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Planning integration of AI and Analytics in Tourism-related Urban Regeneration within Smart Cities: A Smart Initiative of Johor Bahru

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Abstract:

The paper explores the application of artificial intelligence (AI) and data analytics in tourism-related urban regeneration (TrUR) within smart cities, focusing on Johor Bahru, Malaysia. It discusses how AI and analytics can help mitigate issues like urban sprawl, resource management, and infrastructure pressure. Using a quantitative approach combined with a Multi-Criteria Decision-Making (MCDM) model, the study assesses the perspectives of 218 stakeholders on AI's role in enhancing urban regeneration efficiency. The findings indicate a strong correlation between AI adoption and optimized resource management, but ethical concerns, including data privacy and algorithmic bias, remain critical, but also emphasize critical ethical concerns, such as data privacy and algorithmic bias. The proposed MCDM model serves as a framework for decision-makers to integrate AI and analytics into urban regeneration strategies, leading to better outcomes. The study adds to the discourse by addressing the technological, ethical, and socio-economic challenges of AI in urban regeneration, stressing the importance of ethical measures to ensure inclusive and sustainable growth.

Keywords: AI, Analytics, Smart City, Tourism-related Urban Regeneration, Ethical Concerns, Consumer behaviour

1. Introduction

The advent of smart cities represents a transformative movement in urban development that integrates with advanced technologies to enhance the quality of life through the optimization of resource management and foster sustainable economic growth. In most of the developing nations, the role of

artificial intelligence (AI) and analytics has evolved with a central idea that synchronises as critical tools in crafting unique and innovative business models

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for sustainable urban regeneration (Rieder, Schmuck, & Tugui, 2022). Whereas, cities worldwide have encountered with a series of challenges such as rapid urbanization, uncontrolled urban sprawl, environmental deterioration, stressed infrastructures, and decisive automation, which leads AI and data analytics as unrivalled opportunities which are used to superscribe these issues more effectively and efficiently (Cugurullo et al., 2024; Kitchin, 2014; Zanella et al., 2014). Hence, AI and analytics in urban modulation play a crucial role in urban and regional planning towards the revitalisation of an urban ecosystem that enables the assessment of planning regulations, planning in decision support, and urban data analytics (Panori, Kakderi, & Komninos, 2023).

Urban regeneration is the process which involves in renewing and revitalizing urban spaces to significant improvement of economic, social, and environmental conditions. F. Rahman and Halim (2021) illustrated urban regeneration as the process of planning and development of an urban pocket on the principle of 'past' at 'present' for the 'future' generation. Therefore, on integration of this process with the era of automation and intelligence, it is becoming increasingly dependent on metadata-driven decision-making that signifies AI and analytics in providing deep insights into the dynamics of urbanism (Batty, 2013). Such proficiency is helpful in instrumenting in the formulation of efficiency models that tackle present-day urban problems while also preparing for the potential future scenarios and prospects for urban tourism development (Kitchin, 2014; Rodriguez & Mercedes, 2024).

The incorporation of AI and analytics in urban regeneration has been curated with various applications, such as refining through optimized public transit networks and boosting building energy conservation (Lai, 2022). Studies discussed numerous examples, such as AI-powered pre-emptive infrastructure upkeep maintenance can significantly lower the operational cost of city infrastructure, while data analytics can help in enhancing the distribution of urban assets in real-time, making sure that services like sanitation, waste management and public safety are more responsive and efficient (Lai, 2022; McLoughlin, Maccani, Puvvala, & Donnellan, 2021; Rodriguez & Mercedes, 2024). By harnessing smart platforms through AI and analytics that solicit and scrutinize community feedback, there is an opportunity to engender a planning process for sustainable urban regeneration that is not only more inclusive of public participation but also fosters greater transparency in the development discourse and thus, efficiency modelling (Banihashemi & Sohi, 2022). Ultimately, this dynamic, data-driven, and citizen-centric approach to urban regeneration could yield a more equitable and sustainable urban future and tourism.

However, the integration of AI and analytics into the process of tourism-related urban regeneration (TrUR) comes with a complex array of challenges that must be thoughtfully navigated. To ensure equitable and sustainable outcomes in planning in tourism development and urban modelling, issues such as data privacy, disparities in technological access, commonly known as the digital divide, and the ethical implications of AI decisions require vigilant oversight in such smart cities (Cugurullo et al., 2024). Moreover, the efficient effectiveness of these advancements in technologies is intrinsically linked to the establishment of a stable and strong governance structure, the fostering of interdisciplinary collaboration, and the dynamic adaptation of business models which are used to signify the evolution of the urban environment (Allam & Newman, 2018; Cavalheiro, Joia, & Cavalheiro, 2020).

Therefore, this study aims to undertake a comprehensive examination of the multifaceted integration of AI and analytics in developing an efficiency model for urban regeneration to promote tourism within the context of smart cities. An examination of case studies related to Johor Bahru's art, architecture, and tourism with a critical analysis of the technological advancements driving this integration that exemplify the successful implementations, and a discussion of the broader socio-economic implications, this study further aims to contribute to the burgeoning body of knowledge on smart urban development towards tourism promotion. Thereby, on providing a nuanced exploration of such intersection of AI, analytics, and urban regeneration, this paper seeks to offer practical insight and recommendations for policymakers, tourism planners, urban planners, and business leaders committed to shaping the cities of the future.

2. Literature Review

Urban regeneration with respect to smart cities, AI, and business analytics that enhance tourism across the nations has been considerably focusing the scholarly attention in recent years. Research on urban regeneration towards tourism business development emphasizes the prospects of rejuvenation and revitalization of urban spaces that address the social, economic, and environmental challenges (Coletti & Rabbiosi, 2021). Studies stated that, the process of urban regeneration traditionally has been project-based site-oriented, often focusing on physical redevelopment in the name of regeneration, however, in many developing countries with smart development studies highlight the increasing adoption of technologies towards effective urban regeneration (Gomes, Lopes, & Ferreira, 2024; Putra, Putra, & Kurniawan, 2018; Roberts, Sykes, & Granger, 2017).

The concept of smart cities, discussed by Harrison and Donnelly (2011), stated that it integrates information and communication technology with the regeneration process to manage and promote urban resources efficiently. Advancements in technologies and adoption in data-driven development initiatives that promote tourism is associated with the efficiency of the smart city mission (Alahi et al., 2023). By harnessing the power of ICT, urban resources can be managed with unprecedented precision, leading to a significant enhancement of urban living (Sun, Song, Jara, & Bie, 2016). From intelligent planning systems to optimized energy grids, and from cutting-edge healthcare solution to innovative public services, the scope of smart city initiatives is vast and multifaceted (Calza et al., 2022; Yousefimehr, 2019). Furthermore, as Zanella et al. (2014) insightfully demonstrate, the Internet of Things (IoT) has the potential to weave together disparate urban elements, fostering a network of interconnected urban environments that elevate service delivery and citizen engagement to new heights.

As the urban landscape continues to evolve, artificial intelligence (AI) and analytics have emerged as potent catalyst for transformative change within the smart city paradigm (Panori et al., 2023). Batty (2013) discussed on the pivotal role of big data in informing city planning, revealing how AI-driven insights can unlock the full potential of urban management, paving the way for more sustainable, resilient, and adaptive cities. Bibri, Alexandre, Sharifi, and Krogstie (2023) delves deeper into the profound impact of real-time data analytics on urban governance, underscoring the critical importance of continuous data flows in illuminating the decision-making process and fostering a more responsive, agile, and citizen-centric approach to urban leadership.

Since urban regeneration initiatives strive to rejuvenate and transform urban landscapes that promote tourism, business analytics plays a pivotal role in harnessing the power of data to inform and optimize business models and planning strategies (Chung, Lee, Ham, & Koo, 2021). The confluence of technological innovation and urban dynamics has given rise to a new era of smart, connected products, as eloquently demonstrated by Rivadeneira et al. (2023). By leveraging the transformative potential of AI, traditional development models can be reimagined to become more adaptive, responsive, and attuned to the nuances of urban environments (Samara, Magnisalis, & Peristeras, 2020). Moreover, Alahi et al. (2023) discussed on the imperative of creating energy-efficient and low-carbon urban districts, where data-driven approaches can help unlock sustainable and resilient urban future towards tourism promotion.

Moreover, when talked about socio-economic implications of AI and analytics in tourism-related urban regeneration, it remain obstinately underexamined (Peponi, 2023). While, Allam and Newman (2018) discussed the concept of cultural and governance systems for a smart city mission, an in-depth study is needed to unleased the constructs of AI-driven efficiency models that can effectively use to mitigate the issues of such social inequality and promote inclusivity. Unfortunately, the current studies are rather silent on the transformative possibilities of AI and analytics in narrowing the digital divide and in providing the last first mile to the remaining inhabitants of such urban regeneration, thereby exacerbating the existing social schisms.

Furthermore, in account of consideration of the ethical issues and regulatory structures surrounding AI in urban functionaries as these areas remain underexplored in the literature, the use of AI in urban functional model triggers a series of crucial questions concerning data privacy, user's security, surveillance, and algorithmic injustice, which has

been ignored at some extent in current literature. While Raharja et al. (2024) has shaded lights on the technical aspects of cloud-based big data analytics, their work have failed to provide a detailed analysis of the governance mechanisms that are required to address the issues and concerns of such technological advancements.

In conclusion, the review of literature (refer Fig 1) has provided an understanding of significant contribution around urban regeneration, tourism, smart cities, AI, and business analytics. However, it also reveals the essential gap that need to be addressed, and thus, met to promote the application of AI and analytical approaches for the creation of efficiency model for the revitalization of urban areas. Future studies should therefore target to work towards the efficient and more systematic implementation of these technologies, and also focuses on the socio-economic impacts, ethical queries, and governance challenges associated with smart tourism, and thus providing empirical evidence for the successful implication of these advancement in technologies for sustainable urban regeneration. Hence, planners and scholars can harness the effective application of AI and analytics to foster favourable, inclusive, and resilient urban development

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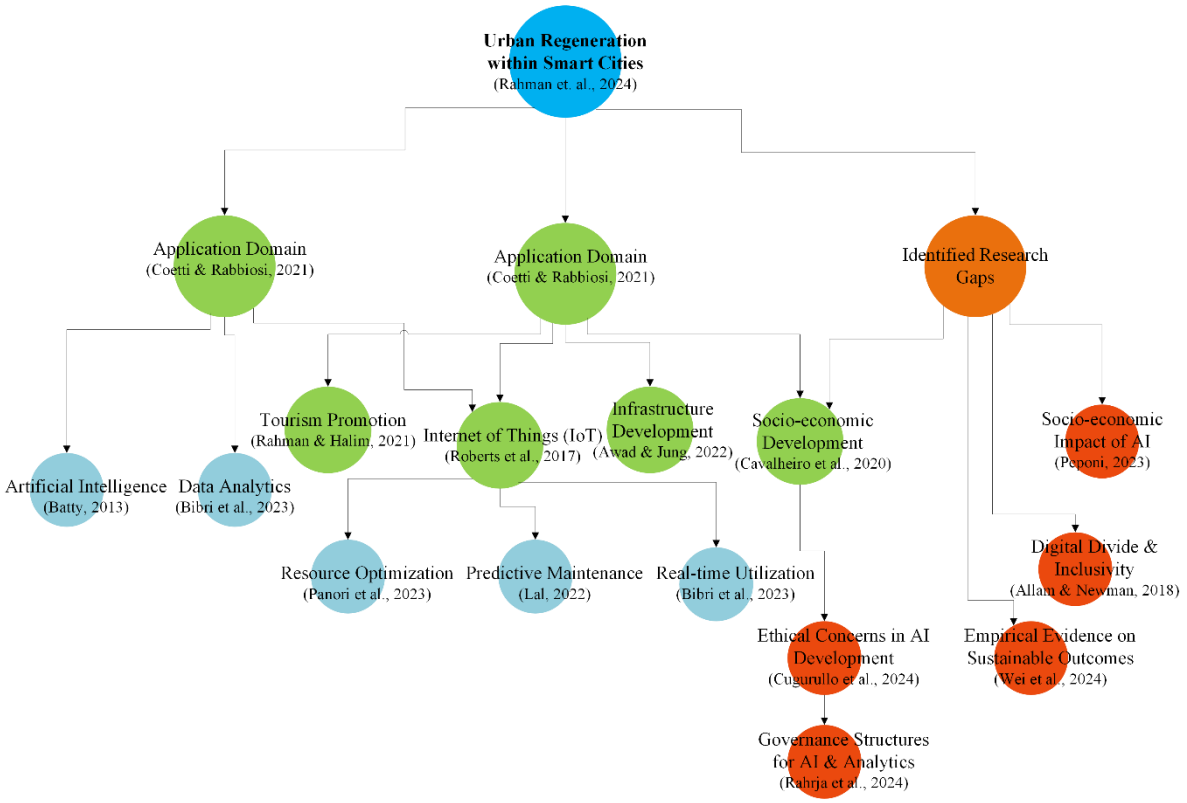

Figure 1: The relationship indicates the gap of current research related to the urban regeneration within the perspective of smart cities

3. Methodology

This research designed to employ a quantitative methodology integrating with case-study approach that provide a comprehensive understanding of the role of AI and analytics and used to develop an efficient model for urban regeneration related to tourism within smart city initiatives. The implication of quantitative methodology allows to collect and analyse data in a systematic way which helps identifying trends, patterns, and relationships within sub-constructs of the research (Goertzen, 2017). The study is a pre-structured deductive quantitative survey that is based on the analysis of variables. The survey is carried on 218 respondents effectively at Johor Bahru, Malaysia (see Table 1). Questionnaire are based on 5-point Likert's Scale, and questions are pilot tested. Means, modes, and values deviations are descriptive in nature and results are tested to determine whether there is any significant difference between item mean score,

and perception of respondents. To validate the results, triangulation of survey findings was performed through a pre-structured interviews with experts and business stakeholders of the region.

Table 1: Survey brief

Research Design Element	**Description**
Type	Quantitative Methodology
Approach	Explanatory (use to explain the role and efficiency of AI and analytics in urban regeneration), descriptive in nature
Strategy	Case-study (stakeholder perceptions examination of Johor Bahru City)
Target Sample	All stakeholder (having belongings to Johor Bahru Heritage City), aged 18 and above
Location	Johor Bahru, Johor, Malaysia
Sample Size	218 valid responses
Sampling error	±3.50% (consideration)
Significance Level	95%
Survey time	Mar-May 2024
Case Study	
Survey Element	**Description**
Type	Pre-structured deductive quantitative survey (On-site and online)
Respondents	207 (valid participation)
Purpose	To gather survey information on stakeholder's perception and expectation of AI and analytics integration in urban regeneration
Questions	Questionnaire based on 5-point Likert's scale and questions are open-ended related to implementation of AI and analytics in urban regeneration towards tourism promotion

To provide a detailed and contextualized examination, this survey has been performed which is based on the specific information gathered on perceptions of stakeholders and their expectation on implementation of AI and big-data analytics in urban regeneration projects at Johor Bahru heritage city. The case studies have been selected based on the scale of the project, implementation techniques and the diversity of AI and data analytics, and the documented outcomes. For the data collection, multiple sources of evidence have been performed which are categorised as project reports, inferential data observations, responses of stakeholders, opinion of experts and planners, and secondary data from industrial and academic publications. Therefore, three case studies have been selected based on the following individual criterion:

1. Johor Bahru Smart City Initiative: This project has been opted based on the integration of AI for resource management and urban planning.
2. Iskandar Malaysia Urban Regeneration Project: Iskandar Malaysia is a visionary and ambitious economic initiative that aims to catalyse the growth of a substantial and worldclass economic corridor in Malaysia's Johor region (Osman, Bachok, & Rabe, 2015). Therefore, this project has been chosen to assess the utilization of analytics for sustainable development and resource management towards business development model.
3. Johor Bahru Central Business District Revitalization: Traditionally, Johor Bahru City Centre resourced as a major source of employment and business which is curated with number of urban functionaries, such as government administrations, heritage, art and architectural values, tourism, and other subsidiary amenities. Therefore, the revitalization project has been selected for a case study to examine the implementation of AI and IoT technologies for the infrastructure improvement and economic growth of the region.

3.1. Data Analysis

To analysis of quantitative data descriptively, statistical analysis technique has been performed where descriptive statistics and inferential statistics methods are executed (refer Table 2). Data is including case study survey (on-site and online), experts' opinion, and physical observations. Software used for the analysis of data are SPSS

27v, and R to perform correlation analysis with multiple regression techniques.

Table-2: Brief of analytical instrument

1. Descriptive Statistics	
Descriptive Statistical Analysis Element	**Description**
Data	Survey data (both on-site and online)
Purpose	Used to identify the pattern and then analyse the survey data using relationship between variables descriptively.
Measures	Statistical data has been analysed descriptively through frequency distribution, mean score, standard deviations, and percentage of responses
Software	SPSS27v and R
2. **Inferential Statistics**	
Inferential Statistics Analysis Elements	**Description**
Data	Survey data (1º and 2º)
Purpose	To develop the inter-factorial relationship and assess the correlation between AI and analytics adoption and their outcomes in the process of urban regeneration and tourism promotion
Test	Correlation analysis followed by multiple-regression techniques
Software	SPSS27v, Power BI, and R

The data from primary sources, case study, opinions from experts, and survey (both on-site and online) is standardised statistically to identify the patterns and trends in the process of implementation related to the role AI and analytics in urban regeneration initiatives. For the collection of data, a purposive sampling has been opted to select experts for the interviews which are based on their expertise and experiences in the field of AI, analytics, tourism, and the process of urban regeneration. A convenient sampling strategy has been adopted to select and segregate the nature of respondents which is based on their availability and interest of participation. Thereby, for analysing the data, descriptive statistical method has been performed to examine the data, and the results are measured through frequency distribution, mean score, values in standard deviations, and percentages of responses. It is thereafter followed inferential statistical method to assess the correlation between variables of AI and analytics adoption in the process of urban regeneration and tourism developments. Therefore, the survey data is examined through correlation analysis followed by multiple-regression techniques. Triangulation of data is performed to check and increase the validity and reliability of the findings.

4. Analysis and Findings

This research aims to examine the inter-factorial relationship and provide a comprehensive and validated understanding of how and to what extent the role of AI and analytics can be efficiently incorporated and effectively integrated into decision model for a sustainable urban regeneration initiatives and tourism in Johor Bahru Heritage City, Malaysia. Hence, the results and findings of this approach of integration used to ensure that the application of AI and analytics are trustworthy, substantiated, validated, and hence capable of prompting with credible solutions to the existing challenges in developing sustainable efficiency model for such urban regeneration initiatives of the region. Therefore, a case-study approach has been performed. The strata of the respondents have been categorised accordingly (refer Table-3).

Table-3: Strata of the respondents for survey

Demographic Variable	Category	Number	Percentage (%)
Gender	Male	120	55 %
	Female	98	45 %
Age	18-25	44	20.18 %
	26-45	76	34.86 %
	46-60	65	29.82 %

	61 and above	33	15.14 %
Sector	Residential	44	20.18 %
	Public	67	30.74 %
	Private	107	49.08 %

4.1. Statistical Analysis

A. Descriptive Statistical Analysis

Assessment of perception on implementation of AI and analytics in the process of urban regeneration related to tourism has been analysed descriptively through the adoption of case-study. A survey on three main strata of respondents with total of 218 (effective) respondents were performed to gather the data and results has been obtained through statistical analysis method (refer Table-4 and Table 5). Perception of respondents has been measured on 5-point Likert's Scale and analysed accordingly.

Table-4: Descriptive Statistical Analysis

Variables	**Statement**	**N**	**Mean**	**Variance**	**Std. Deviation**
AI Adoption	Adoption of AI to improvise urban regeneration efficiency	218	2.81	2.03	1.38
Analytics use	Improvised use of analytics to provide better resource management	218	3.40	1.57	1.22
Ethical concerns in TrUR	Ethical concerns address to support and promote the process of urban regeneration related to tourism	218	4.29	0.91	0.98

Table-5: Frequency Distribution of Responses from Participants

Response category / Variable	Strongly Agree (5)		Agree (4)		Neutral (3)		Disagree (2)		Strongly Disagree (1)		
	Number	%	Number	%	Number	%	Number	%	Number	%	Total
AI adoption to improve UR efficiency	101	46.33	77	35.32	22	10.09	9	4.13	9	4.13	218
Analytics use for better resource management	109	50	69	31.65	21	9.63	11	5.05	8	3.67	218
Ethical concerns to support TrUR	43	19.72	56	25.69	52	23.85	45	20.64	22	10.09	218

1. AI Adoption to Improve Urban Regeneration Efficiency

AI adoption has been opted as variable for this research to measure the perception of the respondents descriptively and examine the effectiveness of AI technologies and their implementation in enhancing the efficiency of urban regeneration initiatives related to tourism in city i.e., Johor Bahru Heritage City, Malaysia. This variable is further divided into two sub-constructs; streamlining processes, and predictive capabilities, and each construct is designed with three items. Hence, total of six (6) items has been designed as questionnaire for the survey to measure the efficiency and effectiveness of the variable and the data is analysed statistically.

Assessment of findings from the survey, the analytical results has concluded as total of 101 respondents (46.33%) have strongly believe that adoption of AI has a substantial positive impact on efficiency of urban regeneration initiatives related to tourism in Johor Bahru. Also, a large number of participants has observed (35.32% of respondents) have shown their agreement on adoption of AI reflecting a general consensus with a benefit in planning and development and thus increases the

efficiency of such regeneration projects. A small group of participants recorded as neutral reply (10.09%), and results concluded as it may due to lack of public involvement and understanding of AI's potential. Moreover, a very small group of respondents i.e., 4.13% of total respondents have shown disagreement on the efficiency of AI adoption in urban regeneration and tourism promotion.

Therefore, the pursuit of urban regeneration and tourism planning the results from survey are often staggered by the complexity of urban systems, and the sheer volume of data-driven analytics required to inform and validate the decision-making. However, the strategic deployment of artificial intelligence (AI) and advancement in technologies, such as machine learning algorithms and predictive analytics can helps in reducing the stress by automating routine tasks and providing a rich and contextual insight to urban planners. Hence, the process of urban regeneration in Johor Bahru becomes data-driven, the potential for AI to users' decision-making and expertise becomes increasingly evident. And therefore, by empowering urban planners and business developers to make them more informed, nuanced decisions, AI plays a crucial role in the formulation of resilient, sustainable, and equitable urban environments.

2. Analytical Use for Better Resource Management

Use of analytics is opted as another variable for the survey to examine the perception of the respondents on the role of data analytics in promoting and enhancing the experience of urban infrastructures through resource management. This variable is therefore subcategorized into two constructs; resource optimization and cost reduction, and each of them is further designed with three items for the survey. Thereby, total of six (6) questions has been designed to measure and examine the perception of the respondents on the use of analytics to provide better resource management.

The survey is analysed descriptively, and the results are concluded as total of 109 (50% of total participants) respondents have shown their interest on strongly agree, and a considerable proportion (31.6%) respondents agreed on statement that data analytics significantly improve urban resource management in Johor Bahru area. Although, a small number of responses (9.63%) are also recorded with a neutral agreement, whereas only few of the participants have shown their disagreement that the use of analytics can be beneficial for improvised resource management.

Therefore, the results from the survey findings suggested that the optimized application of data analytics can enhance the experience of users through urban resource management, and enabling urban areas more effectively to allocate and utilize the urban infrastructures efficiently. By opting a selective pattern and trend within complex datasets, it helps analysts to forecast future demands, thereby leading to more cost-effective and sustainable management practices in the process of urban regeneration and tourism of the region. As a result, it is concluded that, by integration of significantly enhanced operational efficacy through analytics, yielding tangible benefits for the development houses like, municipalities and other urban local bodies and citizens alike.

3. Ethical Concerns to Support Tourism-related Urban Regeneration (TrUR)

Ethical concerns to support urban regeneration is third variable for this research, and it is responsible to assess the ethical issues which may hinder the implementation of AI and analytics in the process of urban regeneration and tourism. The concerns are therefore designed to examined under three sub-constructs: data privacy concern, biasness in algorithm, and community trust. Each construct is itemized to address their respective issues and further designed with five (5) questions for the survey (refer Table 05 and Table 06).

The findings from the data analysis of survey are concluded as a small group of respondents (19.72% of total participants) have shown a strong agreement that in such regeneration initiatives with adoption of AI and analytics, ethical issues are being adequately addressed. However, majority of respondents with total of 56 participants (25.69%) are showing their believe that the ethical concerns are being considered to a satisfactory level, hence, indicating a general perception on the consent towards a fair address of these issues. Similarly, a considerable group of respondents as of 52 out of 218 participants (23.85%) have been observed with a neutral consent, this is because of lower public interaction and inadequate supply of information to

the users or may be due to undecided nature of participants. Whereas a significant number of respondents (as 20.64% on disagree and 10.09% on strongly disagree) are being recorded with the dissatisfied agreement, thus, quantifies their perceptions towards the ethical issues consideration while performing the AI and big-data analytics in the process of TrUR.

Hence, on analysis of data descriptively, the findings are concluded as the integration of AI and analytics on implementation in urban regeneration process, the urban milieus raise significant ethical quandaries that requires careful consideration. The judicious implementation of these technologies and adoption of advancements ensuring the ability of secured use of data and their privacy, preclude the potential for surveillance abuse, and confirming the rectification of algorithmic biasness in AI based decision-making processes. Therefore, it is concluded that the ethical issues incumbent upon policymaker and all stakeholders to deployment of robust measures and guidelines which helps in mitigating the risk associated with the integration of AI and analytics in such urban regeneration initiatives and thus, the concerns are being served consonant with the values of transparency, accountability, and social justice to construct of sustainable urban environment.

B. Inferential Statistical Analysis

Inferential analysis is another analytical method for the statistical data to quantify the survey with regressions. In this study, the data is being processed inferentially and perform a construct correlation analysis followed by multiple-regression techniques, and results are concluded on surveys' findings. Thereby, the data is being collected based on three respective constructs: AI adoption to improve efficiency, analytical use for resource management, and ethical concerns in TrUR. Each construct is further categorized with dedicated sub-constructs (refer Table 6), and following sub-constructs are further dedicated with their respective items. Therefore, in this research questionnaire, total seventeen (17) items have been deployed to perform the survey.

Table 6: Inferential statistical analysis

Construct	Sub-construct	Number of Items	Frequency	% on agreement	Explanation
AI adoption to improve efficiency	Streamlining Process	3	151	69%	Adoption of AI increases the efficiency thus significantly reduces the time in planning and execution process.
	Predictive Capabilities	3	127	58%	Use of AI with predictive analytics can help in increase the project feasibility by anticipating future urban needs in Johor Bahru.
Analytical use for resource management	Resource Optimization	3	155	71%	Use of data analytics helps to optimize the urban resources and increase efficacy while planning.
	Cost reduction	3	140	64%	Data analytics enhances to better resource management and reduces cost by 20% (avg.) and increases productivity.
Ethical concerns in TrUR	Privacy issues	2	124	57%	Management of individual data privacy have significant concern on implementation of AI in regeneration initiatives towards tourism promotion.
	Biasness in Algorithms	2	111	51%	AI algorithms and analytics shows issues of biasness and hence need to be more transparent in decision making.
	Community trust	1	83	38%	Building community trust among stakeholders is another ethical concern and thus become essential for effective implementation.

Hence, the inferential statistical analysis has been performed to identify the correlations between the constructs of AI and use of analytics, and ethical concerns in respective urban regeneration initiatives and the data is being analysed inferentially followed by multiple-regression techniques. The results are concluded on principal components, and data analysed based on perception of the respondents individually. Under

variable AI adoption, sub-construct 'streamlining process' has been appeared through three itemized statements where 69% of respondents showed their agreement on adoption of AI reduces the time and increases the efficiency of the projects. Similarly, 71% of respondents have agreed on the use of analytics can promote optimized resource management. Progressively, regarding variable 'ethical concerns', individuals' data privacy and algorithm biasness need to be address exponentially to minimize the stress on implementation techniques in such urban regeneration initiatives related to tourism.

4.2. Correlation Analysis

Correlation analysis is a statistical analytical tool that progressively used to examine the inter-sectoral dependency, strength and direction of the relationship between two continuous variables (Cohen, Cohen, West, & Aiken, 2013). In this research, correlation analysis used to assess the decisive dependency of covariance which is measured with values of correlation coefficient. Table 7 showing a correlation matrix which examine relationships between three variables. The correlation coefficient with individual variable is 1.000, which shows the variable is perfectly correlated with itself. However, the correlation coefficient between AI adoption and use of analytics has been recorded with 0.719, which indicates a positive correlation, and it is statistically significant at a certain level ($r = 0.719$, $p < 0.01$). The positive correlation indicated that as AI adoption increases, the use of analytics also tends to increase. Whereas, the correlation between variable AI adoption and ethical concerns in TrUR been measured with a coefficient value of 0.832 at a significant level ($r = 0.832$, $p < 0.01$), which signifies a strong positive correlation. Similarly, the value of 'r' between ethical concerns in TrUR and use of analytics has been measured with 0.901 at a significant level ($r = 0.901$, $p <0.01$), which indicates an extremely strong positive correlation. It signifies that, if use of analytics increases, ethical concerns in TrUR also increase.

Table 7: Correlation analysis

Variable	AI adoption	Use of Analytics	Ethical concerns in TrUR
AI adoption	1.000		
Use of Analytics	0.719**	1.000	
Ethical concerns in TrUR	0.832**	0.901**	1.000

The results suggested that the positive correlation between AI adoption and use of analytics concluded as the adoption of AI are more prominent to use of analytics while decision-making in planning. And the strong correlation between AI adoption and ethical concerns may increases due to raise in concerns about individual data privacy, surveillance, and biasness. However, an extremely strong positive correlation between variables suggested that the use of analytics have close relation to the identification and effective management of ethical concerns while implementing in urban regeneration initiatives related to tourism in Johor Bahru.

Independent Samples T-test: Output of Two-Sample T-test

For the comparison between two distinct or independent groups, Two-sample T-test has been performed. Two-sample T-test is a parametric test that used to assess the mean values between items (Table 8).

$$CI = \bar{X} \pm Z\alpha * \sigma\sqrt{1/n}$$

Where, $\bar{X} = mean\ score\ for\ group$

$Z\alpha$ = is the t-statistic (1.96) standard value @95% CI (confidence interval)

σ = is the pooled Stand. Error

n = sample size

$$CI = 2.95 \pm 1.96 * 0.21\sqrt{1/218}$$

= 2.53 to 3.37

Table 8: Two-Sample T-test

Group	Mean	Std. Dev.	Std. Error	CI @95%
AI adoption (Group 1)	2.95	1.18	0.21	(2.53, 3.37)
Analytics use (Group 2)	3.82	1.29	0.27	(3.29, 4.35)
T-test Result				
Variable	**T**	**df**	**Sig, (2-tailed)**	
AI adoption vs Use of Analytics	-16.98	216	0.000	

The test is performed and thus concluded as the data provided to T-test help to compare the mean scores of two independent groups which is used to determine whether there is a statistically significant difference between mean values. The analytical results asserted that the mean score for Group 1 (2.95) is significantly lower than mean score of Group 2 (3.82), which signifies that the mean scores for the groups with 95% confidence level do not overlap and the differences are statistically significant. The T-statistics (T) is -16.98 which indicates that how pooled standard errors and the mean difference is away from the null hypothesis with no difference. Hence, a large T-value indicates that the group mean score have a significant difference. The negative T-value indicates that the mean of Group 2 is greater than Group 1. The p-value (sign. 2-tailed) is 0.000, which is lower than the conventional alpha level of 0.05, and thus it rejects null hypothesis, and the population means indicates a true significant difference.

To re-validate the results, a non-parametric test, 'Wilcoxon Runk-Sum Test' has been executed which compares the itemized distribution of varied components in their groups, and it doesn't require normality or equal variance that is more robust to outliers and non-linear relationships compare to parametric test. The correlation between the itemized variables indicates the strength of the monotonic relationship, and the p-value (refer Table 9) further stated the probability of observing the correlation by chance. Since the p-value is observed as 0.001 which is less than conventional value (0.05), it rejects the null hypothesis and concluded as the correlation is statistically significant.

Table 9: Wilcoxon Rank-Sum test

Group	N	Sum of Ranks	Mean Rank
Group 1 (AI adoption)	109	13961	126.45
Group 2 (use of Analytics)	109	31359	143.55
Test Statistics			
W	**p-value**		
13421	< 0.001		

The test is performed with two groups and each of them have assessed with 109 observations (N) that comprises 218 total sample size (n). On analysis of responses, the Rank-Sum test yields a W statistic of 13421 indicates the sum of the ranks is considered for the group with the smaller rank sum (Group1). The p-value is observed as < 0.001, which is significantly lower than the typical alpha level (as prescribed value 0.05) thus, it leads to reject the null hypothesis. Therefore, the W statistic and p-value stated significant differences between the groups with the median of group 2 is higher than group1. Hence, the findings have shown an important implication for the development of businesses and related organizations which seeks to maximize the benefits of adoption of AI and the use of analytics.

Analysis of Variances

For the analysis of variance, One-Way ANOVA has been performed to check the homogeneity of variances using Levene's test. To evaluate the significance differences between the groups, analytical results of the ANOVA followed by Post-Hoc test has been performed to determine the differences (see Table 10 and Table 11). The result concluded as the variances are not significantly different where p value is 0.008, and therefore the ANOVA asserted equal variances.

Table 10: One-Way ANOVA

Variances	df	SS	MS	F	p-value
Between Groups	2	32.13	16.065	4.92	0.008
Within Groups	216	439.31	2.03		
Total	218	471.44			

Mean and Standard Deviation		
Group	**Mean**	**Std. dev.**
Adoption of AI	2.95	1.18
Use of Analytics	3.82	1.29
Ethical concerns in TrUR	3.37	1.20

Post-Hoc test using Tukey's Honest Significant Difference (HSD) method has been performed to determine the mean score of which specific group is significantly different. Therefore, to analyse the result of post-hoc test, first must calculate the Tukey's HSD:

$$HSD = q * \sqrt{\frac{MS_{within}}{n}}$$

Where: q = standardized range statistic (obtained from statistical table based on number of groups and degree of freedom within

MS_{within} = mean square within groups

n = the number of observations per group (assume equal sample size for simplicity)

Since the sample size is equal for each group (assumed), from the ANOVA data, we have: $MS_{within} = 2.03$, and the 'q' value for 3 groups with df (216) at 95% CL is approved approximately 3.34 (from Tukey's HSD table). The value of 'n' is equal to $109/3 \approx 36.33$.

Hence,

$$HSD = 3.34 * \sqrt{\frac{2.03}{36.33}}$$

$$= 0.793$$

Table 11: Post-Hoc Tests

Comparison	Mean Difference	Std.Err.	p-value	Comparison to HSD
AI adoption vs Use of Analytics	-0.87	0.21	0.001	0.87 > 0.793
AI adoption vs Ethical concerns in TrUR	-0.42	0.27	0.126	0.42 < 0.793
Use of Analytics vs Ethical concerns in TrUR	0.45	0.21	0.032	0.45 < 0.793

The post-hoc test with Tukey's HSD method indicates that the mean score between group 1 and group 2 have shown a significant difference, as the mean difference exceeds the HSD value. However, the mean score difference between group 1 and group 3 (0.42) is less than the HSD value (0.793), which shows no significance difference between mean scores. Similarly, the mean score difference between group 2 and group 3 is less than the HSD value that stated no significance difference. Hence, the test one-way ANOVA reveals that there is a significance difference among the three groups. The post-hoc test using Tukey's HSD method therefore stated as only group 1 and group 2 have shown a significant difference.

Multiple Regression Analysis

Using the given data, the regression analysis has been performed to calculates the coefficients and other statistics. The standard errors, t-values, and p-values are further computed using statistical regression techniques to identify the multicollinearity (refer Table 12). If a 'p-value' less than 0.05 recorded, that signifies the coefficient is significantly different from zero at 5% significance level.

Table 12: Multiple Regression Analysis

Regression	B	Beta	SE B	t	Sig.
Statistics use	0.72	0.61	0.24	3.22	0.001

The unstandardized coefficient (B) is 0.72, indicated that the mean score for dependent variable is expected to increase by 0.72 units, and thus holding all other variables are constant. The observed standardized coefficient (Beta) is 0.61 signifies a strong positive correlation between the use of statistics and the mean score. It is therefore suggested that, since the beta value is higher, the use of statistics has shown a substantial effect on the dependent variable with respect to other components. The higher t-value (3.22) signifies that the coefficient is significantly different from zero. Therefore, the results concluded that the higher t-value and a very low p-value is providing strong evidence towards the use of statistics and the mean score, which is not due to random chance, however, the standard error is observed relatively small, which signifies a high degree of precision in the estimated coefficient.

Table 13: Regression Coefficient and Loading Factor Matrix

Criterion	Sub-Criterion	Regression Coefficient	Loading Factor
AI Adoption	Streamlining Processes	0.35	0.78
	Predictive Capabilities	0.42	0.81
Analytics Use	Resource Optimization	0.50	0.85
	Cost Reduction	0.30	0.70
Ethical Concerns	Data Privacy	0.28	0.65
	Bias in Algorithm	0.22	0.55
	Community Trust	0.33	0.70
Statistics Use (Overall)	-	0.72	0.61 (Beta)

The regression coefficient for all sub-criteria has their respective coefficient values which represents the degree of impact on the overall outcomes (e.g., AI efficiency in urban regeneration). For instance, “resource optimization” (0.50) has a higher positive impact that “bias in algorithm” (0.22). These coefficients represent the strength and direction of the relationship between each sub-criterion and the dependent variable. Similarly, the value of loading factors represents the contribution of each sub-criterion to the overall construct, derived from factor analysis and reloading values. These values illustrate the importance of each factor within its category, such as “predictive capabilities” showing a higher loading factor (0.81) than “streamlining processes” (0.78) under AI adoption. The idea of loading factor reflects how much each sub-criterion contributes to its respective construct.

5. Detailed Discussion and Recommendations

This study therefore discussing on how AI and data analytics can be integrated through a comprehensive analysis that enhances urban regeneration initiatives and promote tourism, particularly within the context of Johor Bahru heritage city, Malaysia. The perception of stakeholder towards adoption of AI and analytical use, and consideration of ethical concerns is observed significantly different which is supported from the findings of the ANOVA and post-hoc tests. Further, a strong positive relationship indicated by a Beta value of 0.61 ($p = 0.001$) through the regression analysis has demonstrate the use statistics which predicts the successful implementation of AI and use of analytics in the process of tourism-related urban regeneration. This is supported by the study of Bakhtiar and Samsudin (2023), as stated that the strong positive relation between variables can helps in successful integration of technologies in smart city mission.

Further, the study discusses the integration and adoption of AI and use of analytics into the process of tourism-related urban regeneration, which is transformative in nature that offers an enhanced efficiency with its maximized potential in resource management, optimized service providers, and predictive maintenance with consideration of ethical concerns. Reduced AI algorithm biasness can further provide a tailored solution in forecasting future needs for the sustainable urban development. This is therefore supported from the studies where AI-powered urban infrastructure maintenance can helps in significant reduction in

operational costs, and also enhances the distribution of urban assets in real-time through big-data analytics that ensures efficient and responsive services (Alahi et al., 2023; Bibri, Krogstie, Kaboli, & Alahi, 2024; Kamchatova, Chashchin, & Dong, 2021; Mahor et al., 2022).

Whereas it is also concluded that, these technological advancements and their integration is fraught with complexities. Notably, the ethical concerns of data privacy, the exacerbation of social inequalities through digital divide, and the ethical concerns of AI-driven decision-making processes require rigorous scrutiny and vigilant supervision that used to ensure the attainment of equitable and resilient outcomes, which is critical to establish a robust but stable governance structure. It fosters interdisciplinary collaborations through the dynamic adaptation of reformed business model with rapid evolving cutting-edge technologies in urban landscape rejuvenation (Ahmad et al., 2022; Allam & Newman, 2018; E. Z. Rahman, Aziz, Shah, & Asrifan, 2024).

However, in this study, the discussed case studies from Johor Bahru, Malaysia used to serve as critical component for paradigmatic illustration of adoption and their integration of AI and use of analytics in such government based urban development initiatives. These innovative initiatives potentially demonstrate the transformative capacity of such advanced technologies that helps in reshaping urban landscape, stimulate sustainable economic growth, and significantly upraise the overall well-being of urban habitants.

Hence, the study from discussion has the following recommendation that can enhances the efficiency and effectiveness of the program:

1. Enhanced Governance and Policy Framework: To mitigate the challenges associated with data privacy and ethical implications it is necessitate to develop a comprehensive governance and effective policy framework (Malleson et al., 2022). To ensuring transparency, accountability, and inclusivity in utilization of AI and analytics in tourism-related urban regeneration processes, these frameworks should be designed efficiently, as recommended by Allam and Newman (2018).
2. Promotion of Interdisciplinary Collaboration: For the successful integration of AI and analytics, it become necessary to collaborate across numerous disciplines that combines to support in enhancing the productivity of the program. It is supported by the study that fostering interdisciplinary collaboration which leads to more holistic and sustainable urban regeneration initiatives related to tourism (Cugurullo et al., 2024).
3. Investment in Digital Infrastructure and Capacity Building: To reduce the stress on biasness in decision-making, bridging the digital divide which ensures equitable access to advancements in technologies, a significant investment in digital infrastructure is needed. This instance encompasses an expanding access to high-speed internet and promoting digital literacy among users of the region (Cavalheiro et al., 2020).
4. Public Engagement and Local Participation: Public participation and their engagement in planning and development process is crucial phenomena the accounts the success of urban regeneration initiatives (F. Rahman, Halim, & Ahad, 2022). Thereby, through leveraging AI adoption and analytics to itemized and analyse community feedback, it can make the planning process more inclusive and transparent that helps in fostering the public trust and thus local participation.
5. Ethical Consideration in AI Deployment: Consideration of ethical concerns should be assigned as the forefront factor in AI deployment in the process of tourism-related urban regeneration. This is supported by recommendation of the study that addressing the issues related to algorithmic biasness in decision-making, and protecting individual privacy in the process of implementation (Cugurullo et al., 2024).
6. Continuous Assessment and Reflexive Evaluation: To identifying the area for improvement, it become imperative to implementing a robust system of continuous monitoring and reflexive evaluation of AI analytical applications,

that helps in ensuring the effectiveness of these technologies in contributing to sustainable urban regeneration (Wei, Yuan, & Li, 2024).

It is therefore, based on the following analysis and discussions, it is recommended to develop an efficiency model that integrates the techniques of AI and data analytics and their adoption in the process of urban regeneration related to tourism that can increase the efficiency of the program through the promotion of tourism to the heritage city.

5.1 Integration of an Efficiency Model for the Heritage City Regeneration

The recommendation to integrate an efficiency model that support and enhance the experience of tourism in a heritage city within smart city initiatives. By reviewing the MCDM model which is used to integrate AI and analytics in the process of TrUR within smart city concept that involve in identifying key component to enhance the productivity of the region. This model will support in strengthening the AI and analytics to improve the feasibility of urban regeneration projects in the heritage cities, i.e., Johor Bahru, Malaysia through addressing the efficiency, resource management, and ethical considerations.

The analysis supports the applicability of innovative quantitative models for decision-making in the public sector, particularly in urban planning and resource management. It is therefore, the research findings connect to the use of quantitative models for public-sector decision-making (Figure 2) where AI adoption and data analytics significantly impact urban regeneration, particularly in resource optimization and cost reduction. This model incorporates various factors, including AI adoption, analytics use, and ethical concerns, that collectively influence urban regeneration. Analytical factors represent multiple criteria that public-sector entities must evaluate when making decisions. Innovative quantitative models like Multi-Criteria Decision-Making (MCDM) can help to integrate these diverse criteria.

Applicability: The public sector can employ MCDM models such as the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to rank potential urban regeneration projects. The criteria weights can be informed by survey findings (e.g., stakeholders' perceptions of AI efficiency, cost optimization) from the research, thus aiding in transparent and data-driven decision-making. The study suggests that such innovative quantitative models could be further applied in the public sector and offers a framework for making more robust, data-centric decisions from an urban planning or policy perspective. By embedding the quantitative models within decision-making processes, urban regeneration initiatives are made more efficient, sustainable, and inclusive.

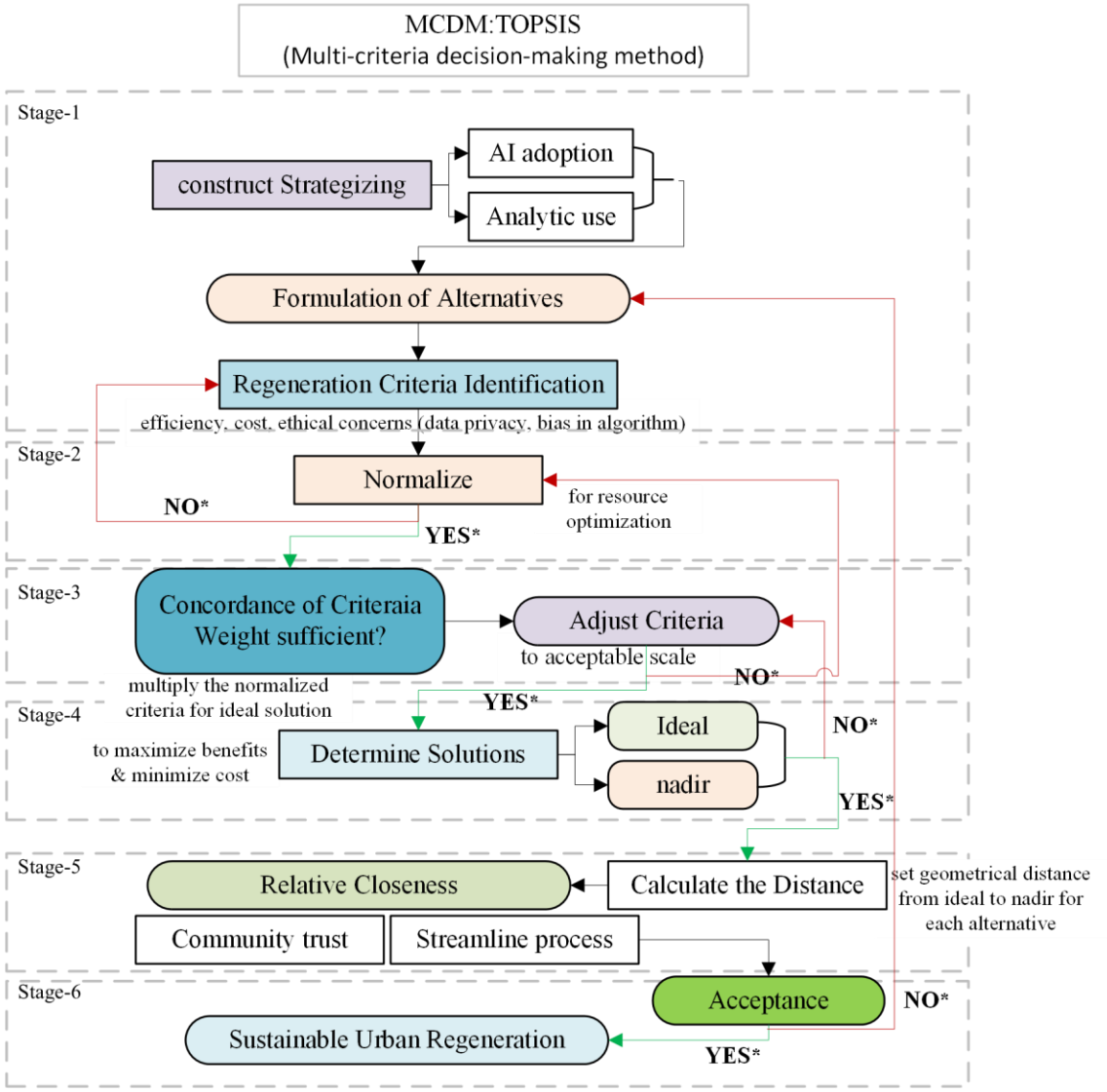

Figure 2: MCDM (Multi-Criteria Decision-Making) model-TOPSIS

(*- if NO, then go back to previous initiating step and revise with loading factor values to validate the model coefficient for confirmation)

MCDM model is designed to assist in decision-making processes by systematically evaluating multiple criteria (Casini et al., 2019). Therefore, it is significantly contributing to urban regeneration projects that require careful assessment of various factors, such as social equity, economic efficiency, ethical concerns, and technological adoption. The model TOPSIS allows policy makers to analyse these factors to rank alternatives based on their geometrical distance from an idea solution to nadir (worst) solution. For an effective approach for TrUR, policymakers using TOPSIS can evaluate each approach's distance from an ideal solution (where all criteria are perfectly met) and choose the one that aligns best with the desired outcomes identified in the research.

Therefore, the MCDM model proposed to underscore the comprehensive approach which is seamlessly integrates AI and data analytics into tourism-related urban regeneration initiatives within smart cities. This integration of framework designed to align with the research findings and addresses the key areas of concerns as identified:

Efficiency Enhancement: The shrewd application of AI and analytics are crucial for enhancing the efficiency and efficacy of such regeneration projects. It is therefore, by harnessing the capabilities of these technological advancement, the municipal governments, ULBs, and urban planners and policy makers can make informed

data-driven decisions, rationalize workflows, and anticipate urban needs with greater precision.

Optimization of Resources Management: From the analysis and discussion it is concluded that the data analytics plays a critical role in optimizing resource management which leads to a substantial cost saving and efficient resource allocation. Hence, this model is proposed particularly to the infrastructure companies, urban planners, and policy makers to navigate the complexities of resource management and ensuring the successful execution of projects.

Addressing Ethical Concerns: The recommended efficiency model acknowledges the paramount importance of ethical considerations while implementing AI and analytics in smart city initiatives. For fostering community trust, the model can ensure the privacy of citizen data and minimize biasness in AI algorithms through efficient implication, which guarantee the long-term sustainability of such government-based urban regeneration projects for the heritage cities, such as Joho Bahru, Malaysia.

Urban planners and Developers- Augmented Planning and Resource Management: The implementation of this model can harness the power of AI-driven analytics which helps to urban planners and developers to enhance planning accuracy, optimize resource management, and mitigate potential risks associated with projects. Hence, it can lead to more successful projects with cost reductions, and improvised returns on investment.

Similarly, while discussing the implications of this resource modelling, it is poised to have a profound impact on the trajectory of tourism-related urban regeneration projects in smart cities which has significant consequences for various stakeholders. By promoting these technological advancements, the local governments can optimize resource allocation, streamline automated decision-making processes, and create more liveable and sustainable cities. The synergistic implication of AI and analytics shows enormous potential for municipal government and ULBs that enabling them to orchestrated highly efficient and effective regeneration projects (Awad & Jung, 2022; Sohi, Banihashemi, Sheikhkhoshkar, & Roshan, 2024).

5.2 Comparison with Prior Research

This efficiency model while comparing with prior research, it is firmly rooted in the literature where consistently underscore the transformative potential of AI and analytics in urban management (Kitchin, 2016; Xu et al., 2024). As the foundation of this research, this model offers a nuanced and contextualized understanding of the role of AI and analytics in such TrUR. Notably, it deviates from earlier studies by placing a pronounced emphasis on the ethical considerations and community trust that are essential for the successful implementation of AI-driven urban regeneration initiatives.

Previously, some studies have largely focused on the technical aspects of AI and analytics, overlooking the critical social and ethical dimensions that are coherent to their adoption and acceptance in urban contexts (Kamrowska-Załuska, 2021; Malleson et al., 2022; McFarlane & Söderström, 2017). However, this recommended model has tried to address this gap by foregrounding the importance of ethical considerations and community trust, in recognition that these factors are crucial in fostering a culture of transparency, accountability, and inclusivity in urban governance.

Therefore, in conclusion this model helps in bridging the gap between theory and praxis and facilitating the translation of academic research into tangible outcomes that can be operationalized in diverse urban context. This innovative business model therefore contextualized within the unique urban landscape of Johor Bahru city, which presents a comprehensive framework for harnessing the transformative potential of AI and analytics in smart city regeneration. It is sued to triangulating the strategic partnerships, utilization of cutting-edge technologies, and a rigorous ethical scaffolding to amplify efficiency gains, optimizing resource allocation, and mitigate the complexities in ethical considerations in such regenerative projects. By acknowledging the distinctive urban character, art and architecture, heritage, and tourism aspirations, this grounded framework can ensure the benefits of AI-driven urban regeneration which are equitably distributed, socially responsible, and environmentally sustainable that helps in yielding tangible improvements in the quality of life for Johor Bahru's residents while fostering a liveable, resilient, and equitable urban ecosystem.

Hence, this study is concluded as it become evident that the judicious deployment of AI and analytics is significantly augment the operational efficiency and resource coordination of tourism-related urban regeneration initiatives within smart cities. However, this potential is technically counterbalanced by profound ethical concerns, primarily the preservation of individual privacy and algorithmic biasness, which is imperative in addressing the development and implementation of comprehensive ethical frameworks and ensuring the integration of AI and analytics in urban regeneration endeavours that is not only effective but also morally grounded, socially responsible, and transparent. By doing so, we can unlock the transformative potential of these technological advancements while mitigating their risks, ultimately fostering sustainable, inclusive, and equitable urban futures.

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