

Towards Inclusive Urban Mobility: GEDSI Insights for Sustainable Transport in Kedungsepur Metropolitan Area

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Abstract This study pioneers the application of Gender Equality, Disability, and Social Inclusion (GEDSI) analysis in a metropolitan context, focusing on transportation behaviours and preferences across genders and vulnerable groups in the Kedungsepur Metropolitan Area (KMA). Through a comprehensive mobility survey involving 6,113 participants, including the elderly, children, low-income groups, and individuals with disabilities, this study investigated the key determinants of public transport use and infrastructure performance. Using descriptive statistics and a logit model, the study reveals significant gender differences in travel behaviour, with women being more likely to use public transport due to safety concerns and their multifaceted roles, while men predominantly rely on private vehicles. Income levels also shape transportation choices, with higher-income individuals favouring private car use. Safety perceptions, particularly among women, have emerged as critical factors influencing public transport decisions. Furthermore, the analysis highlights infrastructure gaps, such as inadequate bike lanes and handicap parking, which deter vulnerable populations from using public transport. By illustrating how demographic factors, such as gender, age, education, safety perceptions, and access to private vehicles interact to shape public transport use and infrastructure performance, this study provides actionable insights for policymakers. The findings emphasise the importance of targeted interventions to enhance public

transport infrastructure and safety, fostering inclusive and sustainable urban mobility.

Keywords Urban Transport, Gender Differences, Vulnerable Groups, Public Transportation, Transportation Policy

1. Introduction

Urban areas are in a constant state of flux driven by population growth, economic transitions, and changing lifestyles [1]–[3]. Central to this dynamic urban evolution are transportation systems, which significantly impact the quality of life, environmental sustainability, and economic prosperity. To address the multifaceted challenges of urban mobility, the European Commission introduced Sustainable Urban Mobility Plans (SUMP) as part of its 2009 Action Plan for Urban Transport. This initiative aims to incorporate sustainability and efficiency into urban transportation, thereby enhancing the overall urban experience. SUMP were designed as structured frameworks to aid cities in developing and implementing sustainable mobility strategies [4], [5].

Since the inception of SUMP, notable advancements have been made, culminating in the publication of official guidelines in 2013. This milestone marked a pivotal

moment in European urban-mobility planning. However, a systematic review of scientific databases has revealed several limitations in the existing literature: a predominant focus on Europe, an emphasis on novel indicators, limited references to prior studies, and a lack of qualitative approaches and stakeholder diversity in the assessment methods [6]. The diversity of indicators and inconclusive findings highlights a fragmented research landscape. Consequently, there is a growing call for SUMP to incorporate more reliable and inclusive assessments with a particular emphasis on local Gender, Equality, Diversity, and Social Inclusion (GEDSI) conditions. Such considerations are essential for further development of SUMP and the broader pursuit of transportation sustainability [7]–[9].

In academic discourse, just as transportation systems shape urban structures, gender also shapes societal frameworks. Gender is an intrinsic component of the broader social setting and interacts with factors such as class, race, ethnicity, income, education, religion, and geographic location [10], [11]. It prescribes societal expectations for conduct, attire, and image, encompassing travel behaviour. Travel patterns are among the most conspicuous gender-biased aspects of life [12].

Adopting a gender-sensitive perspective in transportation planning is imperative when scrutinising how gender shapes travel behaviour and patterns. Evidence underscores the significant impact of transport infrastructure and services on empowering marginalised groups, including women. Transportation plays a crucial role in enhancing the productivity of women and fostering social equity. Recognising the disparities between men and women in terms of transportation needs and experiences, such as access to private transportation, commuting and employment patterns, childcare and eldercare responsibilities, and fundamental attitudes toward private and public transportation, is essential for addressing equity within the transportation sector [13], [14].

Transport requirements are not gender neutral. Research indicates that men and women are differentially affected by time, distance, choice of transport mode, and the purpose of travel [15]. Consequently, it is imperative for transport policies to acknowledge and rectify these disparities [16]. This analysis aimed to explore distinctions among gender groups, encompassing not only women and men but also other vulnerable demographics, such as children, youth, the elderly, and individuals with disabilities. This study applies gender analysis to gauge variations and relevance among each targeted demographic group.

2. Methodology

2.1. Description of Kedungsepur Metropolitan Area (KMA)

This study explores transportation behaviours and preferences among different genders and vulnerable

groups in the Kedungsepur Metropolitan Area (KMA), aiming to inform urban transport policy and planning. The KMA is one of the largest metropolitan areas in Central Java, Indonesia, covering a total area of 4,955.57 km² and is home to approximately 6.57 million inhabitants as of 2020. As shown in Figure 1, the region consists of six districts: Semarang City, Semarang Regency, Demak, Kendal, Grobogan, and Salatiga. It features a diverse mix of urban and rural areas, with significant socioeconomic variations and varying levels of infrastructure development. These characteristics make the KMA a critical case study for examining transportation patterns, particularly among vulnerable groups, who often face challenges in accessing public transport due to the region's uneven development.



Figure 1. Kedungsepur Metropolitan Area (KMA) map

Women in the KMA generally have lower income levels and less representation in strategic positions than men. Disparities regarding gender equality also exist between different districts and cities within the KMA. The Gender Empowerment Index (GEI), which measures women's participation in economic, political, and decision-making processes, was used to assess these disparities. For instance, Grobogan and Demak had moderate GEI, indicating limited female participation in leadership roles. In contrast, other districts and cities such as Semarang had a higher GEI, reflecting stronger gender equality. Thus, women in Grobogan and Demak face greater disparities than those in other areas. The Ministry of Women's Empowerment and Child Protection attributes these gaps to patriarchal cultural norms, which contribute to male dominance in development and economic activities and hinder women's progress.

2.2. GEDSI Analysis

The GEDSI refers to Gender Equality, Disability, and Social Inclusion. It is a framework that focuses on ensuring equal access to resources, opportunities, and services, especially for marginalised and vulnerable groups, such as women, people with disabilities, the elderly, and low-income individuals. In the context of transportation planning, GEDSI analysis examines how different demographic groups experience mobility challenges and identifies barriers to their access to public and private transportation.

Gender analysis, as part of the broader GEDSI framework, is a systematic process aimed at identifying gender disparities and the relevance of gender considerations in transportation planning [17]–[19]. This approach evaluates how policies, facilities, and services affect women and men differently, revealing the influence of societal norms on travel behaviour and patterns. Importantly, GEDSI analysis does not make direct comparisons between genders but instead focuses on the unique mobility needs of different population segments, with an emphasis on inclusivity and equitable access [20].

In this study, the analysis employed descriptive statistical and inferential methods. Given that the sample consisted of diverse demographic populations, the analysis was divided into two sections: gender difference analysis and vulnerable group analysis. The gender difference analysis aims to compare the mobility patterns of men and women in utilising private or public transportation. This includes the examination of travel purposes, mileage, income distribution, transportation costs, access to private vehicles, and safety perceptions. Descriptive statistical techniques were used to identify gender differences in each aspect.

Vulnerable group analysis aims to identify factors that significantly affect the access of vulnerable groups to public transportation. It is worth noting that vulnerable groups can vary in different contexts, but here it is defined as a disadvantaged population, such as people with disabilities, women, children, the elderly, and low-income populations that face additional challenges and for whom transport systems fall short of addressing their mobility needs. These disadvantaged groups are more likely than others to experience higher levels of poverty and significant levels of transport disadvantages and physical barriers in transport systems [21]–[23]. To better understand their access to public transportation, an inferential method, specifically the logit model, was

employed for this purpose. A logit model is a type of statistical analysis that helps predict the likelihood of an event happening, in this case, the likelihood of an individual choosing to use public transport. The model considers various factors (e.g. gender, age, education, safety perceptions, and access to private vehicles) and estimates the probability that someone will choose public transportation over private modes of transport.

The vulnerable groups considered in this study included the elderly (aged 60 or more), children (aged 18 or less), people with disabilities (PWD), and low-income individuals (earning less than 2 million rupiahs monthly). A total of 6,113 respondents were interviewed during the data collection process, from June to August 2022. Of these individuals, nearly half were women (2,717 respondents), with an average age of 34 years. The respondents' employment status varied, with the majority reporting being entrepreneurs (19.8%) or employees (26.8%). Most respondents in the KMA region reported monthly earnings of IDR 3,000,000 – 4,000,000. Educational attainment among respondents showed that the majority (3,693 individuals) were senior high school graduates, while only 22 held a master's or doctoral degree.

Sampling data for this study were collected through a mobility survey. Respondents were selected through stratified random sampling to ensure balanced representation across the KMA. The questionnaire, developed with input from transportation and gender experts, included questions on travel behaviour, safety perceptions, and access to different transportation modes. Data were analysed using descriptive statistics for initial trends and a logit model for detailed insights into the factors influencing public transport use. The sample aimed to achieve a balanced representation of women and men, and included commuters and specific GEDSI respondents, such as the elderly, children, low-income individuals, and people with disabilities (Table 1).

Table 1. Respondents of KMA's mobility survey

No	Questionnaire Surveys	Respondent target			
		Private Vehicle Users		Public Transport Users	
		Male	Female	Male	Female
1.	Semarang – Kendal Corridor	639	302	738	1113
2.	Semarang – Demak Corridor	703	239		
3.	Semarang – Grobogan Corridor	932	486		
4.	Semarang – Kab. Semarang Corridor	344	161		
Sub-total Respondents		3.806		1.854	
GEDSI observation and interview survey		Male		Female	
5.	Children	38		51	
6.	Elderly	35		37	
7.	Poor people	85		102	
8.	Person with disability	105			
Total respondents		6.113			

Despite some limitations, including the inability to collect certain data in the KMA which was subsequently substituted with different respondents, the analysis successfully captured the objectives of the study. The findings are valuable for policymakers, as they inform policy planning, development, and implementation strategies in urban transport. Specifically, the data provided insights into the mobility characteristics of both private and public transport users.

3. Results and Discussion

The promotion of social cohesion and gender equality in transportation requires a comprehensive and systematic approach. This approach involves several key elements: conducting a gender-sensitive analysis to understand diverse transportation needs; developing inclusive policies that address the specific challenges faced by different user groups; and implementing targeted interventions to improve accessibility and equity. This section examines the gendered aspects of transportation in the KMA, focusing on the differences and challenges faced by all users, particularly women and other vulnerable groups.

3.1. Travel Purpose and Behaviour

As shown in Figure 2, the results reveal that the primary travel purpose for both women and men in the KMA is work-related. However, men engage in considerably more travel for work than women do, reflecting gender disparities in employment status. Statistics indicate that a higher number of men in Central Java and KMA districts are employed and actively participate in work-related activities than women. Conversely, women in the KMA are more likely to travel for non-work-related activities, particularly studying and shopping, which aligns with existing literature [24]. Societal gender norms often assign women roles in home maintenance and caregiving, influencing their daily travel behaviour. Interestingly, men in the KMA also travel for family purposes, although their primary travel motive remains work-related, facilitated by greater access to private vehicles.

The survey results further indicate that men in the KMA engage more in social-related activities than women, contrary to traditional expectations. This discrepancy suggests that gender norms and cultural factors play a significant role in travel decisions, affecting women more severely and limiting their leisure opportunities. Women face societal constraints regarding where they can go and what activities they can participate in during their leisure time, reflecting their roles as caregivers and supporters within the household. By contrast, men generally face fewer obstacles and enjoy more privileges in leisure travel.

When examining respondents aged 22 years and older, work emerged as the primary reason for travel for both men and women, whether using private or public transportation (Figure 3). However, women exhibit a higher tendency to use private vehicles, especially for shopping, potentially because of the flexibility and comfort offered compared with public transportation. Women's travel behaviour is shaped by their multiple roles and responsibilities, encompassing employment, household duties, and caregiving responsibilities. Despite a significant reliance on public transportation, it has been suggested that preferences for transportation modes in Semarang can vary based on factors such as destination, distance, route, and travel companions. Private vehicles are often preferred for shopping, because of their perceived time efficiency.

3.2. Preferences to Public Transportation

Gender influences transportation mode preferences in the KMA, as highlighted in Figure 4, which shows that the majority of private transport users are men, whereas nearly 60% of public transport users are women, across all age groups. This disparity underscores the existing barriers to women's access to private vehicles in Semarang, where women often choose more varied transportation modes influenced by travel distances. In contrast, men predominantly favour private vehicles, regardless of their destination, purpose, or travel companions.

Figure 5 shows that women in the Kedungsepur Metropolitan Area (KMA) have access to private vehicles regardless of their household income status. This finding suggests that economic status alone does not determine vehicle ownership. Instead, transportation choices are influenced by various factors, including personal preferences, travel needs, and the quality of public transport options. Women from both lower- and higher-income households may prioritise public transportation because of considerations such as convenience, cost, or the effectiveness of available public transport rather than solely relying on economic status to dictate their vehicle ownership.

The survey identifies BRT Trans Jawa Tengah as the most widely used public transport mode by women in Kedungsepur, followed by BRT Trans Semarang and Angkutan Kota Mikrolet as shown in Figure 6. Similarly, men in the KMA prefer these modes, with BRT Trans Jawa Tengah's extensive coverage across the KMA districts and other Central Java regions catering to the survey's commuter respondents. The perceived convenience and affordability of BRT services subsidised by the government make them popular choices over conventional public transport options.

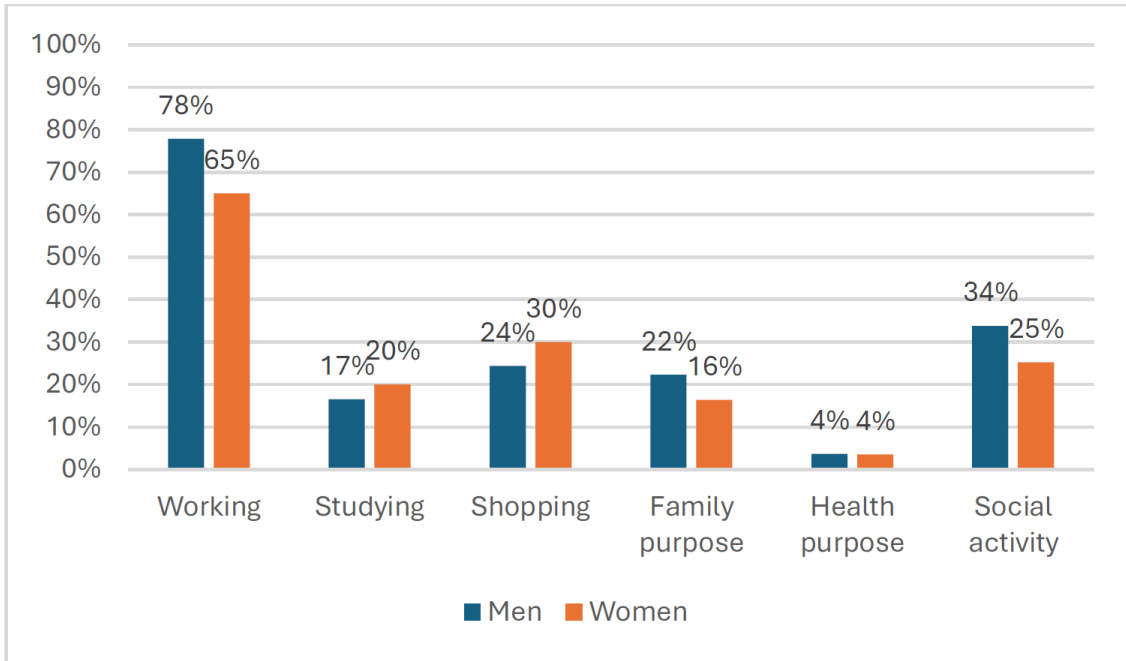


Figure 2. Travel purpose by gender

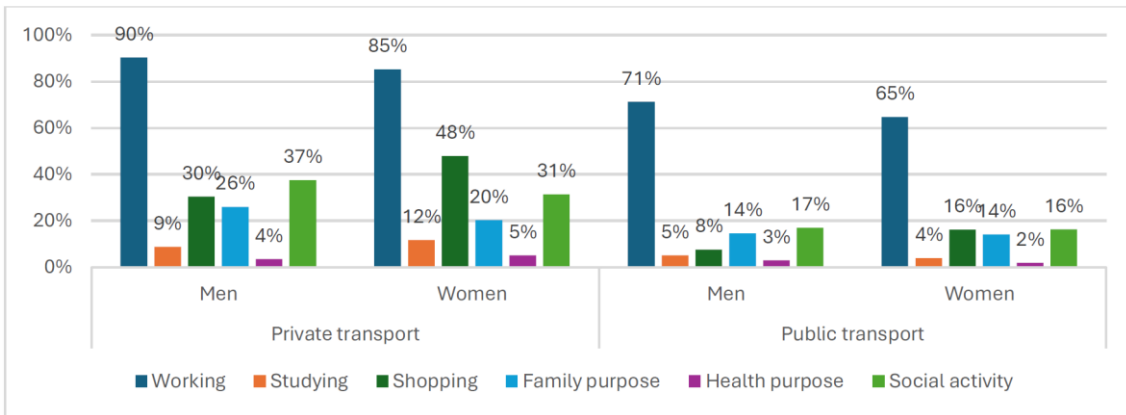


Figure 3. Travel Purposes of Individual Aged 22 and Above by Transportation Types and Gender

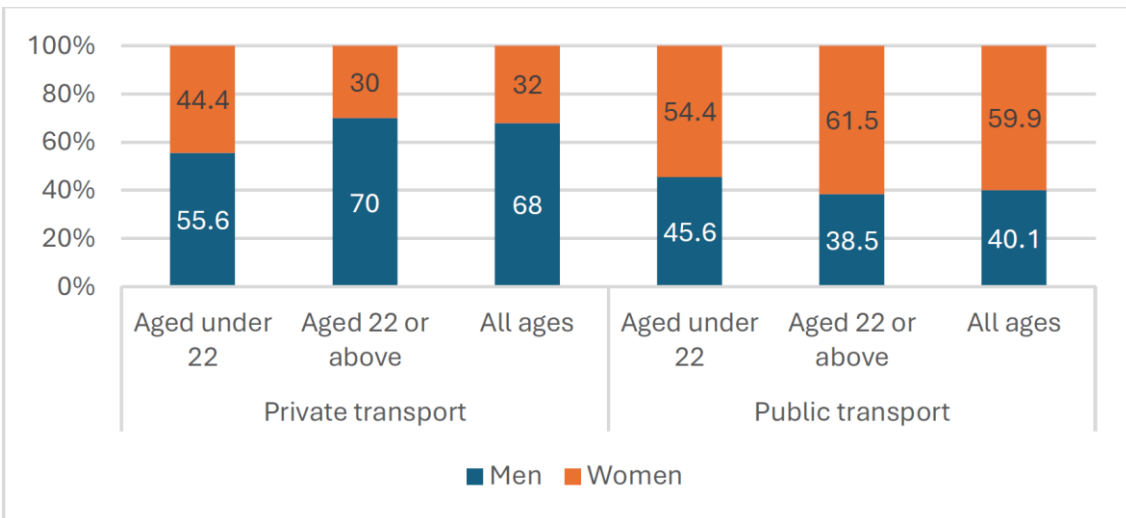


Figure 4. Gender Distribution of Transportation Users by Age Categories and Transportation Types

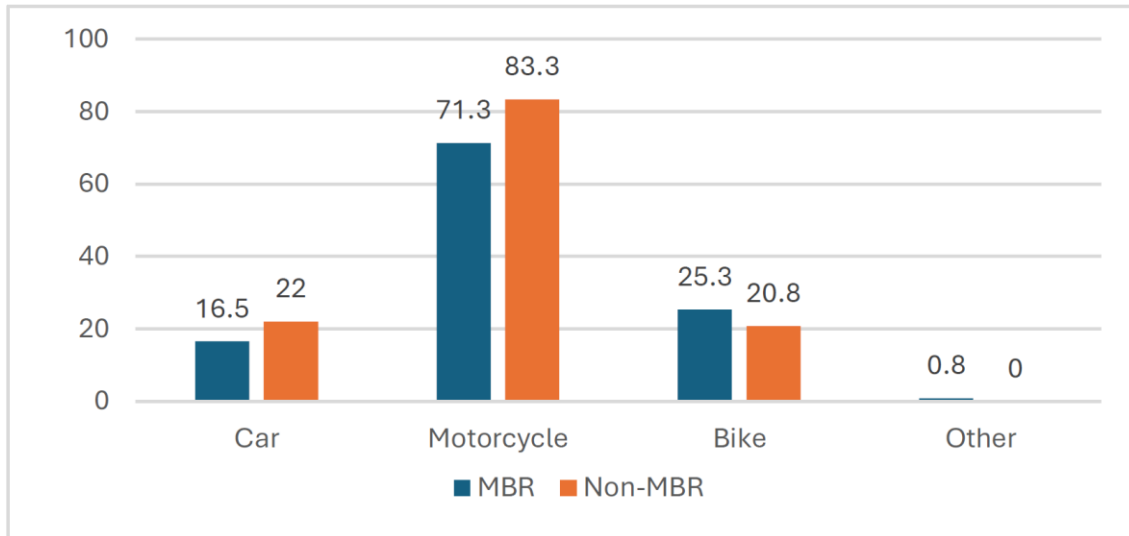


Figure 5. Women's Access to Private Vehicles among Public Transport Users by Welfare Groups

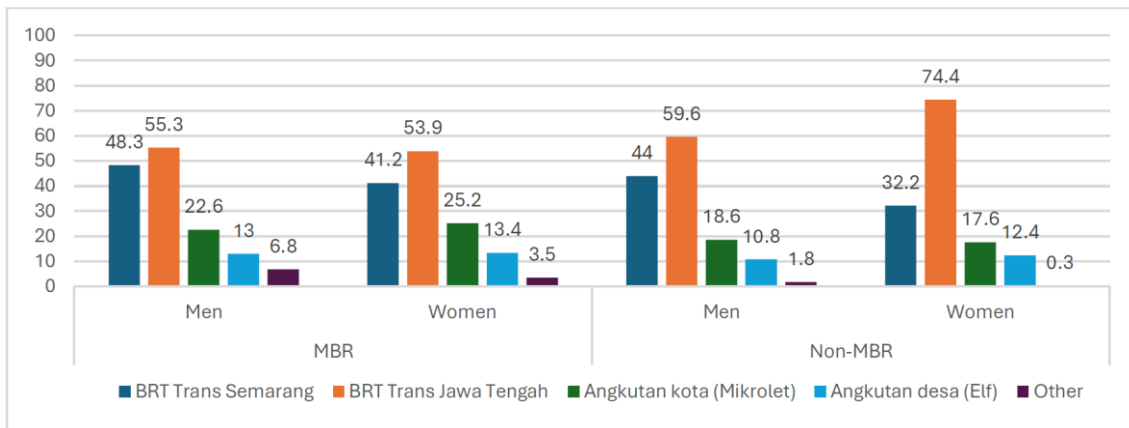


Figure 6. Public transport modes by gender and welfare group

Notably, the usage of BRT Trans Jawa Tengah varies by income group, with higher-income individuals predominantly utilizing this mode, while lower-income groups opt for BRT Trans Semarang or Angkutan Kota Mikrolet (Mikrolet). This distinction reflects differing travel purposes and distances, with non-MBR respondents primarily engaged in formal employment requiring longer commutes, in contrast to MBR respondents, who are often students, homemakers, or freelancers travelling shorter distances.

Affordability emerged as the primary reason for choosing public transport (Figure 7), with BRT Trans Jawa Tengah and Semarang offering lower fares due to government subsidies. The current average fare for public transport users in the KMA is cost-effective, particularly for low-income households. The government subsidises operational costs, keeping fares affordable, while maintaining service quality. Convenience and speed also play a role in mode selection, with BRT Trans Jawa Tengah being noted for its fleet quality and service reliability, making it particularly suitable for longer commutes. Although safety is typically a greater concern

for women, safety considerations rank low among both men and women who use public transport in the KMA. This may reflect the general perceptions or effectiveness of existing safety measures across all modes of public transportation.

3.3. Income Distribution and Transportation Cost

Figure 8 highlights the distinct gender disparity in income levels among private transport users but not among public transport users. On average, male users of private transportation earn significantly more than their female counterparts do. While both male and female private transport users are predominantly within the lower-income bracket (less than 3 million rupiahs), the concentration is notably higher for women. Approximately 80% of women's private transport users earn less than 3 million rupiahs, compared to less than 70% of men. Conversely, the middle-income bracket (3 to 6 million rupiahs) is dominated by men, with 30% of male private transport users falling within this range compared to only 15% of women.

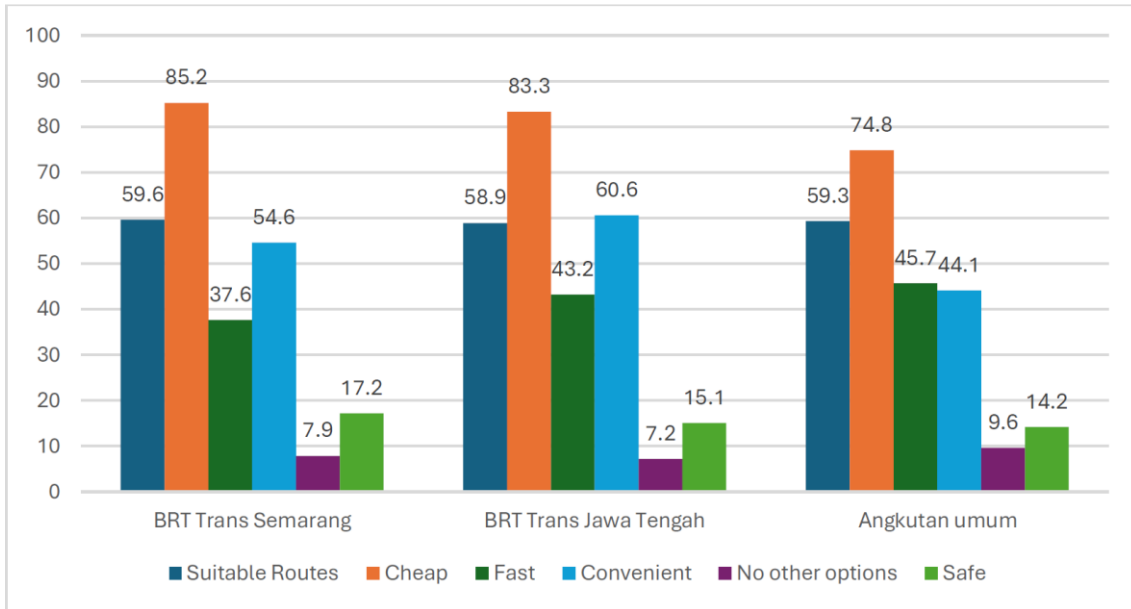
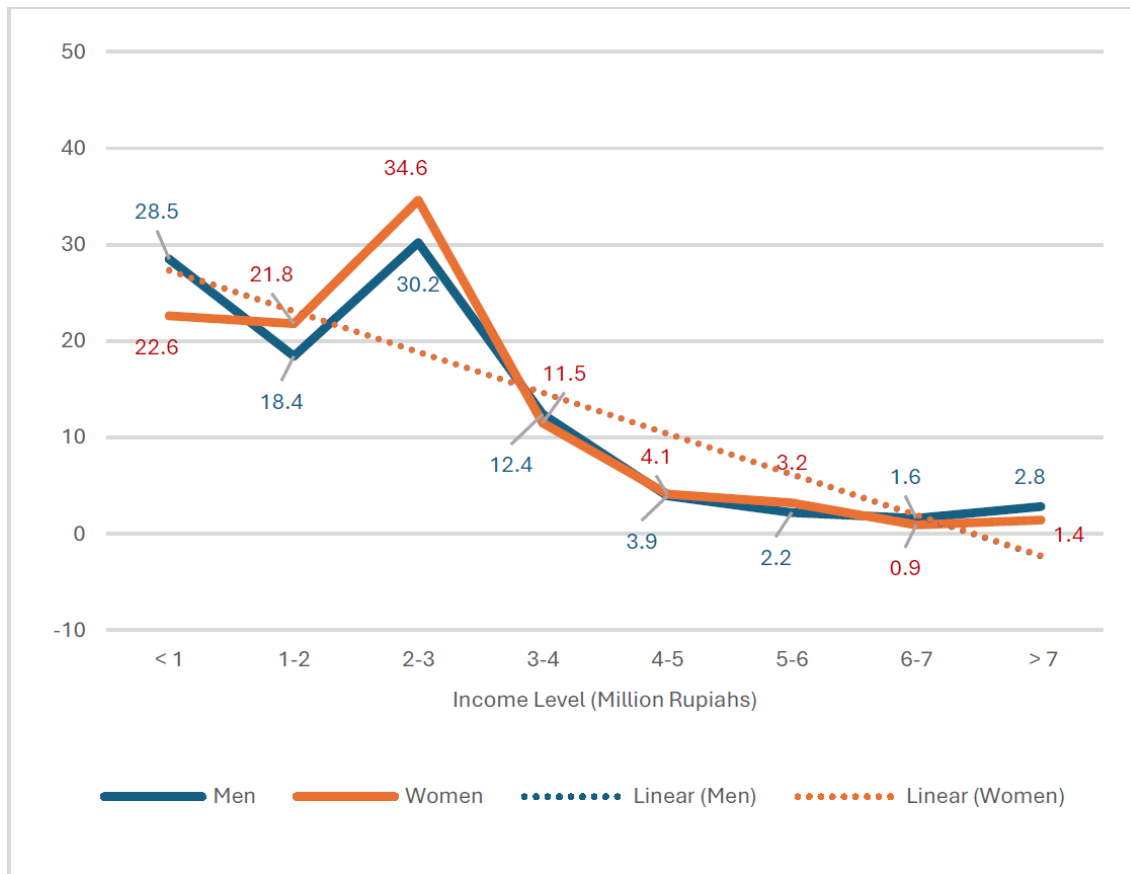


Figure 7. Reasons for Using Public Transport Modes



(a) Private transport users



(b) Public transport users

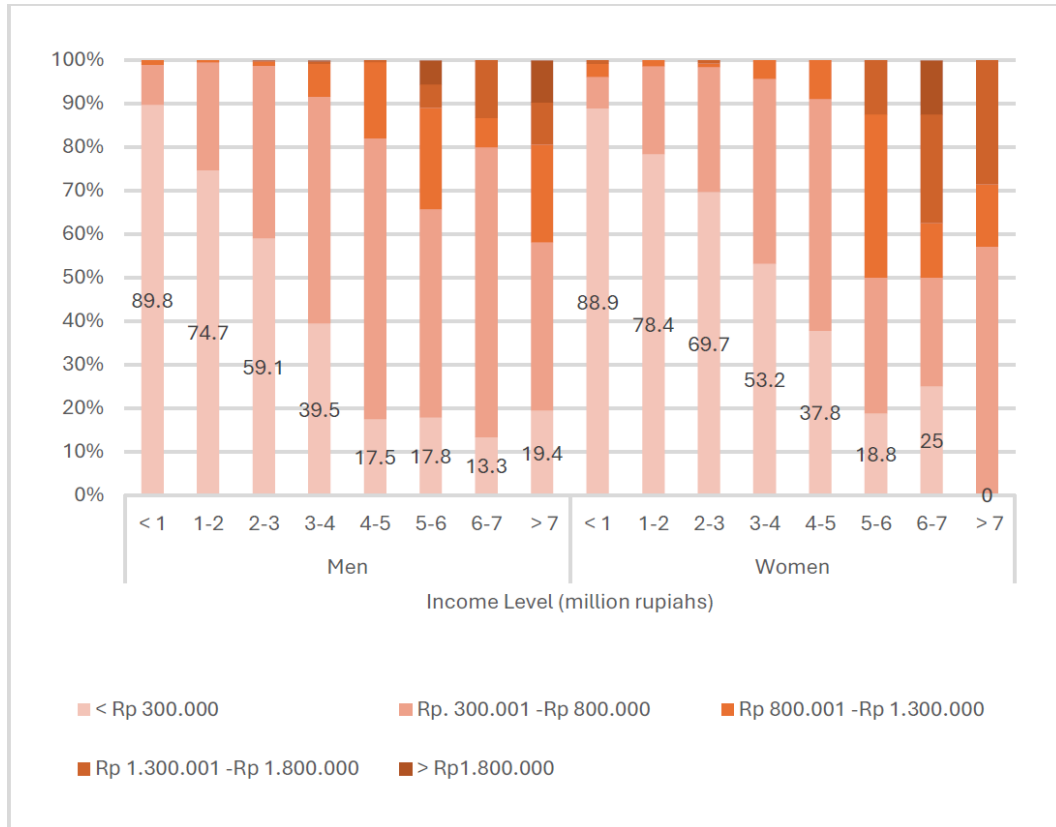
Figure 8. Distribution of income level by gender and transportation type

Regarding transportation costs, Figure 9 demonstrates a clear correlation between income levels and transportation expenditure. High-income individuals spend more on transportation, a trend consistent across genders and for both private and public transportation users. This finding suggests that wealthier individuals tend to travel more frequently. However, spending on private transportation varies more widely than that on public transportation, particularly among high-income individuals. Nearly 20% of the highest-income men spend no more than 300,000 rupiahs on private transportation, whereas a similar proportion spends over 1,300,000 rupiahs. In comparison, 30% of the wealthiest men spend less than 300,000 rupiahs on public transportation, with only approximately 8% spending over 1,300,000 rupiahs. This trend is even more pronounced among women, illustrating that private transportation is considered a superior good, with spending being more responsive to income increases compared to public transportation.

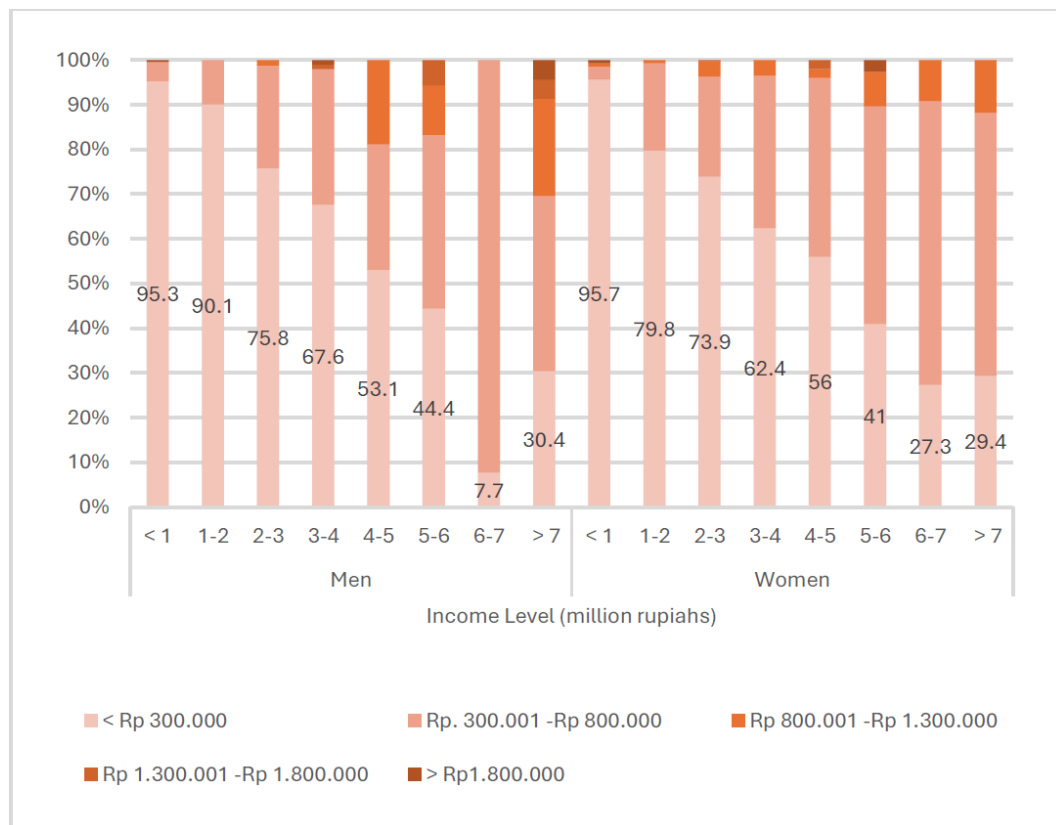
The trend line in Figure 10 underscores the superiority of private transportation. As income levels rise, public

transportation users are increasingly likely to shift to private transportation. This trend is similar for both men and women, and is particularly noticeable between the 3-4 million- and 4-5-million-rupiah income brackets. At the 3-4 million level, 29% of men and 19% of women were willing to switch to private transportation with an income increase. These proportions significantly rise at the 4-5 million level to 62.5% for men and 58% for women, indicating that private transportation offers benefits that justify the higher costs.

The respondents' reasons for choosing private transportation included flexibility, speed, and convenience, as shown in Figure 11. Flexibility is the most cited advantage, followed by speed, despite the congestion potentially affecting car travel times. Convenience is also a significant factor, with cars being most likely to offer this benefit. Interestingly, safety is not the primary reason for choosing private transportation, which is similar to public transport users. This suggests that safety is not a priority concern for KMA residents, regardless of the transportation mode.



(a) Private transport users



(b) Public transport users

Figure 9. Monthly Transportation Spending by Income Level and Gender

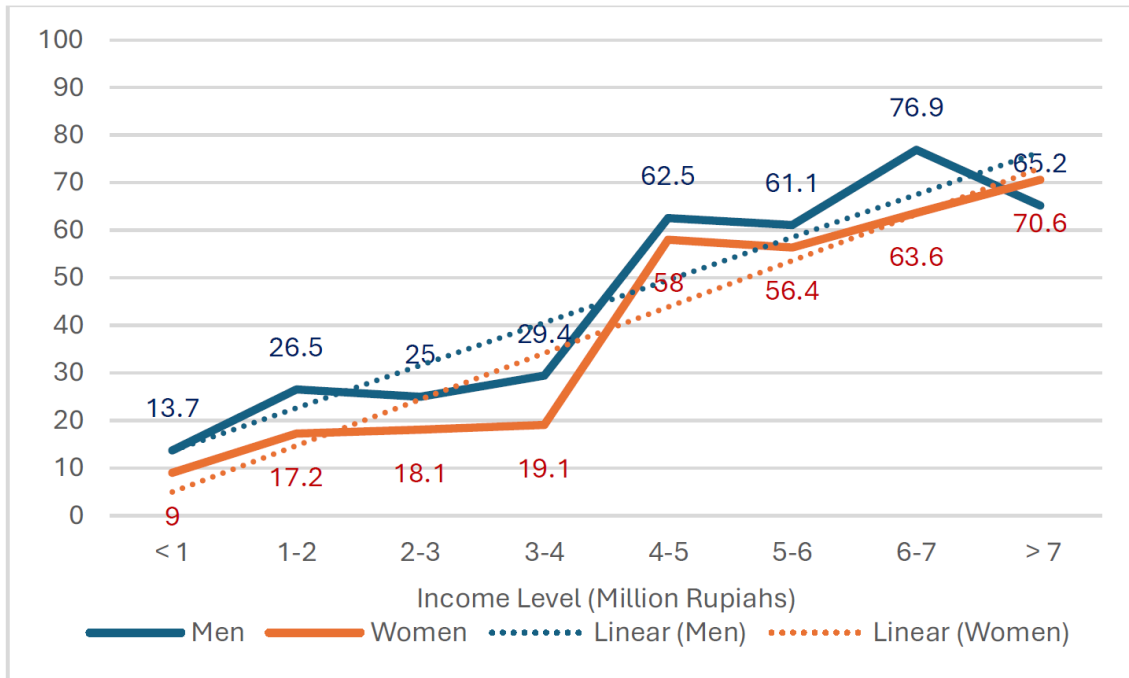


Figure 10. Prevalence of Public Transport Users to Willingly Shift to Private Transport for an Increase in Income

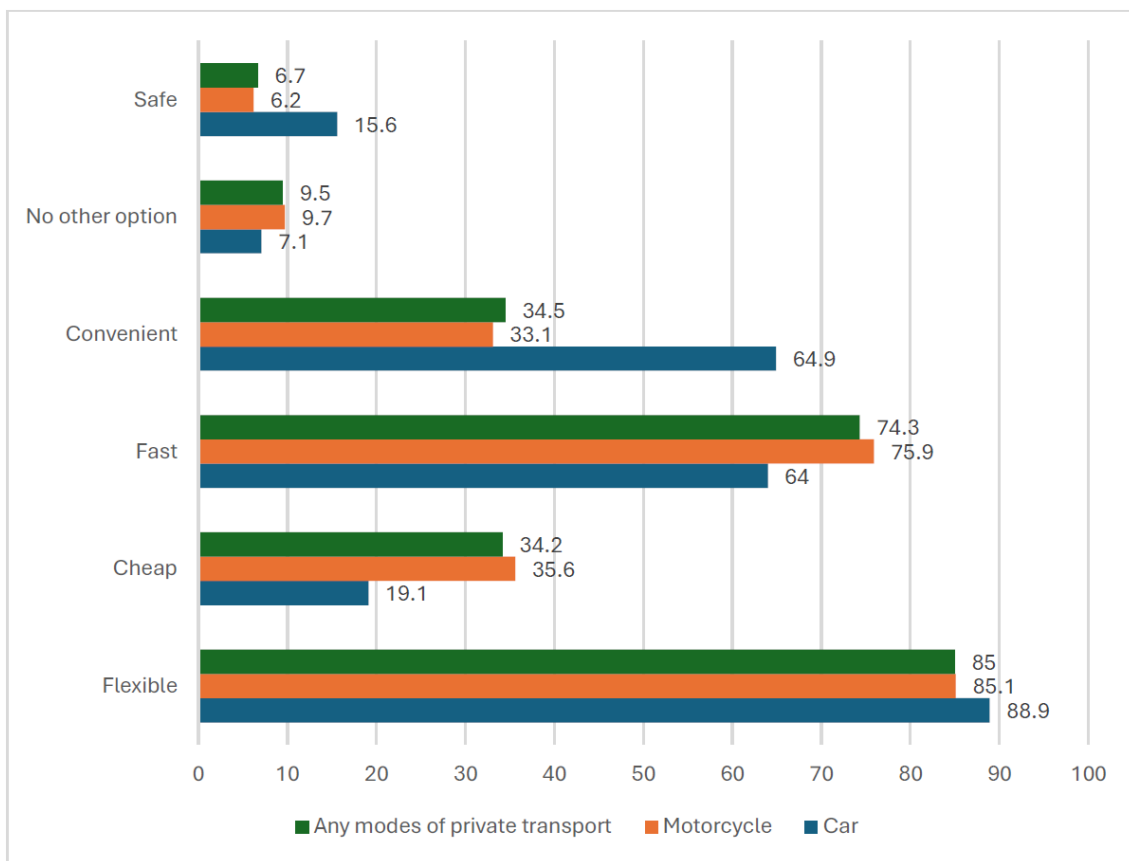


Figure 11. Reasons for Using Private Transport Modes

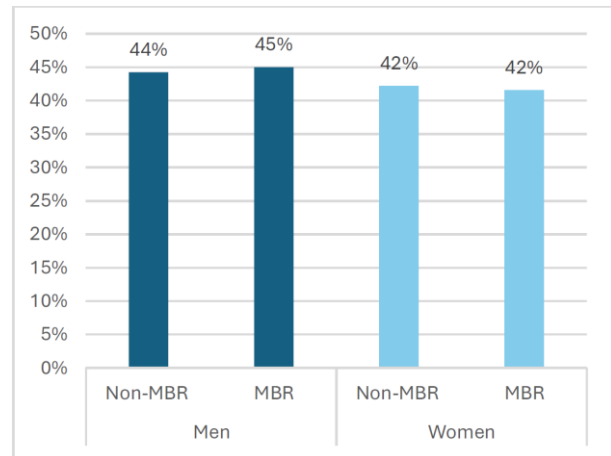
3.4. Perception on Transportation Safety

Safety is a critical component of transportation and often a primary concern for users, particularly women. In the Kedungsepur Metropolitan Area (KMA), women perceive walking in public areas to be less safe than men. As shown in Figure 12, only 40% of the women felt safe walking, which was 3% lower than the percentage of men who felt safe. Among women who use private transport, the sense of safety while walking is even lower, and these women feel unsafe walking at a prevalence rate 2.5 times lower than that of women who use public transport. Notably, none of the women from higher-income (non-MBR) households who use private transport believe that walking in public areas is safe. This can be explained by their limited exposure to walking as private vehicle users are less likely to engage in pedestrian activities. Additionally, higher-income women may have heightened concerns about safety risks, such as theft or harassment, and may prefer private transportation for its perceived security. Only 18% of the female private transport users from lower-income groups felt safe walking. This suggests that women with more exposure to walking, such as public transport users who walk to and from bus stops, may feel safer than those with less experience. Men in the KMA exhibit similar patterns, with public transport users feeling safer walking than private vehicle users.

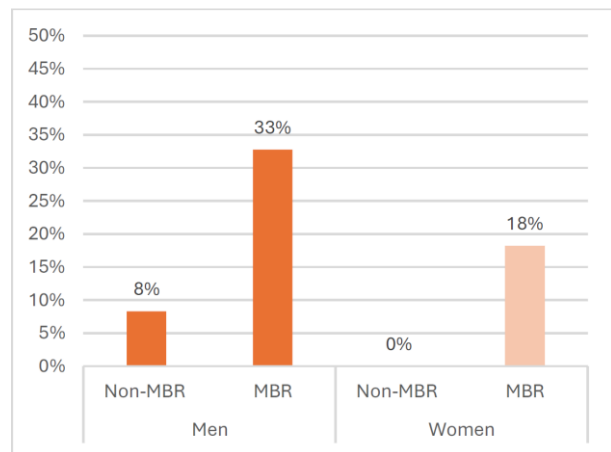
Welfare status also influenced safety perceptions among respondents with private vehicles in the KMA. Both women and men in higher-income groups felt less safe walking than those in lower-income groups, indicating different safety expectations between these groups. High-income individuals may have more experience in walking in well-maintained and safer public places, leading to higher safety standards. In contrast, lower-income groups may have greater tolerance for risks owing to the absence of higher safety benchmarks. This finding underscores the role of individual experience in shaping safety perceptions, which, in turn, affects walking decisions. Craig et al. [25] highlighted the significant impact of psychological factors on the decision to walk in public areas.

The results in Figure 13 show that the primary concern among respondents when walking is the risk of being hit by vehicles owing to poor footpath conditions (26%), highlighting the need for safer, dedicated pedestrian

pathways. Additionally, 17% of the respondents cited the absence of officers to assist with crossing as a significant concern, indicating the importance of better pedestrian management at intersections. Another 14% pointed to the overall poor quality of footpaths and road facilities, such as uneven surfaces and insufficient lighting, as deterrent. These findings emphasise the critical role of infrastructure improvement in enhancing pedestrian safety and encouraging walking.



(a) Public transportation users



(b) Private transportation users

Figure 12. Prevalence of respondent who believe walking in the footpath as somewhat safe by gender, welfare status and type of transportation used

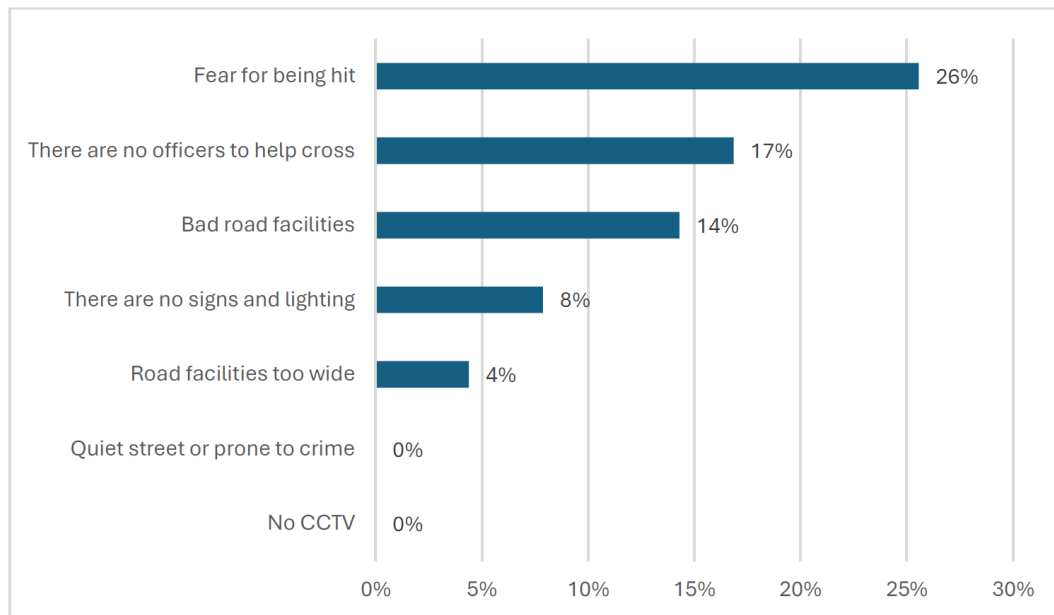


Figure 13. The reasons of fear to walk in the public area

In addition to the fears associated with walking, women in the KMA also perceive public transportation as unsafe. The survey, as shown in Figure 14, found that nearly half of the women (41%) perceived public transport as somewhat unsafe compared to 38% of men. Women who use private vehicles are more likely to perceive public transportation as unsafe than public transport users. Only 16% of women who use private transport believe that public transportation is somewhat safe, which is 2.6 times lower than the same perception among women who use public transportation. Safety perceptions are closely related to individual experience; women who frequently use public transport might perceive it as safer due to their regular exposure, whereas women who use private vehicles may feel unsafe based on limited experience and external information such as news reports.

Therefore, it is essential to consider the implications of safety perceptions in the Kedungsepur metropolitan area (KMA). The fact that 85% of women perceive public transportation as unsafe, particularly those who primarily use private vehicles, highlights the significant challenge of promoting public transport as a viable and sustainable alternative. Safety concerns likely arise from various factors, including inadequate security measures, poor lighting, overcrowding, and reports of harassment, all of which deter women from using public transport. This perception gap, especially between women who use public transport and those who rely on private vehicles, suggests that familiarity and exposure to public transport can improve safety perceptions. Targeted interventions are

necessary to support the KMA's sustainable transport goals. Enhancing safety measures, such as increasing the visibility of security personnel, improving lighting at bus stops and transit stations, and implementing real-time surveillance systems, could help mitigate these concerns. By addressing these critical safety issues, the KMA can foster greater public transport use among women, reduce dependency on private vehicles, and align with sustainability objectives through lower emissions and reduced traffic congestion. These improvements would contribute to a more inclusive and efficient urban transport system that is integral to achieving long-term environmental and social goals.

The survey also indicated that respondents who perceived public transport as somewhat safe generally rated public infrastructure performance positively. However, there are significant gaps between the perceptions of the general population and those of those who feel safe using public transport regarding bus performance in the KMA, as shown in Figure 15. While 41% of the general population perceives the available bus fleets as inadequate, only 30% of public transport users who feel safe share this view. Satisfaction with public transport is often based on travellers' experiences; frequent bus users who feel comfortable and safe may have more positive perceptions of bus performance than general commuters. Regardless of individual perceptions, the transit infrastructure plays a significant role in ensuring safety.

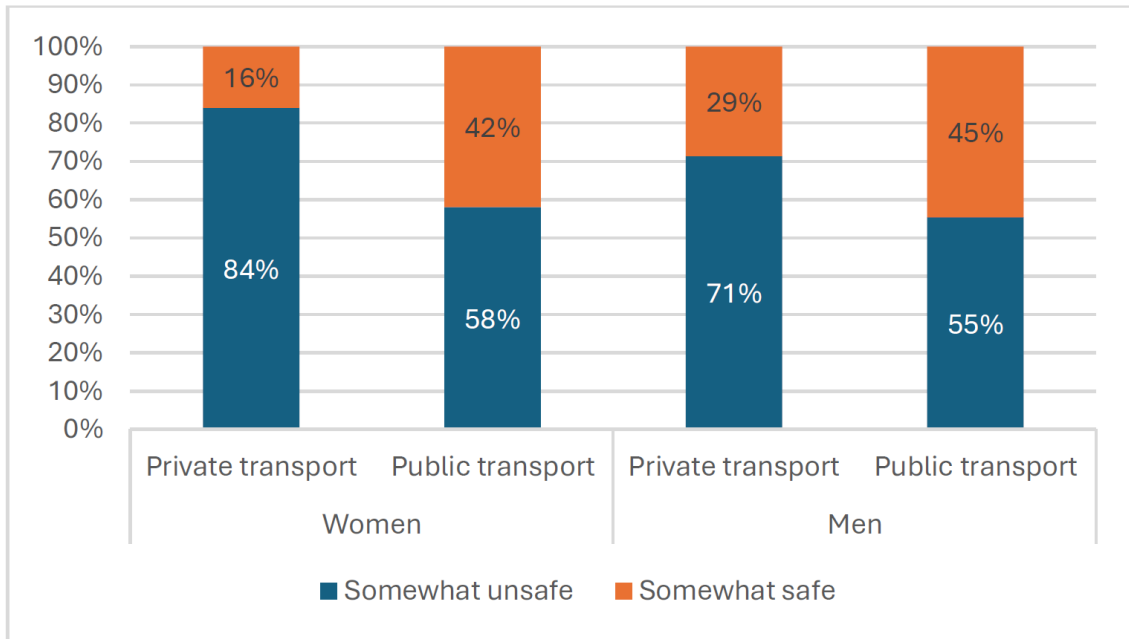


Figure 14. Safety perception on public transport by gender and modes of transportation

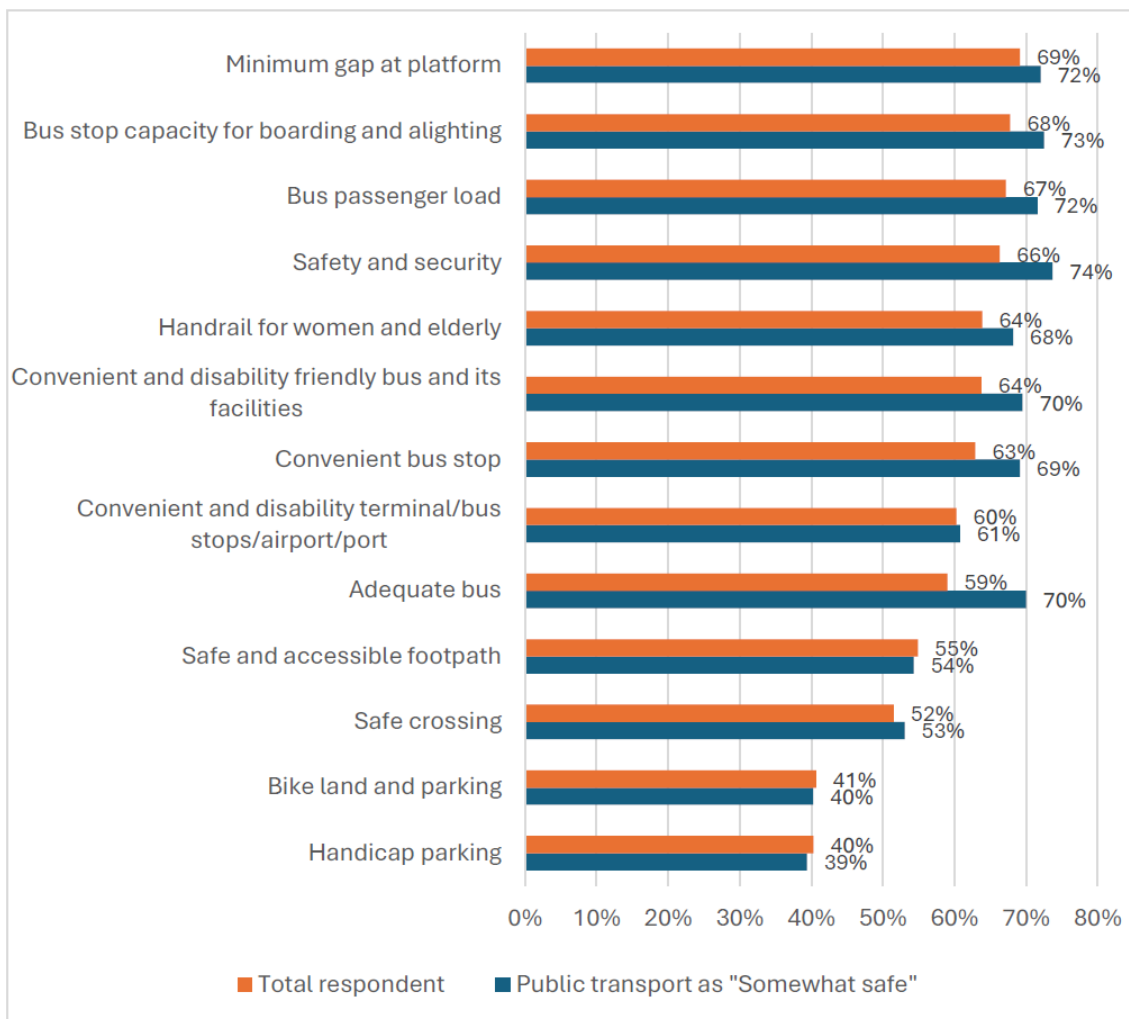


Figure 15. User Perception of public infrastructure performance

3.5. Perception on Infrastructure Performance

Infrastructure plays a crucial role not only in enhancing safety and security in public transportation but also in influencing individuals' decisions regarding their choice of transport. The survey results, as shown in Figure 16, indicate that respondents generally view public transport infrastructure in KMA as performing well, with over 50% expressing satisfaction in most aspects. However, there are notable exceptions, particularly concerning handicap parking and bicycles. In Semarang, bike lanes are often poorly developed and maintained; field observations corroborate these findings. Issues, such as unreadable signage and poorly maintained bike parking facilities, are common. Unclear bike lane markings can lead to potential road accidents because of the lack of clear road segregation, whereas poorly maintained bike parking can deter cycling.

Handicap parking is another area in which infrastructure is perceived as performing poorly. The lack of reasonable accommodation for persons with disabilities extends beyond parking to public spaces and transport facilities in

Semarang and other districts in the KMA. Despite some progress in policy and regulations to protect persons with disabilities, significant barriers remain. Focus Group Discussions (FGDs) with organisations of persons with disabilities (OPDs) highlight challenges such as uneven walkways, dangerous cracks or holes in footpaths, and lack of accessibility accommodations in buses and trains.

When comparing perceptions of infrastructure performance between genders, men in the KMA generally rate public infrastructure higher than women, as shown in Figure 16. This trend holds for most types of infrastructure, except for reasonable accommodations for people with disabilities at terminals, bus stops, airports, and other public transportation facilities. Significant gender differences are also evident in the perceptions of transit capacity for boarding and alighting. Women in the KMA rate their current transit capacity lower than men, likely because of concerns about comfort and the greater risk of harassment in crowded spaces. Women in the KMA demand better crowd management in transit facilities, reflecting their lower satisfaction scores than men.

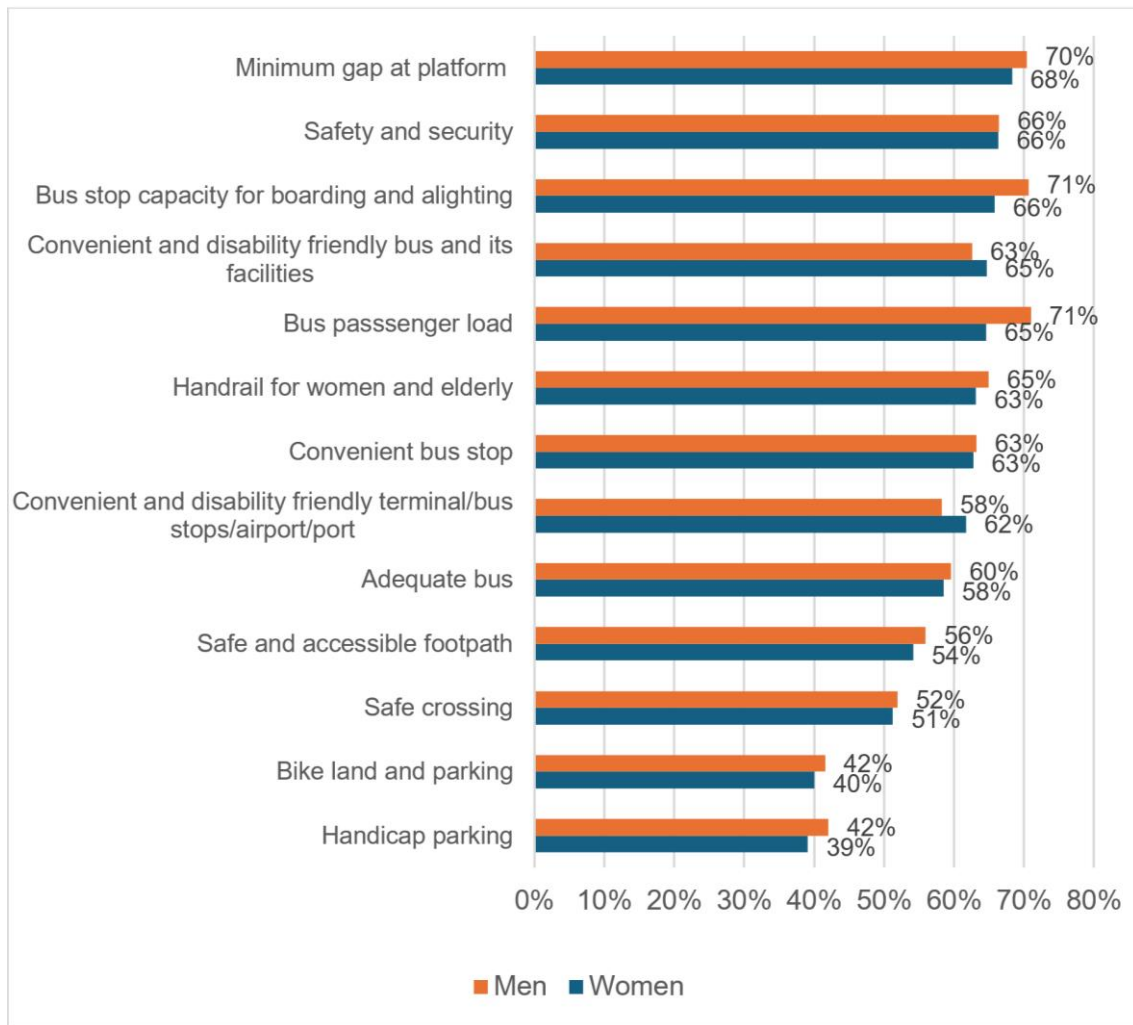


Figure 16. Perception on the public infrastructure by gender

On the other hand, men perceived the need for improvements in bike lanes and handicap parking more acutely, with 40% rating bike lanes and 39% rating handicap parking as moderate in performance. Men often focus on the physical capacity of the infrastructure, including parking and bicycle lanes. While women also rate bike lanes and handicap parking low, their primary concern is comfort when assessing the public transport infrastructure. Women tend to be more attentive to the well-being of vulnerable groups, reflecting their higher ratings for reasonable accommodations in the current infrastructure compared to men. This heightened awareness among women likely stems from their broader perspective of infrastructure performance, encompassing both comfort and accessibility considerations. However, as previously discussed, reasonable accommodations in general infrastructure remain limited not only in Semarang but also in other districts within the KMA.

3.6. Determinant Factors for Vulnerable Groups in Accessing Public Transportation

To achieve the goal of providing sustainable mobility, this analysis seeks to identify the factors that influence the modal choice of vulnerable groups, including women, children, youth, the elderly, and people with disabilities. These groups often face unequal access to public transportation, making it crucial to understand the factors that contribute to their decision to use public transport. This knowledge can significantly inform and improve transportation planning and policies.

The analysis employed a logit model to determine the significant factors affecting the transportation choices of these vulnerable groups. The logit model, specifically the binary logistic regression model, is a statistical method used to model the relationship between one or more independent variables and a binary dependent variable [26]–[28]. In this context, the dependent variable is the choice of transportation mode (public transport vs. private transport), and the independent variables are the various factors that might influence this choice. Table 2 presents the regression analysis results for the test factors (independent variables) including sex, age, education, perception of safety, and access to cars for people with disabilities that influence the decision to take public transport. The bold figures show which factors or independent variables are significantly correlated with the decision to use public transport.

The analysis identified several factors influencing access to public transport for vulnerable groups, such as women, children, youth, the elderly, and people with disabilities. These factors include sex, educational

attainment, age, perception of walking safety, disability status and type, and access to various transportation modes. Gender significantly influenced the decision to use public transport as the primary commuting mode. Women are more likely than men to use public transportation for commuting. This finding reaffirms previous results showing a higher proportion of women using public transport than men in the KMA region. Age and education are crucial factors. Older respondents were more likely to use public transportation than younger individuals. Additionally, people with at least a senior high school education tend to use public transportation more than those with a lower educational background.

Perception of safety while walking in public spaces is another significant factor. Although women in KMA generally feel less safe, the analysis found a positive correlation between the perception of walking safety and the likelihood of using public transport. This suggests that individuals who perceive walking to be somewhat safe are more likely to opt for public transportation. This correlation highlights the importance of psychological factors and individual experiences in shaping safety perceptions and transportation choice.

Access to private vehicles also influences the likelihood of vulnerable groups using public transport. Interestingly, different types of private vehicles have varying impacts on commuting behaviour. For example, access to a car can increase the probability of vulnerable groups using public transportation. This may be due to factors such as traffic congestion, in which individuals may prefer public transport to avoid delays. However, vulnerable groups with access to motorcycles tend to use their private vehicles instead of public transport, likely because of the efficiency and flexibility offered by motorcycles. Further analysis is needed to better understand the correlation between these variables and associated external factors. The analysis also revealed that people with disabilities are more likely to use private vehicles than public transportation. This contrasts with the general population in the KMA and may be explained by the respondents' perception of how accommodating and comfortable public transport is for people with disabilities.

Understanding these factors is crucial for developing inclusive and effective transportation policies. Addressing the specific needs and barriers faced by vulnerable groups could lead to a more equitable and accessible transportation system in the KMA region. Further research and targeted interventions are necessary to enhance the safety, convenience, and overall experience of public transportation for all users, particularly for vulnerable populations.

Table 2. The determinant factors for vulnerable groups in accessing public transportation in KMA region

VARIABLES	Public transport used
Women	1.16***
	(0.43)
Education: Diploma/Undergraduate	0.08
	(1.60)
Education: Magister/Doctor (Omitted)	-
Education: Senior high school	1.79***
	(0.42)
Education: Junior high school or less (Omitted)	-
Age	0.07***
	(0.01)
Inner city commute (dummy)	-4.30
	(6.45)
Public transport perception: Somewhat safe	-0.23
	(1.17)
Walking in the public are perception: Somewhat safe	5.43***
	(1.04)
MBR	0.67
	(0.65)
PWD	-3.64***
	(1.29)
assets: car	2.76***
	(0.91)
assets: motorcycle	-5.38***
	(1.42)
assets: bike	-0.66
	(0.50)
assets: other (Omitted)	-
Constant	-0.03
	(6.58)
Observations	285

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4. Conclusions

This study explored various aspects of transportation behaviour and preferences among different genders and vulnerable groups in the KMA region, providing valuable insights for policymakers and urban planners. The key findings are summarised as follows:

1) Gender Differences in Travel Behaviour and Preferences

The study's figures indicate that women in the KMA predominantly rely on public transportation, a choice influenced by their multiple roles and household responsibilities. This is in contrast to men, who primarily use private vehicles for work and social activities. For example, Figure 5 highlights that women from both lower- and higher-income households have access to private vehicles, but factors beyond income influence their reliance on public transport.

2) Income Distribution and Transportation Costs

There is a strong correlation between income level and transportation choice. High-income individuals spend significantly more on private vehicles, which aligns with the notion that private transportation is a superior good. Figure 9 clearly demonstrates how transportation spending increases with income, particularly among men, suggesting the more frequent use of private vehicles by wealthier individuals.

3) Perception of Transportation Safety

The findings presented in Figure 12 illustrate that safety perceptions are a key factor influencing transportation choice, especially for women. Women generally feel less safe walking in public areas than men do, which reduces their likelihood of using public transport. Furthermore, Figure 14 shows that women who regularly use public transport tend to feel safer in such environments than women who predominantly use private vehicles. This finding reinforces the idea that safety perceptions are closely tied to regular exposure and personal experiences with public transport.

4) Infrastructure Performance

Although the public transport infrastructure in the KMA is generally perceived as adequate, certain areas such as bike lanes and handicap parking require improvement. The performance of the public transport infrastructure, detailed in Figure 15, shows that while most users are satisfied, there are noticeable gaps in service, particularly concerning platform accessibility and passenger loads. Addressing these gaps will enhance the overall efficiency and safety of public transportation.

5) Determinant Factors for Vulnerable Groups

As reflected in the survey data, factors such as gender, age, education, safety perceptions, disability status, and

access to private vehicles significantly influenced public transport usage. The data tables show that women, older individuals, and those with higher educational levels are more likely to use public transportation, highlighting the need for targeted interventions to address the specific needs of these groups.

6) Policy Implications

- **Enhanced Safety Measures:** Improving safety can increase public transport use, particularly among women and vulnerable groups.
- **Infrastructure Improvements:** Better bike lanes, handicap parking, and accessibility features can encourage more equitable use of public transport.
- **Targeted Interventions:** Policies should address the needs of different demographic groups.
- **Income-Based Subsidies:** Financial incentives for low-income individuals can help mitigate economic barriers.

This study underscores the importance of understanding gender and demographic differences in transportation behaviour to create inclusive and effective urban transport systems. By addressing the specific needs and barriers faced by women and vulnerable groups, policymakers can promote sustainable and equitable mobility solutions and enhance overall quality of life in the KMA region. However, it is important to acknowledge the limitations of this study. Although substantial, the sample size may not fully capture the diversity of transportation experience across all districts within the KMA. Additionally, the study's geographic focus on the KMA limits the generalisability of the findings to other regions with different socioeconomic and cultural contexts. Potential biases in self-reported data and variability in infrastructure quality across different areas could also have influenced the results. Recognising these limitations is crucial for a balanced interpretation of the findings, and for guiding future research aimed at addressing these gaps and enhancing the inclusivity and effectiveness of transportation planning.

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Authors' Contributions

- TD: Conceptualisation and prepared the manuscript.
 RS: Prepared the manuscript.
 JJ: Reviewed the manuscript.

AKD: Performed the analysis and reviewed the manuscript.

Data Availability

<https://zenodo.org/records/13751453>

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