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STRATEGIC ANALYSIS OF INFRASTRUCTURE AND URBAN PLANNING IN KOTA KINABALU: A COMPREHENSIVE SWOT/TOWS-AHP APPROACH

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ABSTRACT

This study examines the infrastructure and urban planning landscape of Kota Kinabalu, Sabah, using an integrated SWOT-TOWS-AHP approach to identify strategic priorities for sustainable urban development. Secondary data from government reports, academic literature, and industry publications were analyzed to evaluate the city's strengths, weaknesses, opportunities, and threats. The SWOT analysis revealed key strengths such as strategic location, modern infrastructure projects, tourism potential, and natural attractions, while major weaknesses included traffic congestion, urban sprawl, inadequate drainage systems, and limited affordable housing. Based on these findings, the TOWS matrix was used to formulate strategic alternatives. The Analytic Hierarchy Process (AHP) was then applied to prioritize the proposed strategies through pairwise comparisons. The results indicated that promoting eco-tourism zones integrated with sustainable urban infrastructure was the highest-ranked strategy (38.0%), followed by the implementation of smart city technologies (19.0%) and the development of affordable housing and public transportation initiatives (11.1%). The findings provide a structured framework for policymakers and urban planners to support sustainable, resilient, and inclusive urban growth in Kota Kinabalu.

Keywords: Tourism industry, Ecotourism, SWOT analysis, TOWS matrix, Analytic Hierarchy Process (AHP), Sabah

1.0 Introduction

1.1 Background of the Study

The infrastructure and urban planning sector plays a pivotal role in shaping Kota Kinabalu's growth, directly impacting its economic prosperity, environmental sustainability, and residents' quality of life (Besar et al., 2020). While the city's transportation systems have developed rapidly, further improvements are essential to meet the evolving needs of a growing population (Besar et al., 2020). As Kota Kinabalu continues to expand, strategic planning becomes crucial to promote sustainable mobility, particularly through transit-oriented development (Yap et al., 2021).

Kota Kinabalu's urban landscape has transformed significantly in recent years. Urban development strategies and integrated development plans now play a central role in guiding investment decisions and fostering synergy between different urban zones (Wanda et al., 2019). Strategic planning is essential for coordinating key aspects of urban development, such as land use, housing, transportation, and environmental management, to ensure integrated and sustainable urban growth (Wanda et al., 2019). It is not simply an administrative process but a vital tool for managing the complex challenges of urbanization, including land optimization, affordable housing provision, and efficient service delivery (Yaakup & Healey, 1994).

Moreover, strategic planning allows for the proactive shaping of the urban environment, helping the city build resilience against future uncertainties and promoting long-term sustainability through a balanced approach to economic, social, and environmental goals (Ragheb et al., 2022). To

design effective urban policies, Kota Kinabalu's authorities must deepen their understanding of urban dynamics within the broader context of socioeconomic development (Bidandi & Williams, 2017).

The importance of strategic planning lies in its ability to provide a structured framework for informed decision-making, optimal resource allocation, and outcome-driven initiatives (Chang et al., 2018). It equips decision-makers to anticipate challenges, set clear goals, and develop actionable strategies aligned with the city's long-term vision (Khadour et al., 2023). By adopting a holistic approach, strategic planning integrates diverse elements such as economic development, social equity, and environmental protection, ensuring that development initiatives support the community's well-being.

In addition, strategic planning fosters collaboration among stakeholders, including government bodies, private sector actors, and local communities, encouraging shared priorities and joint action. Integrated planning—both vertically across government levels and horizontally across sectors such as land use, housing, transportation, green spaces, and public infrastructure—is essential for building healthy and sustainable cities (Lowe et al., 2022). Ultimately, applying strategic planning principles ensures that Kota Kinabalu's infrastructure projects are not only economically sound but also environmentally sustainable and socially inclusive, thereby enhancing the overall livability of the city.

1.2 Problem Statement

Kota Kinabalu faces multiple challenges, including rapid urbanization, rising population density, environmental degradation, and insufficient infrastructure. These issues collectively threaten the city's long-term sustainability and livability. Without strategic intervention, the current pattern of urban development could lead to increased traffic congestion, air and water pollution, loss of green spaces, and growing social inequality. Asmawi et al. (2022) emphasize that population growth, unchecked urbanization, urban sprawl, and agricultural land conversion contribute to the development of cities that are both unsustainable and unresilient.

Addressing these challenges requires a comprehensive and integrated approach that acknowledges the interconnectivity of urban systems and promotes synergistic solutions. Urban planning decision-making is inherently complex, requiring tools that can manage trade-offs, balance competing objectives, and ensure transparency and accountability. Decision-makers must consider not only economic growth but also environmental protection and social equity—factors that often involve conflicting priorities and stakeholder interests.

To overcome the limitations of traditional planning approaches—often criticized for being overly subjective or intuition-based—there is a pressing need for a holistic, data-driven decision-making framework. The SWOT-TOWS-AHP methodology offers a structured, analytical approach for evaluating strategic options in urban development. This integrated framework enables planners to assess internal and external factors, formulate strategies, and prioritize actions based on stakeholder preferences and real-world constraints.

The SWOT analysis identifies the strengths and weaknesses within Kota Kinabalu's infrastructure and urban planning sector, as well as the external opportunities and threats influencing its development. Building on this, the TOWS matrix helps generate actionable strategies: using strengths to exploit opportunities, addressing weaknesses by leveraging opportunities, using strengths to counter threats, and minimizing weaknesses to avoid threats (Bottero et al., 2021). Following this, the Analytic Hierarchy Process (AHP) enables stakeholders to rank and prioritize the strategic alternatives systematically. It does so through a step-by-step process that involves defining the problem, structuring it into a hierarchy, collecting expert judgments, converting them into numerical values, calculating priorities, and analyzing sensitivity to changes (Saaty & Paola, 2017).

The integration of SWOT, TOWS, and AHP provides a robust decision-making framework that enhances the transparency, objectivity, and effectiveness of strategic planning in urban infrastructure development. According to Samah et al. (2006), such an approach ensures that decisions are not only data-driven but also aligned with long-term urban sustainability goals. This method is particularly beneficial in complex urban environments like Kota Kinabalu, where relying solely on traditional or intuition-based planning can lead to biased decisions and suboptimal outcomes. By using the AHP Priority Calculator as part of this methodology, decision-makers can make well-informed, stakeholder-aligned choices that enhance the city's overall quality of life.

1.3 Research Objectives

The primary objective of this research is to conduct a comprehensive assessment of the infrastructure and urban planning landscape in Kota Kinabalu, Sabah, using the integrated SWOT-TOWS-AHP methodology. This approach aims to identify strategic priorities and develop actionable recommendations to support sustainable urban development. To achieve this overarching goal, the research is guided by three specific objectives, each contributing distinct insights to inform the formulation of effective strategies:

I. Identify and evaluate key internal and external factors that influence the infrastructure and urban planning sector in Kota Kinabalu. This includes analyzing the sector's strengths, weaknesses, opportunities, and threats (SWOT) to understand the broader context and challenges facing the city.

II. Develop strategic alternatives using the TOWS matrix, which builds upon the SWOT analysis. The TOWS framework helps generate actionable strategies by matching internal strengths with external opportunities, addressing weaknesses, countering threats, and aligning proposed actions with the city's unique context. These strategies are tailored to tackle pressing urban issues such as infrastructure deficits, environmental degradation, social inequality, and climate change vulnerability (Ragheb et al., 2022).

III. Prioritize the identified factors and strategies using the Analytic Hierarchy Process (AHP). AHP involves a structured process of pairwise comparisons and hierarchical weighting, enabling the evaluation of each factor and strategy's relative importance. This method integrates expert judgments and stakeholder preferences, ensuring that the final priorities reflect the collective goals and values of the community. The resulting rankings provide a transparent and rational basis for strategic decision-making in the urban planning context.

By addressing these objectives, the study seeks to offer a robust, evidence-based foundation for guiding Kota Kinabalu's urban development towards a more sustainable and resilient future.

1.4 Scope and Limitation

The scope of this research is centered on assessing the infrastructure and urban planning landscape of Kota Kinabalu, Sabah, to provide context-specific insights and recommendations. The study focuses on evaluating the current state of infrastructure and urban development, identifying key challenges and opportunities, and formulating strategies to support sustainable and resilient urban growth.

While the research aims to offer meaningful contributions, it is important to recognize certain limitations that may influence the scope and generalizability of its findings. One key limitation is the availability and accessibility of data. Comprehensive, up-to-date information on various aspects of infrastructure and urban planning in Kota Kinabalu may be limited or difficult to obtain. Additionally, there may be restricted access to experts in the field of urban planning and infrastructure development within the local context, which could affect the depth of the analysis. Another constraint is the limited timeframe available for the study. Conducting a more extensive and detailed assessment, such as broader data collection or stakeholder interviews, would require additional time and resources beyond the current research schedule. Despite these limitations, the study strives to provide valuable insights

that can inform future planning and decision-making efforts in Kota Kinabalu's urban development landscape.

2.0 Methodology

2.1 Research Design

This research adopts a mixed-methods approach, integrating quantitative analysis through the Analytic Hierarchy Process (AHP) with qualitative insights derived from secondary data sources. This approach leverages both numerical and non-numerical data to capture diverse perspectives and reinforce the reliability of findings (Ginanjar & Prajanti, 2021).

The quantitative component focuses on prioritizing the factors and strategies identified through the SWOT and TOWS analyses. The AHP method will be applied to derive weights and rankings through pairwise comparisons and expert evaluations (Sulistio et al., 2018). AHP offers a structured way to break down complex decisions into manageable elements, enabling a more transparent and rigorous decision-making process (Lada et al., 2024; Putra et al., 2021).

The qualitative component involves an in-depth review of secondary sources, including industry reports, government documents, and academic literature. This component aims to provide contextual understanding, validate findings, and highlight best practices in sustainable infrastructure and urban planning. The use of secondary data enhances the research by offering background insights, verifying key issues, and informing strategy development (Idris et al., 2015).

By combining these two methodologies, the mixed-methods approach supports triangulation, allowing the comparison and integration of findings from both quantitative and qualitative data. This strengthens the validity and reliability of the research and leads to more robust and actionable recommendations for sustainable urban development in Kota Kinabalu (Ariffin et al., 2015). Such an approach is especially effective in addressing infrastructure planning challenges in suburban areas, where it can help prioritize investments based on identified needs (Ismiyanti et al., 2019).

2.2 Data Collection

This research will utilize secondary data collected from a wide range of credible sources, including government publications, industry reports, academic journals, and online databases. These sources will offer a comprehensive overview of the current state of urban planning and infrastructure development in Kota Kinabalu. The data will encompass key elements of the city's urban environment, such as population demographics, economic indicators, land use patterns, transportation systems, infrastructure capacity, and environmental conditions.

The collected information will be analyzed to identify trends, challenges, and opportunities relevant to infrastructure and urban planning in Kota Kinabalu. This analysis will serve as a foundation for the SWOT and TOWS frameworks, supporting the formulation of well-informed and context-specific strategies. In addition, the research will gather insights into stakeholder perceptions, existing policy frameworks, and best practices in sustainable urban development to guide the development of strategic alternatives.

To ensure accuracy and contextual relevance, official documents, such as local development plans, regulatory frameworks, and policy guidelines, will be reviewed alongside academic studies and reports on urban growth in Malaysia (Samsurijan et al., 2022). This approach will provide a well-rounded understanding of the factors shaping urban development in Kota Kinabalu and help generate practical, evidence-based recommendations.

2.3 SWOT/TOWS Analysis

2.3.1 SWOT Analysis

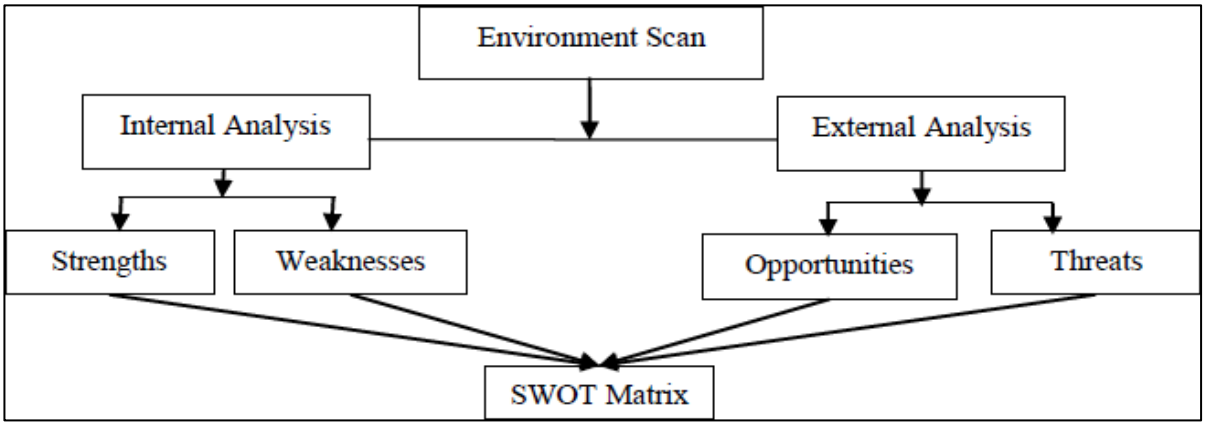


Figure 1: Framework of SWOT

SWOT analysis serves as a strategic tool that helps organizations systematically assess both internal and external elements that impact decision-making (Kenton, 2024). These elements, referred to as strategic factors, play a significant role in shaping the future of an organization or industry. In the SWOT framework, these factors are divided into four categories: Strengths, Weaknesses, Opportunities, and Threats, as shown in Figure 1.

Strengths and weaknesses are internal aspects of a business. They highlight the organization's unique capabilities or shortcomings in comparison to its competitors. Strengths indicate areas where the company excels and maintains a competitive benefit. In contrast, weaknesses identify internal limitations or areas where the business is less effective than others.

In contrast, opportunities and threats come from external sources. Opportunities are favorable external situations that a business can leverage to achieve growth or improve performance. Threats, however, are external factors that may pose risks or hinder the business's success (Peterdy, 2024).

2.4 Analytic Hierarchy Process (AHP)

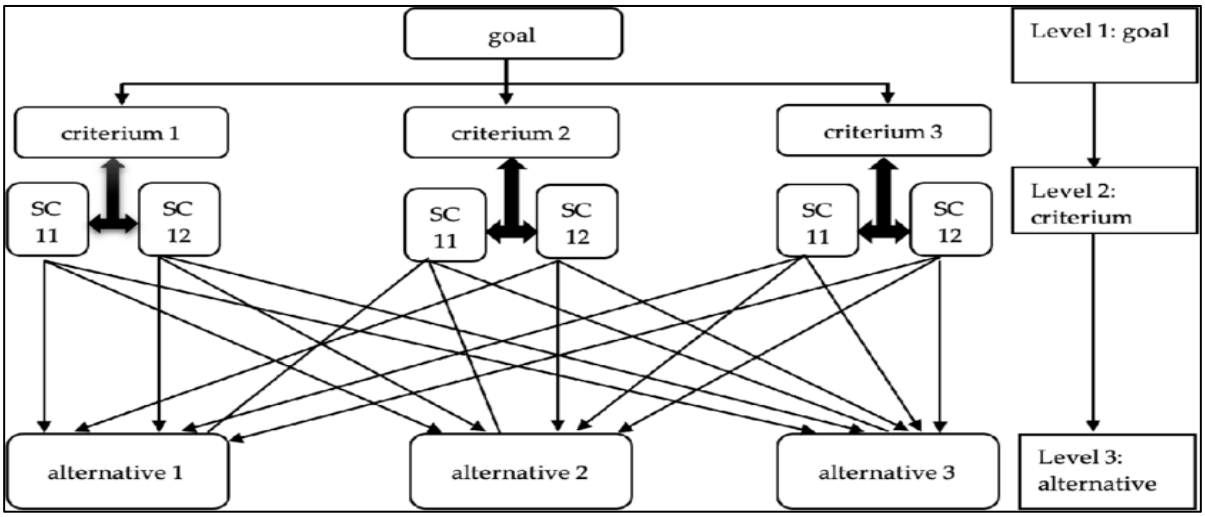


Figure 2: Framework of AHP

The Analytic Hierarchy Process (AHP), developed by Thomas L. Saaty in the 1970s (Taherdoost, 2017), is a widely used multi-criteria decision-making method. It breaks down complex decisions into a hierarchical structure that includes the overall goal, decision criteria, sub-criteria, and available alternatives. AHP is built upon three fundamental principles: (1) structuring the decision model, (2) making comparative evaluations of the elements, and (3) synthesizing the priorities.

AHP has been extensively applied in research and practice to solve various decision-making challenges. The method organizes objectives, criteria, and alternatives into a hierarchy, much like a family tree. Typically, this hierarchy has at least three levels: the primary goal at the top, the criteria in the middle, and the alternatives at the bottom.

In this study, AHP is used to rank elements of a SWOT analysis. Once the problem is broken down and the hierarchy is structured, the prioritization begins by comparing the importance of each criterion. At every level, elements are assessed in pairs relative to their impact, with respect to the criteria at the higher level. AHP uses a standard nine-point scale for pairwise comparisons.

The AHP Process Consists of Four Key Stages:

Stage 1: Define the Problem and Build the Hierarchy
The first step is to clearly define the problem and organize its components into a hierarchical model. The top level of the hierarchy represents the overall goal. The intermediate levels include the sub-goals or criteria influencing the decision, while the bottom level lists the alternative options.

Stage 2: Collect Input Data
At this stage, pairwise comparisons are made to assess the impact of each element on its corresponding criterion in the upper level of the hierarchy. These comparisons are recorded in reciprocal judgment matrices. For instance, if there are seven elements at a certain level and two at the level above, two 7×7 matrices are created. Each matrix requires $\frac{n(n-1)}{2}$ comparisons (e.g., 21 comparisons for 7 elements). The diagonal elements are always 1, and the other values are reciprocals of each other. AHP uses a scale from 1 to 9 to express preferences:

I. 9 = extremely more important
II. 1 = equally important
III. Values between 2–8 express varying degrees of preference.

Stage 3: find the relative weights with the eigenvalue method

The relative priorities of different criteria (sub-criteria) are not easily plausible from the judgement matrix. In this stage, relative weights of a set of objects (criteria, sub-criteria and alternatives) are calculated with the matrix of pair-wise comparison B=bij which is positive and reciprocal (1–9, and 1–1/9).

Thus, the given matrix B such that

$$B = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ b_{n1} & \cdots & \cdots & b_{nm} \end{bmatrix}$$

where $B_{ij} = 1/B_{ji}$ for all I, j = 1, 2, 3..., n

Compute a vector of relative priorities w = (w1, w2... w3). The w is normalized so that it adds up to 1 or 100. If all the judgments are consistent, then

$$b_{ik} * b_{kj} = b_{ij} \text{ for all I, j = 1, 2 ···, n}$$

Then, normalizing any column j of matrix B will generate the wts

$$W_i = \frac{b_{ij}}{\Sigma_{K=1} b_{kj}} \text{ for all I, j = 1, 2K ···, n}$$

Pair-wise judgement is often error-prone, and the condition in the second equation may not be confirmed. Consequently, the result of priorities may depend upon the column chosen for normalization. Such a problem can be solved either by the logarithmic least square (LLS) or eigenvector method developed by Saaty. Latter is a simpler procedure than former and also involves averaging all possible ways of comparing alternatives (Harker & Vargas, 1987). Calculations of the wt. vector as the right eigenvector of the matrix B:

$$Bw = \lambda max$$

Where λ max is the maximum eigenvalue of matrix B. So, the weight vector can be enumerated as

$$Wi = \frac{\sum_{J-1}^{N} bij * wj}{\lambda_{max}}$$

Inconsistencies in judgment can be calculated by eigenvector method. Satty research depicts λ max n for a positive reciprocal matrix. For a perfectly consistent matrix, then λ max = n.

Satty defined a consistency index by the formula

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Also, consistency ratio (CR) is measured as the ratio of CI and random index (RI)

$$CR = CI/RI$$

Therein RI the random index is computed as the mean of the CI of randomly generated matrices of size n. If CR < 0.1, it is acceptable, and if CR > 1, the DM must re-evaluate the decisions to reduce inconsistencies.

Stage 4: Develop a composite priority vector for the bottom-most level of the hierarchy to rate alternative decision strategies.

The final step is to determine the overall priority of each alternative by synthesizing the results from all levels of the hierarchy. This involves combining the weighted priorities from each level down to the alternatives. The alternatives are then ranked based on how well they meet the overall objective, using the aggregated eigenvector values weighted according to the importance of the criteria.

2.5 SWOT-AHP Hybrid Methodology

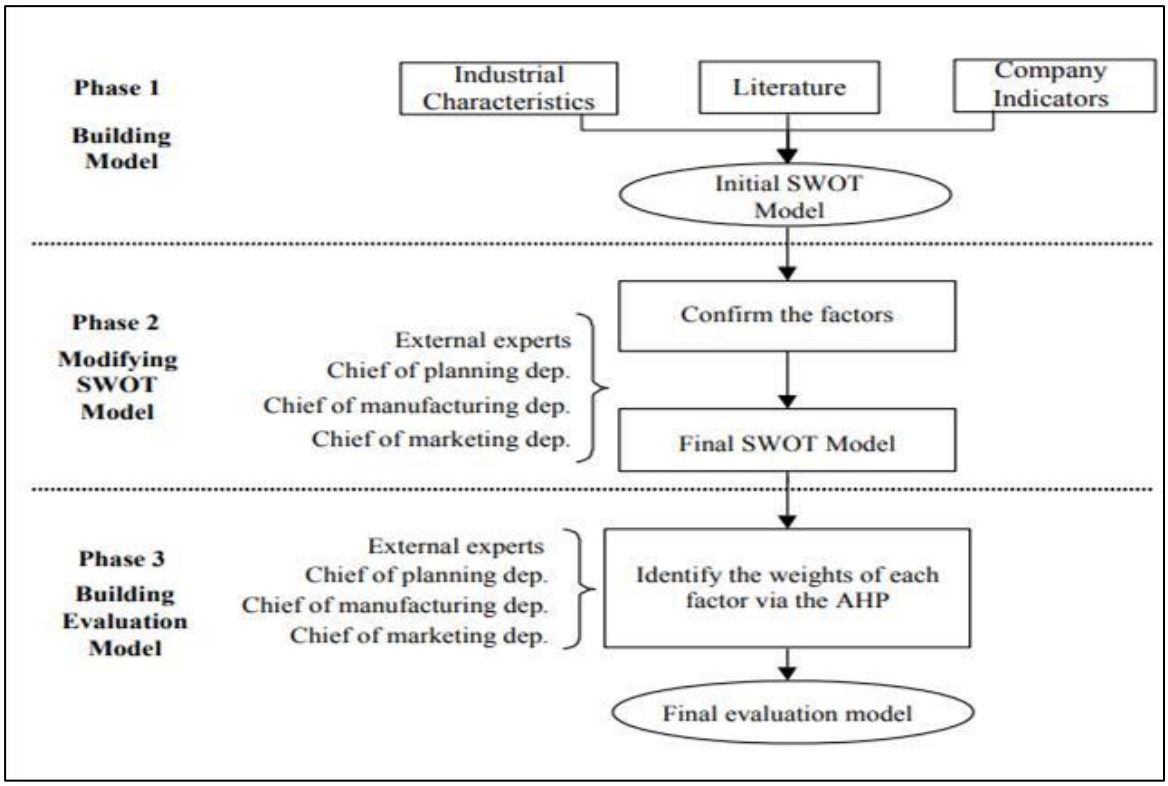


Figure 3: Phases of Proposed Methodology

Figure 3 show a SWOT-AHP based strategic management model. In order to create a SWOT-AHP based strategic management model, three phases model needed which is building initial task, modifying factors, and building an evaluation model. SWOT factors are subjected to pairwise comparisons concerning higher level factors, in order to generate the priority factors using eigenvalue calculations. Although SWOT analysis lacks the quantitative feature needed to generate ranking mechanism for identified factors, the integration of the Analytic Hierarchy Process (AHP) addresses this limitation. The hybrid model of SWOT-AHP systematically qualifies the relative importances of SWOT factors and evaluates their intensity, thereby providing a robust framework for strategic decision-making.

Application of AHP in the SWOT framework is supposed to quantify and evaluate the importance of the SWOT factors systematically. Three major steps are followed in this regard. First and foremost is the identification of the internal and external key factors such as strengths, weaknesses, opportunities and threats. Next is applies the pairwise comparisons to capture the weights of each SWOT group. Finally uses the AHP to derive the relative priorities of each factor within the SWOT groups. The overall weight and ranking of each factor are obtained by multiplying its local weight by the weight of its respective group, resulting in a comprehensive prioritization framework.

Expert opinion on pair-wise ranking of importance of two sub-criteria with reference to the main criteria in tree hierarchy	
If option A and option are equally important	1
If option A is moderately more important than option B	3
If option A is strongly more important than option B	5
If option A is very strongly more important than option B	7
If option A is extremely more important than option B	9
If option A and option B are equally important	1

Table 1: Pairwise Comparison Scale

Table 1 provides a clear representation of the AHP scale which often used for pairwise comparisons in decision-making. In decision-making frameworks such as AHP, a pairwise comparison scale is needed to quantify the relative importance of two criteria or sub-criteria with respect to a higher-level goal or main criterion. After identifying all the key factors for each SWOT category, they are subjected to pairwise comparisons to evaluate their relative importance within each group. For instance, comparing one strength to another strength. Furthermore, higher-level comparisons are conducted to determine the weight of each SWOT category relative to others. For example, the importance of strengths versus threats. Eigenvalue calculations are used to generates quantitative weights for all the SWOT factors and ranking them based on their strategic significance. The pairwise comparison scale is based on a set of values ranging from 1 to 9. This scale ensures consistency and allows decision-makers to mathematically evaluate subjective judgements which are then processed to calculate weights for the key factors of SWOT categories. Furthermore, these weights provide a quantitative foundation for prioritization in strategic analysis.

3.0 Results and Discussion

3.1 SWOT Analysis

Strengths (S)	**Weaknesses (W)**
S1. Strategic location (Besar et al., 2020). S2. Modern infrastructure projects (BIMP EAGA, 2025). S3. Growing tourism sector (Ladin et al., 2020). S4. Natural attractions (BIMP-EAGA, 2025).	W1. Traffic congestion (Besar et al., 2020). W2. Urban sprawl (Besar et al., 2020). W3. Inadequate drainage (Norhisyam et al., 2019). W4. Lack of affordable housing (Henry, 2012)
Opportunities (O)	**Threats (T)**
O1. Smart city initiatives (BIMP EAGA, 2025). O2. Public-private partnerships (PPPs) (BERNAMA, 2024). O3. Eco-tourism & sustainable urbanism (Ladin et al., 2020). O4.Digital infrastructure expansion (Teo, 2025). O5.Climate-resilient urban design (V Jainih & N S H Harith, 2020).	T1. Natural disasters (V Jainih & N S H Harith, 2020). T2. Overdependence on tourism (Chan et al., 2022). T3. Environmental degradation (Ang et al., 2025). T4. Budget constraints (BERNAMA, 2024). T5. Population growth (Besar et al., 2020).

Table 2: SWOT Analysis

A SWOT analysis provides a structured framework for evaluating the strategic position of Kota Kinabalu in relation to its infrastructure and urban planning (M., 2015). This approach examines internal factors—strengths and weaknesses—as well as external influences—opportunities and threats—that shape the city's developmental trajectory (Rebuya & Gasga, 2022).

One of Kota Kinabalu's key strengths lies in its strategic location, which enhances regional trade and connectivity (Besar et al., 2020). The city's ongoing modern infrastructure projects further support economic growth and aim to improve the quality of life for its residents (BIMP-EAGA, 2025). Additionally, the growing tourism sector contributes significantly to local revenue by attracting both domestic and international visitors (Ladin et al., 2020). The presence of educational institutions and government agencies strengthens administrative capacity and fosters innovation. Moreover, Kota Kinabalu's natural attractions, including its coastal landscapes and rich biodiversity, make it a highly appealing location for both residents and tourists (BIMP-EAGA, 2025).

Despite these strengths, Kota Kinabalu faces several weaknesses that hinder its sustainable development. Traffic congestion is a persistent problem, negatively impacting urban mobility and contributing to air pollution (Besar et al., 2020). Urban sprawl, driven by unregulated, low-density expansion, places excessive pressure on existing infrastructure and harms the environment (Besar et al., 2020). Inadequate drainage systems exacerbate flooding during periods of heavy rainfall, disrupting daily activities and damaging property (Norhisyam et al., 2019). Furthermore, a shortage of affordable housing limits access to adequate living conditions for lower-income populations, widening socio-economic disparities (Henry, 2012).

On the other hand, Kota Kinabalu can seize several opportunities to improve its infrastructure and urban planning. The advancement of smart city initiatives holds promise for enhancing urban services through digital technology (BIMP EAGA, 2025). Public-private partnerships (PPPs) offer a mechanism to harness private investment and expertise for infrastructure development (BERNAMA, 2024). Emphasizing eco-tourism and sustainable urbanism can attract environmentally conscious visitors and encourage responsible development practices (Ladin et al., 2020). The expansion of digital infrastructure will also improve internet access, connectivity, and overall economic activity (Teo, 2025). Additionally, adopting climate-resilient urban design can help mitigate the impacts of extreme weather and climate-related hazards, enhancing the city's long-term sustainability.

Nevertheless, Kota Kinabalu must contend with several threats that could undermine its progress. Natural disasters, such as floods and earthquakes, pose ongoing risks to both infrastructure and public safety and must be considered in urban planning efforts (V Jainih & N S H Harith, 2020). The city’s over-reliance on tourism makes it vulnerable to external economic shocks and global disruptions (Chan et al., 2022). Environmental degradation, including deforestation and pollution, threatens the health of ecosystems and residents alike (Ang et al., 2025). In addition, budgetary limitations can restrict the scale and speed of infrastructure development (BERNAMA, 2024). Rapid population growth is placing increasing strain on public services and urban facilities, calling for strategic investment in transportation and housing systems (Besar et al., 2020).

3.2 TOWS Analysis

	Strengths (S)	**Weaknesses (W)**
Opportunities (O)	**S-O Strategies** **[SO1]** Promote eco-tourism zones integrated with sustainable urban infrastructure (Varanasi et al., 2024). (S3, O3) **[SO2]** Implement smart city technology (AI, IoT) for traffic and flood management systems (Kushwaha, 2024). (S2, S4, O1, O5)	**W-O Strategies** **[WO1]** Launch affordable housing & public transport projects via federal and state collaboration (Enekwachi-Akpa, 2024). (W1, W3, W4, O2) **[WO2]** Use GIS and smart planning tools to manage urban sprawl and improve drainage infrastructure (Martin et al., 2020). (W2, W3, O1)

	S-T Strategies	W-T Strategies
Threats (T)	**[ST1]** Develop climate-resilient coastal infrastructure (Yahia et al., 2024). (S2, S4, T1, T3) **[ST2]** Diversify economy by enhancing digital infrastructure and reducing reliance on tourism (Rhena & Kraugusteeliana, 2024). (S1, S2, T2, T4)	**[WT1]** Secure international grants for climate adaptation in infrastructure (Füssel et al., 2012). (W3, T1, T4) **[WT2]** Reform zoning laws and improve planning institutions to mitigate risks from overdevelopment and natural hazards (Garrido & Saunders, 2019). (W2, T5, T3)

Table 3: TOWS Analysis

The TOWS Matrix builds upon the traditional SWOT analysis by systematically aligning a city's internal factors—its strengths and weaknesses—with external influences, such as opportunities and threats. This framework helps generate targeted strategies that not only capitalize on a city's existing advantages but also address its vulnerabilities and prepare for external risks. It is particularly useful for urban development planning, where strategic direction is essential to sustainability and resilience (Syamsuri, Latif, & Osman, 2019).

S-O strategies aim to leverage internal strengths to capitalize on external opportunities. For Kota Kinabalu, this could involve promoting eco-tourism zones supported by sustainable urban infrastructure, such as green-certified buildings and walkable urban areas (Varanasi et al., 2024). These initiatives enhance environmental preservation while attracting environmentally conscious tourists. The city can also implement smart city technologies—including artificial intelligence (AI) and the Internet of Things (IoT)—to manage traffic flow and mitigate flood risks, thereby improving urban efficiency and quality of life (Kushwaha, 2024).

W-O strategies address internal weaknesses by taking advantage of external opportunities. For instance, issues like traffic congestion and inadequate housing can be alleviated through public-private partnerships that fund affordable housing projects and upgraded public transportation systems (Enekwachi-Akpa, 2024). Additionally, the adoption of geographic information systems (GIS) and data-driven planning tools can help control urban sprawl and improve drainage infrastructure, leading to more equitable and efficient urban development (Martin et al., 2020).

S-T strategies use existing strengths to mitigate the impact of external threats. Kota Kinabalu's strategic location and economic diversity can be harnessed to build climate-resilient infrastructure, such as coastal flood defenses and elevated transport corridors, reducing vulnerability to natural disasters (Yahia et al., 2024). Expanding the city's digital infrastructure and encouraging innovation in the tech sector also helps diversify the economy, reducing dependency on the tourism industry, which is susceptible to global economic shifts (Rhena & Kraugusteeliana, 2024).

W-T strategies are the most defensive, aiming to reduce both internal weaknesses and external threats. Kota Kinabalu could pursue international funding, such as grants from UN-Habitat or ASEAN initiatives, to overcome local budget limitations for critical infrastructure projects (Füssel et al., 2012). At the same time, reforming zoning policies and improving institutional planning are necessary to control unplanned development, prevent environmental degradation, and ensure long-term urban resilience (Garrido & Saunders, 2019).

3.3 AHP Implementation

3.3.1 AHP Pairwise Comparison Matrix

	1 (SO1)	2 (SO2)	3 (WO1)	4 (WO2)	5 (ST1)	6 (ST2)	7 (WT1)	8 (WT2)
1 (SO1)	1.00	3.00	5.00	7.00	3.00	5.00	6.00	7.00
2 (SO2)	0.33	1.00	2.00	4.00	2.00	3.00	4.00	5.00
3 (WO1)	0.20	0.50	1.00	2.00	1.00	2.00	3.00	4.00
4 (WO2)	0.14	0.25	0.50	1.00	1.00	2.00	2.00	3.00
5 (ST1)	0.33	0.50	1.00	1.00	1.00	2.00	3.00	4.00
6 (ST2)	0.20	0.33	0.50	0.50	0.50	1.00	2.00	3.00
7 (WT1)	0.17	0.25	0.33	0.50	0.33	0.50	1.00	1.00
8 (WT2)	0.14	0.20	0.25	0.33	0.25	0.33	1.00	1.00

Table 4: AHP Pairwise Comparison Matrix

Principal eigen value = 8.282
Eigenvector solution: 4 iterations, delta = 8.6E-8 Number of
Comparisons = 28
Consistency Ratio (CR) = 2.9%

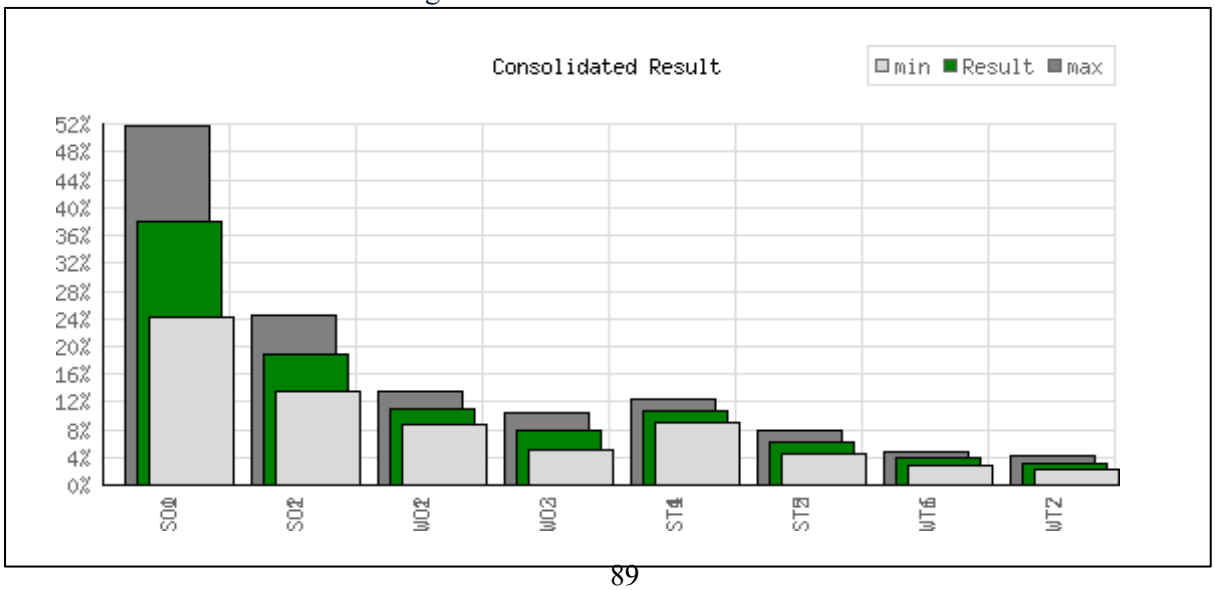
To prioritize the strategic options derived from the TOWS analysis, the Analytic Hierarchy Process (AHP) was applied using a pairwise comparison matrix. This method allows for the systematic comparison of each strategy based on its relative importance toward achieving sustainable urban development in Kota Kinabalu. The AHP Priority Calculator was used to facilitate this process, generating the necessary comparisons and priorities efficiently.

A total of 28 pairwise comparisons were made among eight strategies—two from each quadrant of the TOWS matrix (SO, WO, ST, WT). These comparisons reflect stakeholders' judgments on the relative priority of each strategy based on Saaty's (1980) scale of relative importance.

To assess the consistency of these judgments, a Consistency Ratio (CR) was calculated. The resulting CR of 2.9% indicates a high level of consistency, as it falls well below the acceptable threshold of 10% recommended by Saaty (1980). This demonstrates that the pairwise evaluations are coherent and reliable for decision-making. The use of AHP, supported by a strong consistency ratio, reinforces the objectivity and robustness of the strategic prioritization process. This structured approach ensures that planning decisions are based on clear, well-justified stakeholder input.

3.4 Prioritized TOWS Factors (AHP Result)

Figure 3: AHP Consolidated Result



Cat	Strategy Code	Priority (%)	Rank	(+)	(-)
1	SO1	38.0%	1	13.8%	13.8%
2	SO2	19.0%	2	5.4%	5.4%
3	WO1	11.1%	3	2.3%	2.3%
4	WO2	7.8%	5	2.7%	2.7%
5	ST1	10.7%	4	1.7%	1.7%
6	ST2	6.3%	6	1.7%	1.7%
7	WT1	3.9%	7	1.0%	1.0%
8	WT2	3.2%	8	1.0%	1.0%

Table 5: AHP Prioritized Table

SO1 – Promote eco-tourism zones integrated with sustainable urban infrastructure ranks as the highest priority with a weight of 38.0%**.** This indicates that Kota Kinabalu's greatest potential lies in leveraging its natural strengths, such as its scenic coastal and forest areas, while aligning with sustainability goals. Focusing on eco-tourism not only preserves the environment but also stimulates economic growth and job creation, making it a highly strategic move for urban planning.

SO2 – Implement smart city technologies (AI, IoT) for urban systems holds the second highest priority at 19.0%. This reflects the importance of digital transformation in addressing urban challenges like traffic congestion, energy efficiency, and public safety. As Kota Kinabalu grows, incorporating technology into its infrastructure will be critical to improving service delivery and city management.

WO1 – Launch affordable housing and public transport initiatives is the third-ranked strategy, with a weight of 11.1%. This suggests that addressing basic urban weaknesses,

such as housing shortages and inadequate transport connectivity, remains an important objective. Improving affordability and access will enhance social equity and urban livability.

ST1 – Develop climate-resilient infrastructure (e.g., coastal defences) ranks fourth at 10.7%. Given Kota Kinabalu's coastal location and vulnerability to climate change, this strategy emphasises the need to mitigate future environmental risks. Coastal defences and resilient infrastructure will help protect the city against sea level rise and extreme weather events.

WO2 – Use GIS and smart tools to manage urban sprawl and drainage systems is the fifth priority at 7.8%. While still important, this strategy serves more as a supporting action. It highlights the growing role of data and mapping tools in tackling urban sprawl, flood risks, and poor drainage—challenges that affect city functionality and health.

ST2 – Diversifying the economy via digital infrastructure follows next with 6.3%. While diversifying the economy is vital, this strategy appears to be a longer-term vision rather than an immediate action. Digital infrastructure is a key enabler of innovation and resilience, but it requires foundational systems and policy support first.

WT1 – Secure international funding for climate adaptation holds a low priority at 3.9%. Though securing funding can unlock large-scale projects, it's viewed as uncertain or less controllable compared to internally driven initiatives. Thus, it ranks lower as a standalone strategic focus.

WT2 – Reform zoning laws and improve institutional capacity is the lowest-ranked strategy with 3.2%. Institutional reforms, while necessary, tend to be complex and slow to implement. This result suggests that immediate urban planning efforts should be directed toward more actionable and impactful areas, while reforms can proceed in parallel over the long term.

3.5 Strategic Implications

The results of this research offer valuable strategic insights for both policymakers and businesses in Kota Kinabalu. By prioritizing the top-ranked strategies using the integrated SWOT-TOWS-AHP framework, decision-makers can more effectively address urban challenges and guide the city towards sustainable development.

The highest-priority strategy—promoting nature-based solutions to drive economic growth—highlights the importance of eco-tourism and sustainable infrastructure development. Policymakers are encouraged to establish eco-tourism zones and incentivize environmentally friendly business practices. This approach not only preserves the environment but also supports job creation and economic diversification. Businesses in tourism, hospitality, and construction can align their investments with these objectives by adopting green building standards and low-impact development strategies.

The second priority emphasizes the need to accelerate smart city initiatives. Policymakers should invest in technologies such as artificial intelligence (AI), the Internet of Things (IoT), and big data to improve traffic flow, utility management, and public safety. This presents strong collaboration opportunities for technology firms and infrastructure companies to lead pilot projects and develop digital solutions tailored to the city's needs.

Improving social equity through affordable housing and better public transportation ranks as the third priority. Addressing these gaps can reduce urban inequality and enhance quality of life, especially for low- and middle-income populations. Governments should support inclusive housing schemes and reliable transit systems, while developers and transport operators can respond by providing more accessible and affordable services. There is also potential for innovative approaches such as transit-oriented development and mixed-income housing projects.

Climate-resilient infrastructure is also a critical focus area, particularly given Kota Kinabalu's coastal location and vulnerability to environmental hazards. Policymakers must integrate climate risk assessments into infrastructure planning, while engineering and construction firms should innovate in the design and implementation of flood mitigation systems, coastal protection, and resilient road networks.

Another key strategy involves leveraging Geographic Information Systems (GIS) and smart planning tools to manage urban sprawl and improve drainage systems. Although not ranked at the top, this approach supports long-term resilience and efficiency in land use planning. Municipal agencies should adopt data-driven zoning processes, and tech companies can offer customized solutions to aid local decision-making.

The diversification of the digital economy, while lower in priority, still holds strategic value. Building digital infrastructure, increasing broadband access, and enhancing digital literacy can help future-proof Kota Kinabalu's economy. Policymakers should lay the groundwork for this transformation, while businesses in the digital and creative sectors can prepare to expand into these emerging areas.

Although securing international climate funding was ranked lower, it remains an important opportunity. Policymakers should actively pursue such funding by strengthening local institutions and building compelling proposals. However, reliance on external support should be balanced with internal capacity-building and self-sufficiency.

Finally, institutional reform and zoning law modernization, though ranked lowest, are essential to support all other strategies. These reforms should proceed incrementally, starting with improved transparency, streamlined processes, and staff training. Over time, such changes will enhance the overall effectiveness and accountability of urban planning systems.

In summary, the findings from this research offer a clear and actionable roadmap for sustainable urban development in Kota Kinabalu. Policymakers can use these strategic priorities to guide resource allocation and policy formulation, while businesses can align their operations and innovations with the city's evolving infrastructure and environmental goals. Together, these efforts will contribute to a more resilient, inclusive, and livable city.

4.0 Conclusion and Recommendation

4.1 Summary and Findings

This study evaluated the current state of infrastructure and urban planning in Kota Kinabalu using a combined SWOT-TOWS-AHP framework. The approach provided a structured way to assess internal and external factors, generate strategic alternatives, and prioritize actions based on expert input.

The analysis found that Kota Kinabalu has several strengths, including its strategic coastal location and potential in eco-tourism. However, the city also faces significant challenges such as limited infrastructure capacity, environmental degradation, rapid urbanization, and growing social inequality. Opportunities were identified in the form of smart city development, green economy initiatives, and digital innovation, while key threats included climate risks, institutional limitations, and weak policy enforcement.

Using the TOWS matrix, a variety of strategies were proposed to address these issues. The AHP method was then applied to prioritize these strategies based on expert feedback. The top-ranked strategies included:

I. Promoting nature-based economic development,

II. Implementing smart city infrastructure,

III. Improving social equity through better housing and transport, and

IV. Strengthening climate-resilient infrastructure systems.

These strategies provide a practical guide for urban planners and decision-makers to improve Kota Kinabalu's sustainability and resilience.

4.2 Recommendations

In the short term, it is recommended that Kota Kinabalu prioritizes the promotion of eco-tourism and green infrastructure. Pilot projects in eco-tourism zones can be initiated, alongside incentives for green building development, to encourage environmentally responsible investment and showcase the city’s commitment to sustainability. Additionally, launching smart city pilot initiatives, such as intelligent traffic monitoring systems and smart utility management, can enhance urban efficiency and foster greater public trust in technology-driven governance.

Improving public transport accessibility should also be a key focus. This includes expanding bus routes, enhancing pedestrian access, and making transportation more affordable, particularly for underserved communities. Such efforts will not only reduce traffic congestion but also contribute to greater social equity. To ensure that development strategies are well-aligned with the needs of various stakeholders, structured engagement sessions should be held. These workshops can bring together community members, government agencies, and the private sector to co-create and refine planning priorities.

In the long term, the city should invest heavily in climate-resilient infrastructure. This involves integrating flood mitigation systems, sustainable urban drainage, and coastal

protection into all new planning initiatives to address the increasing risks posed by climate change. Comprehensive zoning reform is also necessary. Modernizing zoning regulations, supported by GIS-based tools, will enable better land use management and help contain urban sprawl.

Another long-term priority is the development of a digital economy roadmap. Expanding internet access, promoting digital literacy, and supporting tech-based entrepreneurship will diversify Kota Kinabalu's economic base and prepare the city for the future. Lastly, building institutional capacity is essential. This includes training local planning personnel, updating governance frameworks, and introducing performance-based accountability to improve policy execution and overall planning effectiveness.

4.3 Future Research

While this study provides important insights into infrastructure and urban planning in Kota Kinabalu, it also has several limitations. The reliance on secondary data and a limited number of expert inputs may reduce the depth and generalizability of the findings. Additionally, due to time constraints, the research did not include primary data collection or direct engagement with local stakeholders through interviews or surveys.

Future research should therefore aim to address these limitations by incorporating primary data collection methods such as structured interviews or surveys with residents, planners, and policymakers. This would offer more grounded and context-specific insights into public perceptions and planning priorities. Comparative studies involving other Malaysian or regional cities could also provide a valuable benchmark, allowing Kota Kinabalu's strategies to be evaluated in a broader context.

Moreover, future studies could benefit from the use of dynamic simulation tools, such as Geographic Information Systems (GIS) and urban modelling software, to forecast the long-term impacts of various development strategies. These tools would offer planners a more data-driven basis for evaluating potential outcomes and trade-offs. Lastly, further research should delve into the challenges of implementing policies, particularly those related to financing, governance structures, and political will. Understanding these real-world constraints can help translate planning strategies into more practical, actionable solutions.

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