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Article

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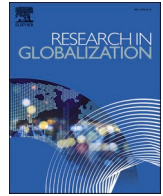
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Smart urbanism, citizen-centric approaches and integrated environmental services in transit-oriented development in Jakarta, Indonesia

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ABSTRACT

This research elucidates the intricate landscape of citizen preferences within Jakarta's Transit-Oriented Development (TOD) domain, navigating through environmental services integration and smart city initiatives. With Jakarta experiencing exponential urbanization, TOD is a pivotal strategy to amalgamate residential, commercial, and recreational spaces, seamlessly coupled with effective public transportation systems. However, achieving optimal urban living within TODs demands a deep understanding of Jakarta's citizens' diverse and nuanced preferences and needs. This study fills significant gaps in the existing literature by investigating citizen preferences' heterogeneity and willingness to pay (MWTP) for integrated environmental services in TODs. Employing advanced methodologies like the Random Parameter Logit (RPL) and the Latent Class Model (LCM), this research offers a granular insight into citizens' varied preferences and their financial commitments toward enhanced environmental services. The insights derived have been crucial in formulating pragmatic recommendations for refining TOD management strategies and policies in Jakarta, ultimately contributing to urban landscapes' equitable and sustainable development. Through a detailed exploration of preference heterogeneity and the integration of smart city concepts within TOD frameworks, this study paves the way for more inclusive, innovative, and citizen-centric urban development paradigms.

1. Introduction

In the wake of relentless urbanization and population growth globally, cities are grappling with the paramount task of redefining urban development strategies to facilitate sustainable and equitable growth (Bibri, 2021; Allam et al., 2022a). This pressure is particularly acute in bustling metropolises like Jakarta, which must navigate the intricate dynamics of rapid urban expansion, technological evolution, and demographic diversification. Transit-oriented development (TOD) is increasingly recognized as a transformative approach to urban development in Jakarta (Endangsih et al., 2021; Ricardianto et al., 2023), amalgamating residential, commercial, and recreational spaces and interlinking them with efficient, accessible public transportation systems. In this regard, the integration of smart city concepts, utilizing advanced technologies and data-driven approaches, emerges as a pivotal facet, aiming to optimize urban infrastructures, enhance service

provision, and elevate the overall quality of urban living (Bibri, 2020; Allam et al., 2022b).

Incorporating smart city principles within TOD frameworks in Jakarta is crucial to navigating and mitigating the multifaceted challenges of urbanization, providing solutions that are not only innovative but also sustainable and resident-centric. This involves the enhancement and integration of various environmental services, including advanced sanitation, the development of green spaces, and initiatives to improve air quality, all adapted to the diverse preferences and needs of Jakarta's citizens. However, the realization of smart, sustainable TODs hinges on a profound and nuanced understanding of the citizens' heterogeneous preferences and their willingness to contribute to improving environmental services within these developments. Recognizing this diversity is pivotal for crafting resonant and impactful urban development strategies and policies, ensuring the equitable and effective provision of environmental services, and fostering a harmonious and sustainable

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urban ecosystem (Tehupeiory et al., 2023; Zhang and Kim, 2023; Jing et al., 2023).

While extensive literature exists on various facets of TOD environmental management (Ali et al., 2021; Yap et al., 2021; Yu et al., 2022), a conspicuous gap exists in exploring the intricate tapestry of citizen preferences, particularly in their willingness to pay for augmented environmental services and integrate smart city initiatives within TOD frameworks. This lack of integrated perspectives, which should ideally encompass sanitation, environment, access services, and smart solutions, underscores a significant research opportunity and necessitates a comprehensive exploration of citizen preference heterogeneity in TOD management in Jakarta. The prevailing research predominantly lacks granular exploration into the heterogeneous preferences of citizens within TOD frameworks, leading to a profound knowledge void. This void is particularly noticeable in deciphering how different population segments within urban locales value and prioritize various elements of TOD (Xiao et al., 2021). There's a clear, unmet need for deeper exploration into citizens' diverse and nuanced preferences and needs, particularly in dynamic urban landscapes like Jakarta.

In addition to this, there's a palpable absence of comprehensive approaches that synthesize sanitation, environmental quality, and access services within the ambit of TODs. Prior studies have scarcely offered integrated perspectives, presenting a fragmented view of how these pivotal elements interweave and impact citizen preferences and the overall quality of urban living (Suryawan and Lee 2023a; Tehupeiory et al., 2023). This scenario underscores a critical need for research endeavors that offer a more holistic and integrative examination of these elements, and their interconnected implications. Furthermore, research concerning citizens' willingness to make financial commitments for enhanced and integrated environmental services within TODs is notably scarce. Understanding citizens' financial inclinations and commitments is paramount for formulating and realizing effective policies, yet this area remains largely unmapped in the existing academic dialogue. The gap extends to the integration of smart city concepts within TOD frameworks. Despite the global momentum surrounding smart city initiatives, there's a noticeable lack of research exploring the amalgamation of these innovations within TOD paradigms (Shamsuzzoha et al., 2021; Zhu et al., 2022). The untapped potential of smart city initiatives in optimizing urban infrastructures and enhancing service delivery in TODs is glaring and warrants an in-depth exploration. Finally, the focus of existing literature reveals a marked gap, with limited emphasis on approaches that are cantered around the citizens in TODs. A shift towards research that is more aligned with citizens' actual and evolving preferences and needs is imperative, to ensure that TOD management strategies and policies are resonant and citizen centric.

This study is positioned to navigate these nuanced and multifaceted gaps by leveraging meticulous methodologies and analytical models to unravel the complexities of citizen preference heterogeneity, their willingness to pay for elevated environmental services, and the incorporation of smart city concepts within TOD frameworks. By offering synthesized, nuanced, and citizen-centric insights on TOD management, this study aims to enrich the understanding of urban development paradigms and contribute to formulating inclusive, sustainable, and innovative urban strategies, particularly in expansive and diverse metropolises like Jakarta. In addressing these gaps, this study aspires to expand the existing corpus of knowledge and foster a more informed and pragmatic discourse on urban development and sustainability. This study, thus, aspires to bridge this existing knowledge chasm, employing state-of-the-art methodologies and analytical models to unravel the complexities and diversities of citizen preferences and their willingness to pay (MWTP) for integrated environmental services in TODs, harmonized with smart city innovations. It strives to provide nuanced insights and pragmatic recommendations, shedding light on Jakarta's citizens' diverse preferences and needs and propelling forward-thinking, equitable, and sustainable urban development strategies congruent with the evolving smart city paradigm. By synthesizing these insights, the study

seeks to contribute significantly to refining and enhancing TOD management strategies and policies, fostering a more inclusive, sustainable, and innovative urban landscape in Jakarta.

1.1. Current situation

The current policy and the conditions prompting this research highlight the dynamic landscape of urban development in Jakarta, particularly in the context of Transit-Oriented Development (TOD). With Governor Regulation Number 15 of 2020, Jakarta's move towards TOD as a strategic urban development model integrated with the transit system is a testament to its commitment to sustainable city living (Peraturan Gubernur and Nomor, 2020). This regulation positions the Mass Rapid Transit (MRT) Jakarta Limited Company as the manager of the TOD corridor, underlining the city's focus on creating accessible, comfortable, and sustainable urban spaces. TOD in Jakarta is designed to intertwine transit points with human activities, buildings, and public spaces, thereby optimizing space utilization and enhancing access to public transportation. This approach is particularly relevant given Jakarta's high levels of congestion, and TOD development could bring about positive transformations for the city and its residents. The development of TOD areas in Jakarta follows the principles outlined in the Minister of Agrarian Affairs and Spatial Planning/National Land Agency Regulation Number 16 of 2017, with PT MRT Jakarta and PT Integrasi Transit Jakarta spearheading the development around MRT Jakarta stations, particularly along the Lebak Bulus-Dukuh Atas route (Kementrian Agraria dan Tata Ruang/Badan Pertanahan Nasional, 2017). The successful implementation of TOD in global cities like Stockholm, Copenhagen, Hong Kong, Tokyo, and Singapore (Knowles et al., 2020; Toan et al., 2022) serves as an inspiration for Jakarta. These cities have demonstrated that managing economic growth, urban transportation, and land use in a coordinated manner can lead to more efficient urban environments. However, implementing TOD in Jakarta is not without challenges. The RDTR 2030 DKI Jakarta outlines specific zoning for TOD areas, indicating the potential for land use changes with the development of the MRT Fatmawati. These challenges are part of Jakarta's complex urban problems, including urbanization, security, transportation, environmental management, and social issues.

2. Method

2.1. Study site

Governor Regulation Number 15 of 2020 mandates the Mass Rapid Transit (MRT) Jakarta Limited Company as the Transit-Oriented Development (TOD) corridor manager, a strategic urban development model in Jakarta, which is integral with the transit system (Peraturan Gubernur Provinsi Daerah Khusus Ibu Kota Jakarta, 2020). The TOD in Jakarta aims to create an environment where residential areas, trading centers, service centers, offices, open spaces, public spaces, and other community services are easily accessible by walking, cycling, or public transport, through nearby halts and transit places. This regulation envisages a model of urban development that is in sync with Jakarta's smart city initiative, attempting to converge modern, sustainable urban living with efficient public transportation systems. It aligns with the objectives of the smart city to optimize urban operational efficiency, improve the quality of public services and life, and foster sustainable development, focusing on enhanced connectivity and accessibility.

Transit-oriented areas began when the MRT was first developed in Jakarta in 2015, leveraging land around the stations for property development. PT MRT Jakarta has incorporated the TOD concept since the first phase of MRT station development with the Lebak Bulus-Dukuh Atas route. Jakarta's smart city initiative, underlined by the Governor's Regulation, is not only emphasizing technological advancements but is also focusing on making urban living more harmonious and sustainable through strategic urban planning and development, like the TOD, which

is poised to redefine urban mobility and accessibility in the city. The integration of TOD in Jakarta's urban landscape is a substantial step towards realizing a smart city's vision, addressing the urban population's multifaceted needs while promoting sustainability and enhanced quality of life.

In our research focusing on TOD areas in Jakarta, we meticulously selected 450 respondents across five key TOD zones: Blok M, Fatmawati, Istora Senayan, Lebak Bulus, and Dukuh Atas (Fig. 1). This selection was conducted in June 2023 through systematic random sampling, a method chosen to ensure a comprehensive and representative cross-section of the population residing and working in these areas (Suryawan and Lee 2023a; Suryawan et al., 2023). This process, to ensure a comprehensive and representative cross-section of the population involved with and

impacted by TOD policies. The methodology was thorough, factoring in diverse elements like population density, the frequency of TOD facility usage, and an array of demographic factors including age, gender, occupation, and residential status. This was done to encapsulate the wide-ranging perspectives and experiences reflective of Jakarta's diverse population, particularly those residing and working in these TOD areas.

The process of gathering data involved conducting face-to-face interviews with residents and frequent users of the TOD facilities. In each household or point of interaction within these areas, one citizen over the age of 20 was interviewed to glean deeper insights and ensure the accuracy and reliability of the information collected. The high response rate achieved in the survey, with a significant percentage of targeted

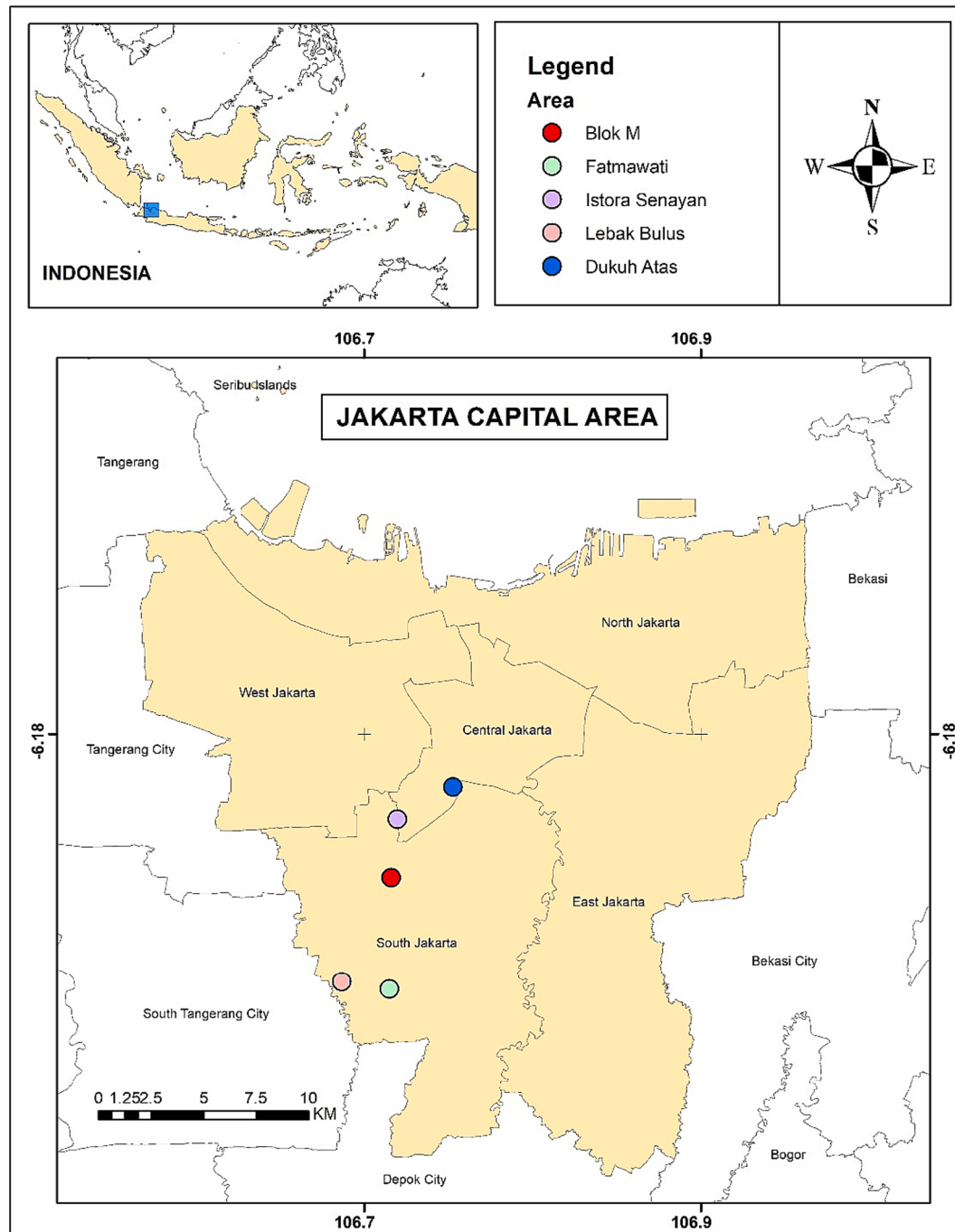


Fig. 1. TOD area in Jakarta.

respondents providing complete responses, attests to the effectiveness of our approach. Only a minimal percentage of responses were excluded due to incompleteness or inconsistencies, ensuring the integrity and quality of our research data. The determination of the sample size from each TOD area was based on specific population characteristics of that area. This strategy ensured a proportionate representation of each area's demographic composition within our overall sample. Such a detailed and considerate approach to sampling was pivotal in accurately representing the varied viewpoints and experiences related to environmental services in TOD management in Jakarta, providing a solid foundation for the conclusions drawn in our study.

2.2. Integrated environmental services in TOD apartment in Jakarta and choice Experiment

In refining Transit-Oriented Development (TOD) in Jakarta, we established a comprehensive model to study the heterogeneity of citizen preferences, incorporating perspectives on integrated services like sanitation, urban space, and access (Table 1). This model addresses the prevailing challenges in Jakarta, primarily concerning sanitation issues related to wastewater (Cecilia et al., 2023) and municipal solid waste management (Suryawan and Lee 2023a). Solutions are formulated at different levels, with Level 1 focusing on incorporating advanced wastewater treatment technologies and methods and Level 2 concentrating on enhancing waste management practices through the 3R concept: Reduce, Reuse, Recycle. In parallel, the city substantially emphasizes environmental advancements, specifically augmenting green urban spaces and air quality (Sari et al., 2020; Muhamad Nor et al., 2021). Level 1 in environmental advancements involves expanding and improving green open spaces, while Level 2 encompasses initiatives to ease air quality. The approach to TOD in Jakarta also integrates residential, commercial, and recreational spaces with efficient and

dependable public transport options to facilitate access (Baobeid et al., 2021; Yap et al., 2021; Kruszyna and Makuch, 2023). Level 1 in access improvements primarily targets reducing traffic congestion and fostering sustainable urban living by optimizing accessibility to public amenities and services. In contrast, Level 2 seeks to enhance accessibility to shopping facilities, ensuring that commercial services are readily available to the public. These integrated efforts illustrate the multifaceted approach to enhancing the living conditions and sustainability of TOD apartments in Jakarta by understanding and addressing the diverse preferences of its citizens.

These integrated environmental services (sanitation, urban space, and access) in TOD apartments in Jakarta demonstrate a multifaceted approach to enhancing urban living conditions and advancing sustainability. By concentrating on diverse aspects such as advanced wastewater treatment, effective waste management, development of green urban spaces, air quality enhancement, and improved accessibility, the model addresses the environmental challenges of urban living in a comprehensive manner. Central to this approach is understanding and addressing the diverse preferences of Jakarta's citizens, highlighted by the concept of Willingness to Pay (WTP). WTP is crucial as it measures residents' financial contribution towards these environmental improvements (Nowacki et al., 2023; Shi et al., 2023), reflecting the value they place on enhancements in their living environment. The significance of WTP lies in its ability to gauge community support for environmental initiatives, guiding prioritization of investments and financial planning for TOD projects. A high WTP indicates robust community backing, essential for the successful implementation and sustainability of urban development projects. It also aids in tailoring solutions to meet specific resident needs and encourages participatory urban planning, ensuring development aligns with public expectations. In essence, WTP serves as more than a financial metric; it is a key indicator of the community's commitment to sustainable urban development, offering insights for optimizing environmental management in a manner that resonates with the values and priorities of its citizens, thereby ensuring the long-term success and acceptance of TOD initiatives in urban landscapes.

The CE method provides a robust framework, revealing citizen preferences across designated attributes and levels, and is versatile enough to assess divergences in preferences and values in non-market sectors (Wang et al., 2020; Suryawan and Lee 2023a; Sutrisno et al., 2023). This method constructs specific scenarios from attributes and levels where citizens can select their preferred alternatives, including maintaining the status quo. The CE is crucial in studying attributes and levels about goods and services, with the cost attribute being essential for assessing the Marginal Willingness to Pay (MWTP). It has been applied in TOD environmental management research, showing that citizens often express a willingness to contribute more to environmental conservation and species protection within TOD management. However, prior applications of CE haven't delved into the diversity of preferences and MWTP, specifically in the context of TOD environmental management.

An advanced model, the Random Parameter Logit (RPL) model, extends the capabilities of the CE method, enabling the evaluation of each citizen's heterogeneous preferences and welfare for each attribute. Coefficients obtained through the RPL are crucial for estimating MWTP across diverse scenarios- (Suryawan and Lee 2023a; Suryawan and Lee, 2023b). Additionally, the Latent Class Model (LCM) categorizes citizens into distinct preference-based groups, aiding in comparing preferences among different socioeconomic strata and thus refining market targeting. In this research, to analyze the multifaceted preferences related to TOD environmental management scenarios in Jakarta, both RPL and LCM were deployed. Integrating insights, this study amalgamated the attributes and levels of TOD environmental management into the CE model.

$$V_i = \beta_1 \text{Sanitation}_i + \beta_2 \text{Urban spaces}_i + \beta_3 \text{Access}_i + \beta_4 \text{WTP}_i \quad (1)$$

Table 1

Attribute and level for a multifaceted approach to sustainability of TOD apartments in Jakarta.

Attribute	Level	Code
Sanitation	Current situation: Jakarta faces challenges with sanitation, predominantly concerning wastewater	SNT*
	Level 1: Implementation of more advanced wastewater treatment technologies and methods.	SNT1
	Level 2: Enhancement of waste management practices, employing the 3R concept: Reduce, Reuse, Recycle.	SNT2
Urban spaces	Current situation: The emphasis is on green urban spaces and air quality in Jakarta's environmental advancement strategies.	ENV*
	Level 1: Expansion and enhancement of green open spaces.	ENV1
	Level 2: Focused initiatives to improve air quality.	ENV2
Access	Current situation: TOD in Jakarta aims to merge residential, commercial, and recreational spaces with efficient and reliable public transportation options.	ACS*
	Level 1: Initiatives to reduce traffic congestion and promote sustainable urban living by ensuring public amenities and services are more accessible.	ACS1
	Level 2: Improved access to shopping facilities, making commercial services more readily available to the public.	ACS2
Willingness to Pay	IDR. 0/month IDR. 5000/month IDR. 10,000/month IDR. 15,000/month	Payment

IDR: Indonesian Rupiah (1 USD = 15.424,30 IDR) (data from Google on 22 June 2021).

Equation (1) represents citizens' preferences for TOD environmental management strategies, where V_i is the utility function associated with each alternative, and the β coefficients represent the estimated values of each attribute. The results of the CE model are essential to understanding the marginal welfare effects, with MWTP calculated as the ratio of the attribute coefficient ($\beta_{\text{attribute}}$) to the payment coefficient (β_{Payment}) as illustrated in Eq. (2).

$$MWTP = \beta_{\text{Attribute}} / -\beta_{\text{Payment}} \quad (2)$$

2.3. The CE design and survey execution

The amalgamation of different attributes and levels, as depicted in Table 1, generated 108 potential profiles, derived from the permutations of the different levels and attributes ($3 \times 3 \times 3 \times 4$). To streamline the decision-making process for participants, an orthogonal main effect plan was executed (utilizing SPSS 25.0), which pared down the profiles to 25.

Following excluding implausible combinations, a concise list of 9 alternatives was produced. These were methodically assorted into choice sets, each encompassing two alternatives alongside a status quo choice.

Participants were presented with three of such choice sets. Within each set, they were prompted to pinpoint their most favored option to facilitate the completion of the questionnaire. An exemplification of a choice set is portrayed in Fig. 2, which integrates various aspects and levels pertinent to TOD environmental management. Despite each option corresponding to identical TOD environmental management, each possessed distinctive descriptive level criteria for TOD environmental management, denoted as attribute levels. The finalized questionnaire, assembled in June 2022, was partitioned into three segments. The initial segment served as an introduction and concentrated on the participants' perspectives and behaviors in relation to TOD environmental management. The succeeding segment embedded the CE, forming the cornerstone of the research by capturing participants' selections among the proposed integrated TOD environmental management scenarios. The

Attribute	Scenario 1	Scenario 2	Current Situation
Sanitation	 Enhancement of waste management practices, employing the 3R concept: Reduce, Reuse, Recycle.	 Jakarta faces challenges with sanitation, predominantly concerning wastewater.	 Jakarta faces challenges with sanitation, predominantly concerning wastewater.
Urban spaces	 Focused initiatives to improve air quality	 Focused initiatives to improve air quality	 The emphasis is on green urban spaces and air quality in Jakarta's environmental advancement strategies.
Access	 TOD in Jakarta aims to merge residential, commercial, and recreational spaces with efficient and reliable public transportation options.	 Improved access to shopping facilities, making commercial services more readily available to the public	 TOD in Jakarta aims to merge residential, commercial, and recreational spaces with efficient and reliable public transportation options.
Willingness to Pay	IDR. 25,000/month	IDR. 10,000/month	IDR. 0/month
Please choose your preferences.	☐	☐	☐

Fig. 2. Example of choice set.

concluding segment incorporated queries about the participants' demographics. In total, 9 questionnaire variations were developed, with [Appendix A](#) illustrating one such version.

[Table 2](#) delineates the socio-demographic composition of the respondents. It is observed that a majority of the respondents were females, comprising 52.2 % (235 individuals) of the total, while males constituted 47.8 % (215 individuals). In the context of income, 20.7 % (93 individuals) earned below the minimum wage of IDR 4.641.854, 26.9 % (121 individuals) had an income ranging between the minimum wage and IDR 10.000.000, and a considerable 47.6 % (214 individuals) earned between IDR 10.000.001 and IDR 15.000.000. Only a minority, 4.9 % (22 individuals), reported an income exceeding IDR 15.000.000. Regarding the age distribution, the largest age group was the 30–39 age bracket, representing 30.7 % (138 individuals) of the total respondents, followed by the 20–29 age group at 27.1 % (122 individuals). The age groups of 40–49, 50–59, and 60+ comprised 22.7 % (102 individuals), 11.3 % (51 individuals), and 8.2 % (37 individuals) respectively.

About marital status, 59.3 % (267 individuals) of the respondents were married, while 40.7 % (183 individuals) were single. Examining residence type, self-ownership was predominant at 49.3 % (222 individuals), with renting following at 35.1 % (158 individuals). Riding from relatives and office facilities represented 8.0 % (36 individuals) and 7.6 % (34 individuals) respectively. When asked about the significance of the developer in their decision to purchase a TOD apartment, 53.8 % (242 individuals) perceived it as unimportant, while 46.2 % (208 individuals) deemed it important. Finally, the majority of respondents, 59.1 % (266 individuals), were non-permanent residents, with permanent residents constituting 40.9 % (184 individuals) of the respondent pool.

3. Result

After formulating a conceptual framework for enhanced

Table 2
Socio-demographic composition of the respondents.

Attribute		Frequency	Percent
Gender	Female	235	52.2 %
	Male	215	47.8 %
Income	<IDR Minimum wage (IDR 4.641.854)	93	20.7 %
	IDR Minimum wage (IDR 4.641.854) – IDR. 10.000.0	121	26.9 %
	IDR. 10.000.001 - IDR. 15.000.000	214	47.6 %
	> IDR. 15.000.000	22	4.9 %
Age	20–29	122	27.1 %
	30–39	138	30.7 %
	40–49	102	22.7 %
	50–59	51	11.3 %
	60+	37	8.2 %
Marital status	Married	267	59.3 %
	Single	183	40.7 %
Residency	Office facilities	34	7.6 %
	Rent	158	35.1 %
	Riding from relatives	36	8.0 %
	Self-ownership	222	49.3 %
Developer importance for buying TOD apartment	No	242	53.8 %
	Yes	208	46.2 %
Origins	Non-Permanent Residence	266	59.1 %
	Permanent Residence	184	40.9 %

environmental services using the Choice Experiment (CE) method, we evaluated the diversity in citizens' preferences concerning environmental services for Transit-Oriented Development (TOD) management in Jakarta. The empirical findings of the Random Parameters Logit (RPL) model are detailed in [Table 3](#). The log-likelihood function and the log-likelihood ratio (LLR) outlined in [Table 3](#) verify that our models exhibit substantial goodness of fit (GOF) for the additional environmental services, enabling the exploration of citizens' preference diversity and their Marginal Willingness to Pay (MWTP) in TOD management. The results from the RPL model reveal that the coefficients related to the levels of SNT2 (waste management services) and ACS1 (access to public transport) attributes are significantly positive. This denotes that respondents are inclined to contribute more financially to these specific strategies to enhance the prevailing conditions of TOD services. Moreover, the elucidated citizen preference variability and MWTP in TOD management disclose a preference for measures to alleviate traffic congestion and encourage sustainable urban living by enhancing the accessibility to public amenities and services (ACS1), with an MWTP of IDR 4237/month. This is succeeded by a preference for advancing waste management strategies, incorporating the 3R methodology: Reduce, Reuse, Recycle (SNT2), with an MWTP of IDR 3028/month.

We used the LCM to divide respondents into distinct classes according to their preferences and examine variances in the preferences among groups based on their socioeconomic backgrounds. The results of the LCM analysis showed that respondents were divided into two classes ([Table 4](#)). Latent class 1 was the lower (38.8 % of the sample), comprising permanent resident of Jakarta. = In contrast, latent class 2 (61.2 %) mainly included non-permanent resident. In latent class 2, respondents strongly preferred SNT2 with MWTP IDR 5623/month and ENV2 IDR 3912/month. Furthermore, the log likelihood function and the LLR value 350.817 (in [Table 4](#)) showed a high GOF for the target segmentation of TOD management than chi square 28.869.

Despite Indonesia's robust economic environment, as indicated by Indonesia's GDP per capita of around 4,798.12 U.S. dollars in 2022 ([O'Neill, 2023](#)), the WTP values for environmental services in TOD management appear moderate. For instance, the MWTP for improving waste management services is around IDR 3028/month, and for enhancing access to public transport is about IDR 4237/month. These relatively modest figures suggest that despite the general economic prosperity, residents' individual financial commitments towards these services are cautious and measured. This disparity between the high GDP and individual WTP values might stem from a variety of factors, including personal financial priorities, perceived value of the services, or a broader economic awareness. The LCM results add another layer to this understanding. The LCM segmented respondents into two classes, revealing that even non-permanent residents, who showed a higher

Table 3
Random Parameters Logit model.

Attribute and Level	Coefficient	S.E	MWTP (IDR/month)
SNT1	0.016	0.065	
SNT2	0.258***	0.055	3,028
ENV1	0.061	0.061	
ENV2	−0.018	0.056	
ACS1	0.361***	0.068	4,237
ACS2	0.092	0.064	
PAYMENT	0.0000852***	0.0000234	
Goodness of Fit			
Log-likelihood function	−1322.281		
Log-likelihood ratio (LLR)	321.751		
χ^2 (0.01,13)	27.688		
Choice sets	1350		

IDR: Indonesian Rupiah (1 USD = 15.424,30 IDR) (data from Google on 22 June 2023); ***, **, *: significance at 1 %, 5 %, and 10 % levels, respectively.

Table 4
Latent Class Model.

Attribute and Level	Cluster 1 (38.8 %)		Cluster 2 (61.2 %)		
	Coef.	S.E	Coef.	S.E	MWTP (IDR/month)
SNT1	24.756	2,373,000	−0.250	0.168	
SNT2	−21.155	2,306,000	0.447***	0.159	5,623
ENV1	6.409	972,862	−0.082	0.147	
ENV2	−16.165	1,050,000	0.311**	0.140	3,912
ACS1	22.142	1,314,000	0.001	0.254	
ACS2	−0.247	797,292	−0.050	0.141	
Payment	0.00057	34.154	0.0000795	−0.440	
Constant	−0.439	0.39482			
Cluster 1 sociodemographic					
Importance of developer	−0.018	0.197			
Permanent residence	0.351*	0.204			
Higher than IDR. 10.000.000, -	−0.336	0.206			
Goodness of Fit					
LLR	350.817				
AIC/N	1.964				
χ^2 (18,0.01)	28.869				

IDR: Indonesian Rupiah (1 USD = 15.424,30 IDR) (data from Google on 22 June 2021); ***, **, *: significance at 1 %, 5 %, and 10 % levels, respectively.

MWTP for certain services, still had moderate WTP values in the context of GDP per capita. This observation underscores the complex relationship between a region's economic strength and its residents' willingness to invest in environmental improvements.

4. Discussion

The application of the RPL model revealed nuanced insights into citizen preferences and willingness to pay (WTP) for various attributes in Transit-Oriented Development (TOD) management in Jakarta. The empirical observations from the RPL model depicted a pronounced inclination of citizens towards waste management services (SNT2) and access to public transport (ACS1), with the coefficients for these attributes being positively significant. This signified that the respondents were willing to pay a premium for advancements in these specific strategies, reflecting a heightened valuation of enhanced waste management and accessible public transport in augmenting the quality of TOD services. Analyzing citizens' WTP further, it was discerned that the initiatives aimed at curtailing traffic congestion and fostering sustainable urban living, by rendering public amenities and services more accessible (ACS1), registered a WTP of IDR 4237/month. This was trailed by the willingness to endorse the augmentation of waste management practices, leveraging the 3R concept: Reduce, Reuse, and Recycle (SNT2), with a WTP valued at IDR 3028/month. These monetary valuations mirror citizens' emphasis on sustainable and convenient living conditions (Sabyrbekov et al., 2020; Luo et al., 2022), underlining their aspiration for a balanced coexistence between urban development and environmental conservation. Furthermore, the results accentuated the preference heterogeneity among citizens regarding environmental services for TOD management. The discrete preferences reflected the divergent valuation and expectations citizens harbor for environmental services (Hua and Chen, 2019; Margier et al., 2023), urging a reevaluation of existing strategies to align them more closely with citizen priorities and values. These findings imply a need for policy recalibrations that focus on accentuating waste management services and improving public transport accessibility, as citizens perceive these as paramount in enhancing the overall TOD experience in Jakarta. Moreover, the discerned preference heterogeneity underscores the imperative of a more tailored approach in policy formulation, one that is conscious of the diverse needs and expectations of the citizenry.

The insights from the LCM uncovered two latent classes, demonstrating differentiated preference structures and willingness to pay

(WTP) across the identified classes. In the first latent class, which comprised 38.8 % of the sample, a predominant concentration of permanent residents of Jakarta was observed. This class presumably embodies the perspectives and preferences of individuals with a longstanding association with the city. Therefore, their preferences are likely shaped by their sustained interactions with Jakarta's urban environment and TOD management systems. Conversely, the second latent class, which represented 61.2 % of the sample, was primarily composed of non-permanent residents. This class manifested a significantly strong preference for enhanced waste management services (SNT2), expressing a WTP of IDR 5623/month, and improved air quality (ENV2), willing to allocate IDR 3912/month for enhancements in this realm. These preferences and WTP values could indicate the specific needs and values of non-permanent residents, possibly stemming from their transient interactions with the city and its environmental services. The differential preferences and WTP values observed across the two classes underscore the heterogeneous nature of citizen expectations and valuation of environmental services (Suryawan and Lee 2023a) in TOD management. This heterogeneity in citizen preferences illuminates the inherent diversity within the populace of Jakarta, with varying degrees of emphasis placed on different environmental attributes by permanent and non-permanent residents.

Thus, the elucidation provided by the LCM results is instrumental in shaping nuanced policy frameworks tailored to accommodate the diverse preference structures inherent in the citizenry of Jakarta. It necessitates the development of flexible and inclusive TOD management strategies designed to resonate with the varied preferences and expectations of the different segments within the population (Ibraeva et al., 2020; Phan et al., 2023), thereby ensuring the equitable provision and enhancement of environmental services in alignment with citizen values and needs. This detailed examination and segmentation of citizen preferences via LCM provide pivotal insights that can drive more precise and inclusive policy formulations and interventions, fostering an environment that reflects the collective aspirations and values of the diverse populace in Jakarta.

4.1. Policy recommendation for smart city

The current policy framework for Transit-Oriented Development (TOD) in Jakarta, as mandated by Governor Regulation Number 15 of 2020, designates the Mass Rapid Transit (MRT) Jakarta Limited Company as the TOD corridor manager. This regulation is a strategic move

towards integrating urban development with the transit system, aiming to create an environment where residential areas, trading centers, service centers, offices, and public spaces are interconnected and easily accessible through various modes of transportation like walking, cycling, or public transport. This policy aligns with Jakarta's smart city initiative, which seeks to optimize urban operational efficiency, improve the quality of public services and life, and foster sustainable development with a focus on enhanced connectivity and accessibility. The inception of TOD in Jakarta began with the development of the MRT in 2015, leveraging land around the stations for property development and integrating various aspects of urban life.

Adopting a comprehensive and integrative approach to environmental services is crucial to addressing the disparate needs and preferences highlighted by this study. This approach should be rooted in smart city concepts, leveraging advanced technologies and integrated solutions to optimize urban living. Incorporating smart city principles can lead to improved waste and wastewater management, enhanced air quality, increased green spaces, and more sustainable urban environments (Li, 2022; Liu et al., 2022), all reflecting the diverse preferences of Jakarta's citizens. Identifying preference heterogeneity among citizens mandates the adoption of nuanced urban development and planning strategies (Patil et al., 2020; Wu et al., 2023). This necessitates the creation of a sustainable urban habitat that accentuates accessibility and accommodates the diverse preferences of both permanent and non-permanent residents, leveraging smart city technologies to enhance connectivity, resource management, and service provision.

Policies should prioritize the seamless integration of reliable public transportation options with residential, commercial, and recreational spaces, leveraging smart city innovations to optimize traffic management, enhance mobility, and improve urban living experiences. This integration is foundational for advancing sustainable urban living and mitigating congestion, contributing to a more harmonious urban environment (Grace et al., 2023; Bianchi and Schmidt, 2023). Establishing multidisciplinary collaborations involving citizens, urban planners, and developers (Pykett et al., 2020; Sassmannshausen et al., 2021) is essential for crafting and implementing effective TOD management strategies informed by smart city insights. Active engagement with various stakeholders and integrating smart solutions are vital for ensuring that policies are well-rounded, effective, and resonate with the citizens' needs and preferences.

Moreover, creating adaptable policy frameworks enriched by smart city concepts is vital to address the dynamic preferences and varying willingness to pay for environmental services among citizens (He et al., 2021; Suryawan and Lee 2023a). Policies should be agile, evolving in response to the changing needs and preferences of the citizens and leveraging data-driven insights from advanced analytical models to ensure alignment with citizens' actual needs. Continued educational efforts and awareness campaigns are paramount to fostering an informed and conscious citizenry (López-Alcarria et al., 2019; Schneiderhan-Opel and Bogner, 2020), aware of the benefits of integrated environmental services in TODs and the value of sustainable urban living imbued with smart city principles. Emphasizing enhanced waste management services, including adopting the 3R concept, requires prioritization in policy formulation, coupled with establishing incentive structures to encourage the adoption of sustainable practices by both developers and citizens. To foster inclusive and equitable urban development, providing services must consider the diverse needs of all population segments. Utilizing smart city technologies can facilitate the creation of a more inclusive, sustainable, and hospitable urban environment in Jakarta, accommodating the diverse preferences of its citizens. By implementing these recommendations, policymakers can catalyze the transformation of Jakarta into a smart city characterized by innovation, sustainability, and inclusivity, thereby fostering a more harmonious and equitable urban living experience for all its citizens.

5. Conclusion

This study has delved into the intricate facets of Transit-Oriented Development (TOD) within the sprawling metropolis of Jakarta, illuminating the heterogeneous preferences of its citizens and shedding light on their willingness to contribute to the enhancement of integrated environmental services. It is evident that Jakarta, with its dynamic urban landscape and burgeoning population, is at the cusp of urban innovation, and the TOD is a pivotal catalyst in redefining urban living, enhancing accessibility, and fostering sustainability within the city. The study's findings underscore a diverse spectrum of preferences and needs among the citizens of Jakarta, revealing significant preference heterogeneity, necessitating nuanced and diversified approaches in TOD management and policy formulation. The integrated environmental services within TODs have the potential to elevate the quality of urban living substantially, but the realization of this potential hinges on the alignment of policies and management strategies with the diverse and evolving needs and preferences of the citizens.

Incorporating the smart city concept within the policy framework of Jakarta's TOD is integral in advancing sustainable urban development and aligning urban planning strategies with the principles of sustainable living and advanced urban solutions. The smart city concept accentuates the importance of integrating technological innovations, data-driven insights, and sustainable practices in urban development, ensuring resource optimization, urban service enhancement, and sustainability. In essence, this study provides valuable insights and pragmatic recommendations, contributing to the refinement of Jakarta's urban development strategies and policies. The nuanced understanding of citizen preference heterogeneity and their willingness to pay for integrated environmental services in TODs gained through this study is crucial for formulating impactful and resonant policies, paving the way for realizing a more sustainable, inclusive, and harmonious urban environment in Jakarta.

CRedit authorship contribution statement

I Wayan Koko Suryawan: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft. **Rachmat Mulyana:** Conceptualization, Data curation, Formal analysis, Project administration, Resources, Writing – original draft. **Iva Yenis Septiariva:** Data curation, Formal analysis, Investigation, Software, Writing – original draft. **Wisnu Prayogo:** Data curation, Formal analysis, Methodology, Writing – original draft. **Sapta Suhardono:** Conceptualization, Data curation, Formal analysis, Visualization. **Mega Mutiara Sari:** Conceptualization, Formal analysis, Writing – review & editing. **Nova Ulhasanah:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Dear Participant,

We are exploring to delve deep into the intricacies of citizen preferences and their willingness to pay for integrated environmental services within the domain of Transit-Oriented Development (TOD) in Jakarta, Indonesia. This endeavor is oriented towards analyzing the landscape of smart urbanism and citizen-centric approaches in one of the most dynamically urbanizing metropolises in the world.

Understanding the nuanced preferences and willingness to contribute to environmental service enhancements in TOD is crucial for shaping policies and practices that resonate with the principles of sustainable and smart urban development. In a city experiencing

unrelenting urbanization like Jakarta, TOD emerges as a critical urban development strategy, aiming to amalgamate residential, commercial, and recreational spaces while ensuring their seamless integration with efficient public transportation systems.

This research seeks to understand the dynamics of citizen preferences within the TOD framework and explore how integrating smart city initiatives and environmental services can elevate the quality of urban living. The insights gained through this study will be pivotal in formulating pragmatic and resonant policies and strategies, refining TOD management in Jakarta, and contributing significantly to urban landscapes' sustainable and equitable development.

Our exploration into the myriad of citizen preferences and behaviors is instrumental in aligning urban development and management strategies with the sustainability goals and smart city principles, ensuring that the urban habitat we create is advanced and sustainable and attuned to the diverse needs and preferences of its citizens.

Your invaluable insights and experiences will illuminate the intricate terrain of smart urbanism and preference heterogeneity in TOD, contributing to creating more inclusive, innovative, and citizen-centric urban environments. By participating in this study, you are playing a crucial role in shaping a future where urban development is not only conscious and respectful of the environment but also is more aligned with the needs and aspirations of its citizens.

We sincerely thank you for your valued contribution to this pivotal

urban landscapes in Jakarta.

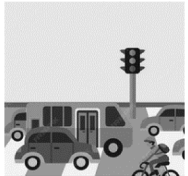
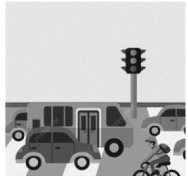
Warm Regards,

Section I

You are now entering a section of this survey where you will be asked to make a series of choices. These choices are constructed to help us understand your preferences, values, and willingness to pay for various aspects and features related to TOD in the context of Jakarta's urban environment and smart city initiatives. Please read the instructions and the provided information carefully before making your choices. In each choice task, you will be presented with different scenarios or alternatives, each described by a set of attributes. These attributes represent different aspects of TOD, such as environmental services, accessibility, and amenities. Your task is to review these alternatives and choose the one that you prefer the most. Please consider each alternative and attribute carefully and consider how much value you place on each attribute when choosing.

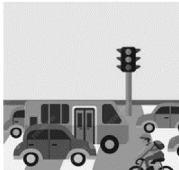
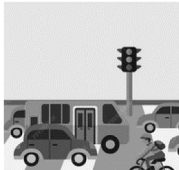
Remember, there is no right or wrong answer in this section. We are interested in your individual preferences and the choices that best reflect your values, needs, and aspirations regarding urban living and TOD in Jakarta. Please be as accurate and honest as possible in your responses, as this will aid in developing a deep understanding of citizen preferences and contribute to the formulation of effective and resonant urban development policies and strategies.

CHOICE SET 3

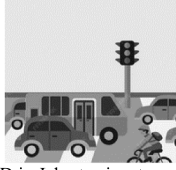
Attribute	Scenario 1	Scenario 2	Current Situation
Sanitation	 Enhancement of waste management practices, employing the 3R concept: Reduce, Reuse, Recycle.	 Jakarta faces challenges with sanitation, predominantly concerning wastewater.	 Jakarta faces challenges with sanitation, predominantly concerning wastewater.
Urban spaces	 Focused initiatives to improve air quality	 Focused initiatives to improve air quality	 The emphasis is on green urban spaces and air quality in Jakarta's environmental advancement strategies.
Access	 TOD in Jakarta aims to merge residential, commercial, and recreational spaces with efficient and reliable public transportation options.	 Improved access to shopping facilities, making commercial services more readily available to the public	 TOD in Jakarta aims to merge residential, commercial, and recreational spaces with efficient and reliable public transportation options.
Willingness to Pay (IDR/month)	IDR. 25,000/month	IDR. 10,000/month	IDR. 0/month
Please choose your preferences.	☐	☐	☐

exploration. Your participation is crucial in our collective journey toward realizing smarter, more sustainable, and more citizen-centric

CHOICE SET 3

Attribute	Scenario 1	Scenario 2	Current Situation
Sanitation	 Implementation of more advanced wastewater treatment technologies and methods.	 Implementation of more advanced wastewater treatment technologies and methods.	 Jakarta faces challenges with sanitation, predominantly concerning wastewater.
Urban spaces	 Expansion and enhancement of green open spaces.	 Focused initiatives to improve air quality	 The emphasis is on green urban spaces and air quality in Jakarta's environmental advancement strategies.
Access	 TOD in Jakarta aims to merge residential, commercial, and recreational spaces with efficient and reliable public transportation options.	 Improved access to shopping facilities, making commercial services more readily available to the public	 TOD in Jakarta aims to merge residential, commercial, and recreational spaces with efficient and reliable public transportation options.
Willingness to Pay	IDR. 25,000/month	IDR. 10,000/month	IDR. 0/month
Please choose your preferences	☐	☐	☐

CHOICE SET 3

Attribute	Scenario 1	Scenario 2	Current Situation
Sanitation	 Enhancement of waste management practices, employing the 3R concept: Reduce, Reuse, Recycle.	 Jakarta faces challenges with sanitation, predominantly concerning wastewater.	 Jakarta faces challenges with sanitation, predominantly concerning wastewater.
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Willingness to Pay	IDR. 25,000/month	IDR. 10,000/month	IDR. 0/month
Please choose your preferences.	☐	☐	☐

Section II: Social-Demographic Data

- Gender: ☐ Male ☐ Female
- Income: ☐ ≤ IDR 5.000.00 ☐ IDR 5.000.000 – IDR. 10.000.000 ☐ IDR. 10.000.001 - IDR. 15.000.000 ☐ > IDR. 15.000.000
- Age: ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59
- Marital status: ☐ Single ☐ Married
- Residency: ☐ Office facilities ☐ Rent ☐ Riding from relatives ☐ Self-ownership
- Developer importance for buying TOD apartment: ☐ No ☐ Yes
- Origins: ☐ Non-Permanent Residence ☐ Permanent Residence

Thank you for your cooperation and thoughtful consideration in this section of the study. Your insights are invaluable in our pursuit to understand preference heterogeneity and to integrate citizen-centric and smart approaches in the development of sustainable and inclusive urban landscapes.

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