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CHARACTERISTICS AND PATTERNS OF WORKER MOBILITY FROM PERI-URBAN AREAS TO BANDA ACEH CITY

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Abstract

Daily mobility from peri-urban areas to Banda Aceh City contributes significantly to increased urban traffic volumes. This study aims to identify the characteristics and patterns of worker mobility from the peri-urban districts of Darul Imarah, Darussalam, and Ingin Jaya to Banda Aceh. Employing a quantitative approach, the research utilises questionnaire data and applies the Origin-Destination matrix technique to analyse movement patterns. The findings reveal that 89% of respondents are employed in the formal sector, with 62% commuting using private vehicles. Mobility frequency does not consistently correlate linearly with distance, as the destination's function also plays a key role. The observed mobility pattern is polycentric, distributed across all districts of Banda Aceh, with a high concentration towards both the old and new city centre areas – specifically Banda Raya, Baiturrahman, and Syiah Kuala – which function as administrative and public service hubs.

Keywords: Mobility Characteristic, Mobility Pattern, Origin Destination, Peri-urban, Polycentric

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INTRODUCTION

The rehabilitation and reconstruction efforts following the 2004 tsunami marked a pivotal point in the development trajectory of Banda Aceh. Two decades later, the city has experienced significant densification driven by population growth and the expansion of built-up areas, which now cover nearly the entire city. This urban growth has resulted in a marked decline in available land, with only 190.3 hectares remaining for development as of 2021, while land prices continue to escalate (Zahara et al., 2021). The expansion of built-up areas has extended both northwards and southwards within Banda Aceh, and has also spilled into the neighbouring Aceh Besar Regency, which shares a direct boundary with the city. This development pattern signifies ongoing urban expansion into adjacent areas (Al-Fath & Marsoyo, 2023). The growth of Banda Aceh has significantly influenced land use on the urban fringe. These fringe zones – referred to as peri-urban areas – are not defined by administrative boundaries but by the emergence of built-up land driven by urban sprawl and the formation of new activity centres (Giyarsih, 2010). This phenomenon is evident in several districts within Aceh Besar Regency, such as Darussalam, Ingin Jaya, and Darul Imarah.

As peri-urban areas, these three districts maintain strong economic, social, infrastructural, and transportation linkages with Banda Aceh. Their proximity to the city, in contrast to the more distant administrative centre of Aceh Besar, reinforces these connections. A critical aspect of this relationship is the economic dependence of the peri-urban areas on Banda Aceh, particularly in terms of employment opportunities. This dependency fuels daily commuting from the districts of Darussalam, Ingin Jaya, and Darul Imarah into the city (Al-Fath & Marsoyo, 2023; Fadhly, 2019; Helmi et al., 2019).

The emergence of sub-service centres contributes to the development of surrounding residential areas, resulting in increased traffic volumes. The high level of dependence of peri-urban residents on urban core activities drives significant daily movement. This increase in private vehicle use and commuting intensity can exacerbate transportation issues, including rising traffic volumes and congestion in both Banda Aceh and Aceh Besar (MG. Brilliant et al., 2024). These challenges underscore the need for proactive solutions. However, existing transportation systems often fall short in addressing Indonesia's complex mobility issues (Maulana & Yudhistira, 2020). One method for anticipating and managing these issues involves analysing movement patterns using the Origin-Destination (O-D) matrix technique.

Unlike the majority of mobility studies in Indonesia, which predominantly examine cities in Java, dominantly large metropolitan areas such as Jakarta, Surabaya, and Bandung, this research focuses on Banda Aceh - a medium-sized, post-disaster city exhibiting distinctive peri-urban development characteristics. By directing attention to a non-Java urban context that remains

underrepresented in existing scholarship, this study offers a meaningful contribution by addressing a notable gap in the literature and providing empirical evidence on mobility patterns within a less-examined urban system. This study aims to examine the characteristics and mobility patterns of workers commuting from peri-urban areas into Banda Aceh. Understanding these patterns is crucial, as they reflect the extent of interdependence and interaction between peri-urban zones and the urban core. This knowledge is fundamental for formulating inclusive economic policies aimed at reducing overreliance on the city centre (Aulia, 2020). Moreover, such analysis provides essential insights to support the planning and development of public transport systems and road infrastructure.

LITERATURE REVIEW

Peri-Urban

According to Yunus (2008), peri-urban areas occupy transitional zones situated between distinctly different environments – urban settings on one side and rural landscapes on the other. The global phenomenon of urbanization has contributed to the emergence and expansion of these peri-urban areas. Often functioning as reservoirs of labour, these areas supply workers to urban centres, particularly in the industrial, service, and informal sectors. However, peri-urban areas typically lag behind urban centres in terms of infrastructure and public services, such as water supply, sanitation, healthcare, and education (Simon, 2008; Tacoli, 2006).

The relationship between peri-urban areas and cities is characterized by strong interdependencies, particularly in economic activity, infrastructure provision, and population mobility. Studies in several major Indonesian cities – such as Bandung, Surabaya, and Jakarta – highlight these dynamics (Santoso et al., 2019; Somantri, 2022; Winarso et al., 2015). Residents of peri-urban areas often seek employment in city centres due to the availability of better job opportunities and higher wages (Sari & Santoso, 2017). However, this high volume of daily mobility from suburban to urban areas can give rise to various negative externalities, including increased population density, traffic congestion, and air pollution. To address these issues, strategic planning and development of peri-urban areas are essential, particularly to improve infrastructure and reduce over-reliance on city centres (Somantri, 2022).

Characteristics and Patterns of Movement

Population mobility is primarily shaped by socio-economic routines, such as typical working hours, shop operating times, school schedules, public entertainment, and social events. Movement patterns can generally be categorised into daily, weekly, and seasonal types. The characteristics of mobility include various attributes frequently utilised in research, such as the purpose of movement, distance travelled, time of travel, and frequency of movement (Tamin,

2000; Usman, 2020). However, key variables often emphasised in mobility studies include the purpose of movement, mode of transport, and frequency of movement (Permatasari & Hudalah, 2013; Sari & Santoso, 2017).

Movement patterns can be illustrated using an Origin-Destination (O-D) matrix, a two-dimensional matrix that captures the volume of movements between zonal locations within a specific area. This tool aids in explaining the spatial interrelation between origin and destination areas (Tamin, 2000, 2008). The matrix typically includes data on the frequency of daily and weekly movements from origin points to destination points. Such information is essential for the effective planning, design, and management of transportation systems that are responsive to the actual needs and travel behaviours of the population (Ramli et al., 2020; Zhao et al., 2024). Therefore, the use of the O-D matrix is both appropriate and essential for the purposes of this study.

METHODOLOGY

This study employs two primary variables: mobility characteristics and mobility patterns. The indicators used to assess mobility characteristics are the purpose of travel (limited to work-related purposes) and the mode of transportation. For mobility patterns, the variable is measured using the frequency of movement as the primary indicator. Data was collected through questionnaires distributed both online and via door-to-door surveys to individuals working in Banda Aceh but residing in three peri-urban districts within Aceh Besar Regency: Darul Imarah, Darussalam, and Ingin Jaya, on August 2023 (Figure 1). These districts were selected due to their strong connectivity to Banda Aceh and the availability of adequate respondent databases. A stratified random sampling technique was employed. The sample size was calculated using the Slovin formula with a 10% margin of error and then proportionally distributed based on the worker population in each district. A minimum target of 30 respondents was set for each district to ensure adequate representation. In total, the study gathered responses from 50 individuals in Darul Imarah, 30 in Darussalam, and 35 in Ingin Jaya. This research adhered to ethical guidelines for human subject studies. Informed consent was obtained from all respondents, and participation was voluntary and anonymous.

The research employs a quantitative approach, using descriptive statistical analysis to examine mobility characteristics and Origin-Destination (O-D) matrix techniques to analyse mobility patterns. The O-D matrix is a two-dimensional framework in which rows represent origin zones and columns represent destination zones. Each cell within the matrix indicates the volume of movement from the origin to the destination, measured by the frequency of trips per week. In this study, the origins are the peri-urban districts of Darul Imarah, Darussalam, and Ingin Jaya, while the destinations are the nine districts of Banda

Aceh: Baiturrahman, Meuraxa, Lueng Bata, Banda Raya, Kuta Alam, Syiah
 Kuala, Kuta Raja, Jaya Baru, and Ulee Kareng.

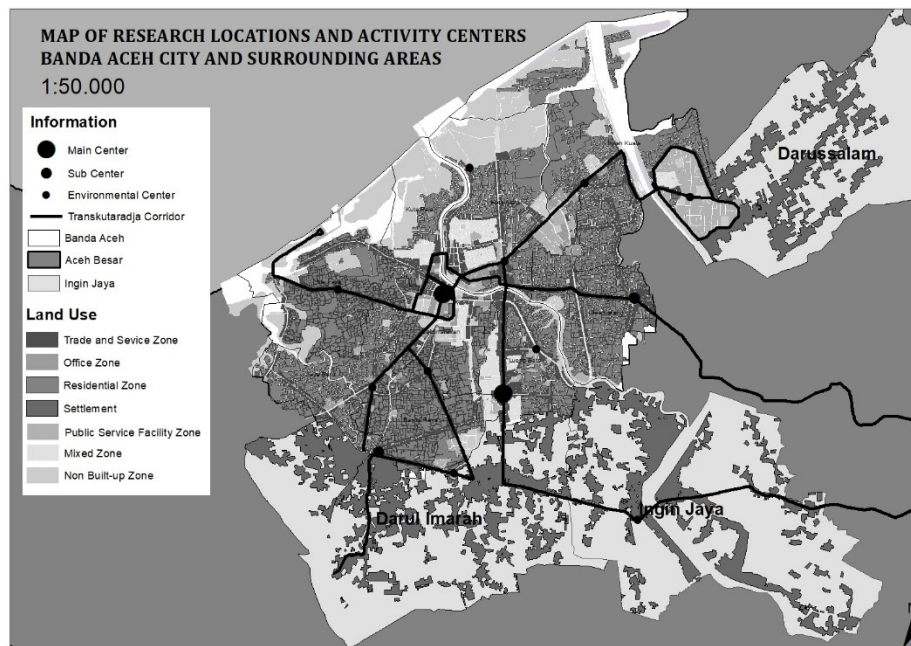


Figure 1: Research Location Map

RESULT AND DISCUSSION

Questionnaires distributed to 115 respondents revealed that the majority were middle-class individuals, earning between Rp.2,500,000 – Rp.3,500,000 per month. The characteristics of worker mobility are identified based on the purpose of travel and the mode of transportation used (Table 1 and Table 2).

Table 1: Purpose of Travel Among Respondents

District	Number and Percentage of Respondents by Travel Purpose			
	Formal Sector		Non Formal Sector	
Darul Imanah	44	88%	6	12%
Darussalam	29	97%	1	3%
Ingin Jaya	30	86%	5	14%
Total	103	89%	12	11%

Source: Authors, 2024

Table 1 presents the distribution of travel destinations according to the employment sectors of respondents from each district. The formal sector includes destinations such as government offices, private companies, clinics or hospitals,

and educational institutions. The findings show that the vast majority of respondents (over 85%) across all three districts commute to formal sector workplaces in Banda Aceh. In contrast, only a small proportion of workers travel for non-formal employment, with 12% from Darul Imarah, 3% from Darussalam, and 14% from Ingin Jaya engaging in such mobility.

These patterns suggest that Banda Aceh serves as a key employment hub, offering diverse opportunities largely concentrated in public service and institutional facilities. A contributing factor to this trend is the limited availability of suitable employment within Aceh Besar, where job offerings often do not align with the qualification or expectations of the workforce (Simah Bengi & Jamal, 2017).

Table 2: Transportation Mode Used by Respondents

District	Transportation Mode							
	Walking		Private Vehicle		Public Transport		Online Transport	
Darul Imarah	0	0%	15	30%	19	38%	16	32%
Darussalam	0	0%	26	87%	4	13%	0	0%
Ingin Jaya	1	3%	33	94%	0	0%	1	3%
Total	1	1%	74	62%	23	20%	17	15%

Source: Authors, 2024

Table 2 illustrates the modes of transportation used by respondents, revealing that private vehicles – specifically motorcycles and cars – are the predominant means of commuting across all districts. Overall, 64% of respondents commute to work using private vehicles. When examined by district, private vehicle use is particularly high among respondents from Ingin Jaya and Darussalam, where more than 85% rely on this mode for commuting. In contrast, respondents from Darul Imarah display more varied transportation preferences. Approximately 30% commute using private vehicles, while an equal proportion utilise public transportation and online ride-hailing services.

The preference for private vehicles is influenced by factors such as convenience, flexibility, and comfort (Affandi & Parikesit, 2022). Furthermore, the availability and accessibility of public transport also significantly impact modal choices (Widjaya, 2024). Currently, Banda Aceh’s public transportation is represented by the Trans Koetaraja Bus, which has been operational since 2016. However, its coverage in peri-urban areas remains limited, reaching only parts of Darul Imarah and Ingin Jaya (as depicted in Figure 1). Notably, public transportation usage in Darul Imarah stands at 38%, surpassing both private and online transport options. This is attributed to the bus route passing through several residential areas in the district, thereby facilitating greater accessibility. Conversely, none of the respondents from Ingin Jaya reported using the Trans

Koetaraja Bus. Although the route passes through this district (as shown in Figure 1), the residential density along the route is relatively low, possibly limiting its utility. Meanwhile, 13% of respondents from Darussalam reported using the bus service, despite the route only extending to the district's border, indicating a willingness to walk or connect via other means to access the service (Figure 1).

Online transportation services are most frequently used by respondents from Darul Imarah. Nevertheless, when aggregated across all respondents, online transport accounts for just 15% of total usage – less than public transportation at 20%. The latter figure reflects a latent interest among peri-urban residents in using public transit options, particularly the Trans Koetaraja Bus. In response to this growing interest, the Aceh Provincial Transportation Department plans to introduce new routes, including one connecting Darussalam to Pasar Lam Ateuk (Dinas Perhubungan Aceh, 2025). This expansion aims to improve the accessibility and attractiveness of public transportation, particularly for residents of Darussalam, thereby enhancing overall connectivity between the peri-urban areas and Banda Aceh City.

Table 3: Origin-Destination Matrix (Trips per Week)

Origin/ District	Destination Zone/District									Total
	1	2	3	4	5	6	7	8	9	
Darul Imarah	28	5	35	66	40	28	12	13	13	240
Darussalam	45	19	18	5	15	48	0	0	16	166
Ingin Jaya	43	20	18	36	20	10	11	17	21	196
Total	116	44	71	107	75	86	23	30	50	602

Notes: The code for the zone (district) is as follows:

1 = Baiturrahman	2 = Meuraxa	3 = Lueng Bata
4 = Banda Raya	5 = Kuta Alam	6 = Syiah Kuala
7 = Kuta Raja	8 = Jaya Baru	9 = Ulee Kareng

Source: Authors, 2024

The mobility pattern was analysed using an Origin-Destination (O-D) matrix and subsequently described in spatial form. The commuting flows from the origin zones – Darul Imarah, Darussalam, and Ingin Jaya – to the various zones within Banda Aceh City are presented in Table 3. The data reveal that the highest number of weekly work trips is directed towards Baiturrahman (116 trips), followed by Banda Raya (107 trips), and Syiah Kuala (86 trips). As illustrated in Figure 1, these three destination zones are situated adjacent to their respective origin zones, between Darussalam and Syiah Kuala, as well as Darul Imarah and Banda Raya. These areas serve as central nodes within Banda Aceh, functioning as administrative, governmental, and public service centres at both the provincial and city levels.

In contrast, the Kutaraja and Jaya Baru districts record the fewest work-related trips, with only 23 and 50 trips per week, respectively. Although these zones form part of Banda Aceh's urban core, they are largely residential in character and host relatively fewer public facilities associated with the formal employment sector. The dominance of formal-sector employment among respondents not only shapes their travel destinations but also influences their preference for private vehicles, reflecting the limited coverage of public transport services in peri-urban areas.

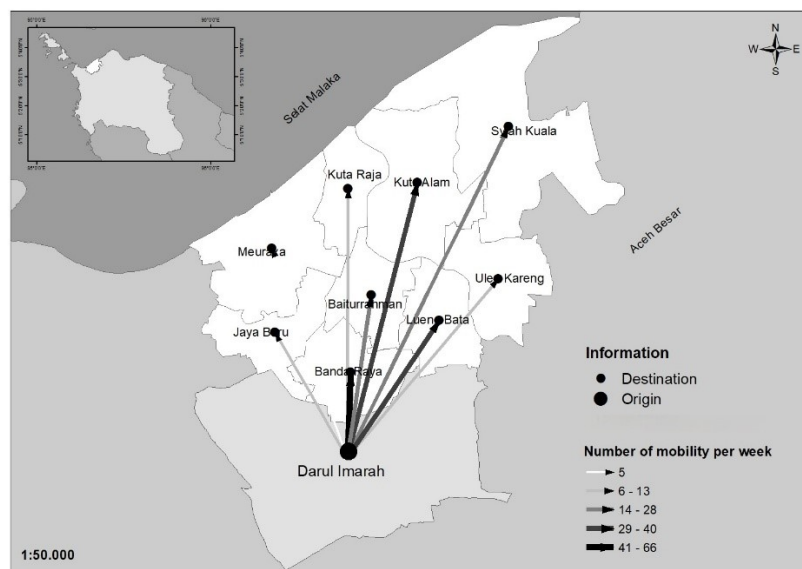


Figure 2: Spatial Distribution of Mobility Frequency from Darul Imarah District
Source: Authors, 2024

The spatial distribution of worker movements from Darul Imarah district, as shown in Figure 2, demonstrates that all districts in Banda Aceh function as employment destinations. The highest number of trips – 66 per week – is directed toward Banda Raya. According to the Banda Aceh Spatial Plan 2009 – 2029, Banda Raya is designated as a new urban development zone, serving as a hub for sports facilities, terminal infrastructure, trade and services, and warehousing (Qanun Rencana Tata Ruang Wilayah Kota Banda Aceh Tahun 2009- 2029, 2009). However, for respondents in this study, institutional and office buildings remain the dominant destinations, particularly for those employed in the formal sector. Another major destination is Kuta Alam district, recording 40 trips per week. As the administrative centre for various government offices (Figure 1), it naturally attracts a high volume of formal sector workers.

Lueng Bata district, which recorded 35 trips per week, is also emerging as a new urban centre with functions similar to Banda Raya.

In terms of spatial proximity, Banda Raya directly borders Darul Imarah, indicating a strong relationship between available residential land in Darul Imarah and employment opportunities in Banda Raya. This adjacency likely contributes to the high commuting frequencies between the two areas. By contrast, other nearby districts such as Jaya Baru and Meuraxa generate relatively fewer trips – between five and 13 per week. Although Kuta Alam is a key employment centre, its greater distance from workers' residences may affect commuting patterns. It is important to note that this study does not examine the underlying motivations behind the selection of residential and workplace locations. Therefore, mobility patterns from Darul Imarah district are not solely attributable to distance. While Handy et al (2005) suggest that workers tend to choose residential locations that minimise commuting time, this tendency is not clearly reflected in the current findings.

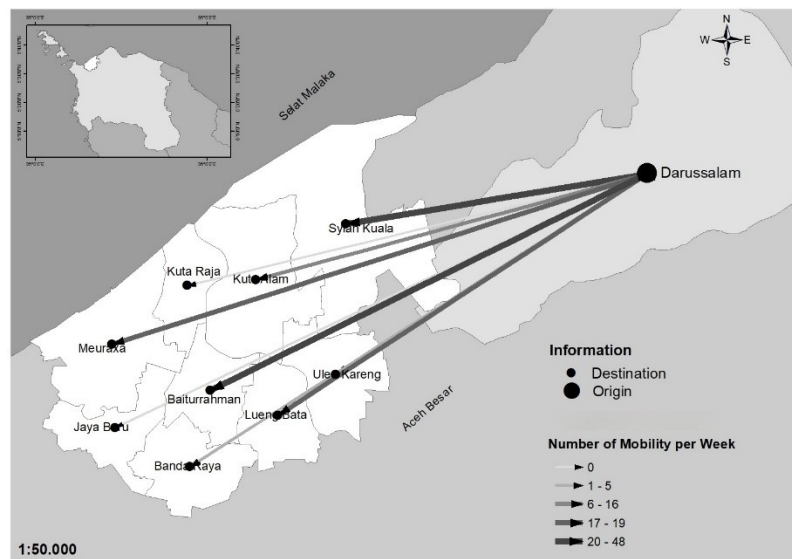


Figure 3: Spatial Distribution of Mobility Frequency from Darussalam District
 Source: Authors, 2024

Based on Table 2 and Figure 3, the highest number of worker movements from Darussalam district is directed toward Syiah Kuala and Baiturrahman, with 48 and 45 trips per week, respectively. According to Qanun Rencana Tata Ruang Wilayah Kota Banda Aceh Tahun 2009- 2029 (2009), Syiah Kuala, adjacent to Darussalam, is designated as a higher education hub and currently hosts two state universities. Most formal sector workers from

Darussalam are employed as teachers or lecturers, making Syiah Kuala a primary commuting destination. Meanwhile, Baiturrahman district serves as the historic city centre and functions as a key node for regional trade and government administration (Qanun RTRW Kota Banda Aceh Tahun 2009-2029, 2009).

Conversely, worker movements toward Kuta Raja, Jaya Baru, and Banda Raya are minimal, with frequencies ranging from 0 to 5 trips per week. Although these districts – located approximately 15 kilometres from Darussalam – are designated urban development areas in the city’s spatial plan (Qanun RTRW Kota Banda Aceh Tahun 2009- 2029, 2009), they attract relatively few commuters from Darussalam.

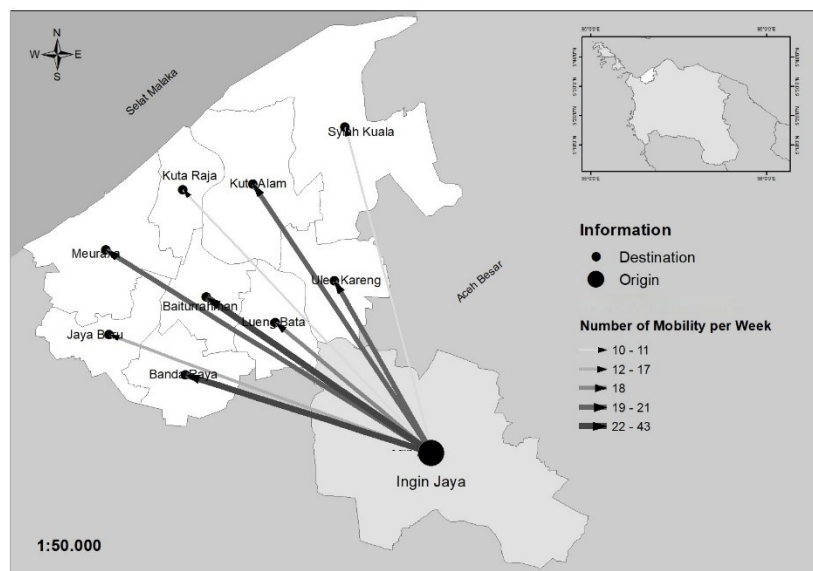


Figure 4: Spatial Distribution of Mobility Frequency from Ingin Jaya District
Source: Authors, 2024

Based on Table 2 and Figure 4, worker movements from Ingin Jaya are relatively well distributed across all districts in Banda Aceh. The primary destinations are Baiturrahman and Banda Raya. Baiturrahman functions as the historic city centre, while Banda Raya is designated as part of the new city centre development, serving as a hub for trade, services, and warehousing (Qanun Rencana Tata Ruang Wilayah Kota Banda Aceh Tahun 2009- 2029, 2009). These characteristics make both districts key destinations for formal sector workers residing in Ingin Jaya. The relatively short distance of approximately 5 –10 kilometres enhances their accessibility and attractiveness as commuting targets.

Conversely, the lowest number of worker movements – around 10 trips per week – are directed toward Kuta Raja and Syiah Kuala. Both are part of Banda Aceh's old city centre development area. Kuta Raja functions as a centre for trade and administrative offices, while Syiah Kuala is designated as the city's higher education hub.

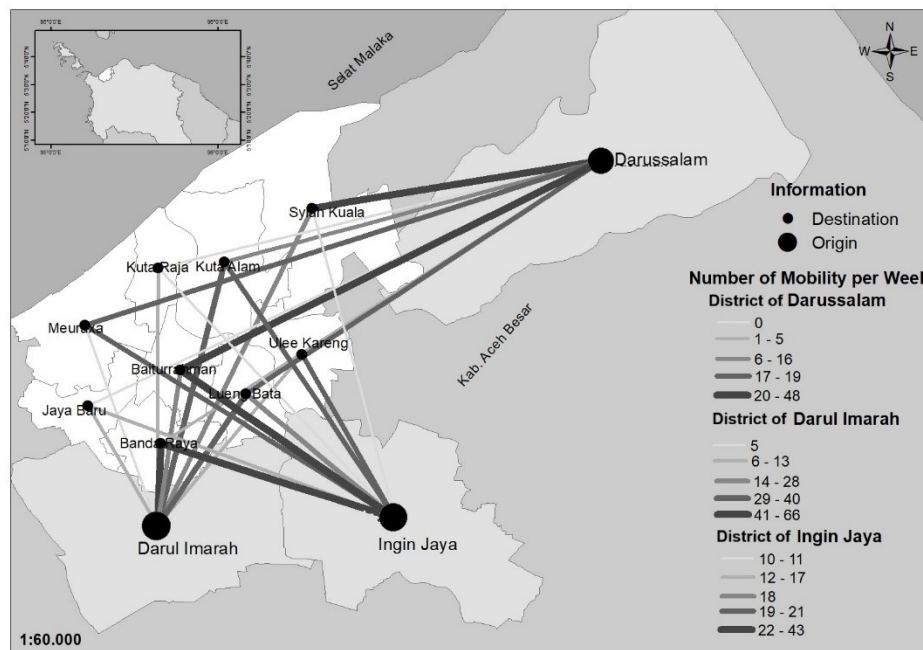


Figure 5: Spatial Distribution of Mobility Frequency from the Districts

The mobility patterns of workers commuting to Banda Aceh City are predominantly shaped by employment in the formal sector, including government institutions, private enterprises, and educational institutions. This trend is largely influenced by Banda Aceh's status as the provincial capital and its role as a hub for administrative, healthcare, and educational services. Consequently, the city's development as a central functional area may lead to the expansion of built-up zones for public facilities, potentially displacing residential functions to peripheral areas. As Banda Aceh continues to develop, commuter flows from peri-urban areas are likely to intensify – not only from the three districts studied here but also from others in Aceh Besar Regency, such as Krueng Barona Jaya and Baitussalam. To manage this expansion sustainably, coordinated efforts between Banda Aceh City and Aceh Besar Regency are necessary. Strategic urban policies and strengthened regional partnerships should be implemented to mitigate the negative effects (Rizkiya et al., 2023).

The prevalence of formal sector employment among respondents also influences their commuting behaviour and transport mode choices. Approximately 62% of workers rely on private vehicles, a preference that is shaped by factors such as vehicle ownership and the availability or lack of public transportation (Widjaya, 2024). The Trans Koetaraja Bus, for example, services densely populated residential areas in the Darul Imarah district, contributing to higher public transport usage in that locale. However, the system does not yet comprehensively cover all peri-urban areas, limiting its overall impact. Although designed as an environmentally friendly commuting option (Purwoko et al., 2022), the bus service has yet to adequately support the mobility needs of all workers. Commuting behaviour is further shaped by variables such as distance, travel duration, and transportation availability. While both private and public transport enable mobility, most workers in this study own and use private vehicles for their daily commutes. Since commuting is inherently linked to non-residential activities, the spatial distribution of land use within the city significantly influences travel behaviour (Tamin, 2000). Therefore, a transportation planning framework that prioritises the community by actively considering local needs and movement patterns in infrastructure development could help establish a more inclusive and sustainable mobility system for both rural and peri-urban populations (Khalisha et al., 2025). Additionally, factors such as age, life cycle stage, economic circumstances, and lifestyle should serve as key considerations in policy design, especially in efforts to promote the long-term sustainability of public transport systems (Sugito et al., 2024).

Figure 5 illustrates that the most frequented destinations are Baiturrahman, Banda Raya, and Syiah Kuala districts. Their high trip volumes are attributable to their functions as centres for government and public services – primary destinations for formal sector workers. Interestingly, the volume of trips does not correlate linearly with distance. High-frequency commutes occur across both long and short distances, such as the relatively distant journey from Darussalam to Baiturrahman.

This indicates that pull factors, such as employment opportunities in the public sector, play a more decisive role in travel behaviour than distance alone. Helmi et al (2019) similarly found that in Darussalam factors including age, household employment structure, and vehicle ownership influence travel frequency. The designation of these districts as centres for government and public services acts as a strong attractor for population movement, regardless of travel distance. Recognising this dynamic is crucial for informing transportation and spatial planning efforts aimed at accommodating existing mobility patterns.

The mobility patterns of workers from peri-urban areas to Banda Aceh City are not only determined by distance but also by the spatial orientation of their destinations. These patterns reveal a dispersed or polycentric distribution of

work trips across all districts, with varying frequencies. This is consistent with the usage patterns of online transportation services in Banda Aceh, which show trip concentrations at multiple key points (Rizkiya et al., 2024). Tondobala (2015) highlights that in a polycentric model, population density and economic activity are distributed across several service zones rather than concentrated in a single urban centre. Similarly, Permatasari & Hudalah (2013), in their study on the daily mobility of industrial workers in Cikarang, Bekasi, found that commuting patterns have shifted from core urban centres towards emerging employment nodes in suburban areas.

The polycentric structure of worker mobility reflects Bandar Aceh's ongoing spatial expansion. This presents opportunities to enhance public transport usage among peri-urban commuters. Expanding the coverage of the Bus Trans Koetaraja network could serve as a strategic approach to improve transportation infrastructure, particularly for residents of Aceh Besar commuting to the city.

CONCLUSION

The commuting patterns of workers travelling to Banda Aceh City are predominantly driven by employment in the formal sector, reflecting the city's role as the provincial capital and a hub for government and public services. Private vehicles remain the primary mode of transport, while usage of the Trans Koetaraja Bus is concentrated among workers from the Darul Imarah – likely due to its routes serving higher-density residential areas. The findings indicate a clear polycentric mobility pattern, with trips dispersed across multiple districts rather than concentrated in a single urban core. The frequency of these movements does not show a clear or linear relationship with distance, suggesting that the choice of residential location is not necessarily determined by proximity to the workplace. These findings underscore the need to improve public transport infrastructure, particularly through the expansion of the Trans Koetaraja Bus network to better serve peri-urban residential areas. Such improvements are necessary for promoting sustainable urban mobility and accommodating the evolving spatial dynamics of the Banda Aceh metropolitan region. However, the findings should be interpreted cautiously due to the relatively small sample size (115 respondents) and the study's reliance on descriptive statistics, which may limit broader generalizability. Further research with larger samples and more advanced analytical methods is recommended.

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