green financing, advanced technologies, and stringent environmental regulations. This paper explores Kuala Lumpur's vision for sustainability by 2040, with a focus on architecture and urban planning.

Architecturally, by increasing neighbourhood density and the lifespan of buildings - a common misconception is that skyscrapers inherently lead to high urban density. Despite being ranked 7th globally in skyscrapers, Kuala Lumpur is not among the densest cities. To promote sustainable growth, the implementation of a vacancy tax on overhang units, supported by Khazanah Research Institutes, is a critical step towards achieving sustainable economic development. Extending the lifespan of high-rise buildings through renovation and adaptive reuse significantly contributes to environmental sustainability. High-rise buildings are major contributors to greenhouse gas emissions due to energy consumption and construction materials. By renovating and repurposing existing structures, carbon emissions can be reduced, resources can be conserved, and demolition waste can be minimized. This approach aligns with the world’s net-zero energy standards, with Malaysia's Green Building Certification serving as a tool to promote sustainable development and preserve architectural heritage.

Improving public transit in Kuala Lumpur is expecting to bring a significant change. Kuala Lumpur's urban population is projected to grow from 2.1 million to 2.35 million by 2040, with an estimated urban density of 9,700 people per square kilometer, higher than the 15-minute walk city's standard of 5,000 people per square kilometer. However, Kuala Lumpur still heavily relies on private car vehicles as the main mode of transportation compared to other global cities. To address this, transforming Kuala Lumpur into a 15-minute city enhance social equity and urban liveability by ensuring residents can access essential services, amenities, and workplaces within a 15-minute walk or bike ride. Addressing the "last mile problem," where public transport fails to reach specific destinations, is a key challenge. With the completion of MRT2, MRT3, and the High-Speed Rail, integrating the Kuala Lumpur Pedestrian and Cycling Master Plan with the rail network is recommended to enhance sustainability and community well-being. By prioritizing mixed-use development, public spaces, and efficient public transport, Kuala Lumpur can create more inclusive neighbourhoods that enhance well-being and social cohesion. This approach not only reduces transportation emissions but also fosters a stronger sense of community. Finally, as public transport use is expected to increase, converting up to 60% of car park areas into parks or other community spaces will optimize land use and contribute to a more sustainable urban environment. This repurposing would not only enhance urban greenery but also reduce the urban heat island effect, improve air quality, and support sustainable growth by promoting alternative transportation modes.

Kuala Lumpur's pursuit of sustainability by 2040 requires a multifaceted approach that integrates environmental, economic, and social strategies. Through collaborative efforts and innovative solutions, the city can serve as a model for sustainable urban development, ensuring a high quality of life for its residents while safeguarding the environment for future generations.

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