International Journal of Transport Development and Integration
Vol. 8, No. 4, December, 2024, pp. 529-536
Journal homepage: http://iieta.org/journals/ijtdi

Optimising Urban Spatial Structure: The Role of Settlement Systems, Socio-Economics, and Movement Actors in Palopo City, Indonesia

Hasbi[1,2*], Muh Natsir Abduh[3], Murshal Manaf[4], Syafri[4]

[1] Departement of Civil Engineering, Universitas Andi Jemma, Palopo 91023, Indonesia
[2] Urban and Regional Planning Doctoral Program, Universitas Bosowa, Makassar 90231, Indonesia
[3] Departement of Civil Engineering, Universitas Bosowa, Makassar 90231, Indonesia
[4] Urban and Regional Planning Program, Faculty of Engineering, Universitas Bosowa, Makassar 90231, Indonesia

Corresponding Author Email: hasbi@unanda.ac.id

https://doi.org/10.18280/ijtdi.080404

Received: 16 August 2024
Revised: 12 November 2024
Accepted: 21 November 2024
Available online: 26 December 2024

Keywords:
urban spatial structure, settlement systems, socio-economics, movement actors

ABSTRACT

The sustainability of urban development embodies settlement patterns and transport systems that are affected by residents' travel preferences and the urban spatial structure. This study aims to analyze the influence of settlement and social and economic systems on movement actors toward the confirmation of cumulative integration in the structure of urban service centers. The research approach was quantitative based on multivariate statistics with the structural equation analysis method (SEM-PLS). Data were collected through observation, documentation, and survey. The results illustrate the distribution and concentration of residents, as well as the socio-economic conditions of the movers that influence the movers. Whereas movement actors have a weak influence on service centers, this is because access and connectivity to service centers can be reached from the periphery to the city center for medium-sized cities. The cumulative integration pattern illustrates that the service center is still dominated by a monocentric spatial structure as evidenced by the distribution of economic and socio-economic activities as well as movement actors who perform mobility to the city service center. This research contributes to urban planning to encourage sustainable urban growth.

1. INTRODUCTION

Sustainable urban development requires a delicate balance between settlement patterns and transportation systems [1-4]. The growth of cities has led to significant changes in transport systems and the way people move within the city. Transport and its infrastructure drive socio-economic prosperity in city centers [4, 5]. A good transport system is influenced by the shape of the city and the travel preferences of residents. However, poor start and end connectivity and irregular public transport services can encourage the use of private vehicles, causing congestion, environmental damage, and increased resource consumption [6]. An integrated urban transport system promotes opportunities for spatially distributed activities and ensures effective accessibility [7].

The steady migration of populations from rural to urban areas has fueled a rapid increase in city populations, consequently giving rise to a host of challenges pertaining to the development and functioning of urban centers [8]. This burgeoning urban population has in turn generated a substantial increase in the demand for transportation services as city dwellers strive to commute across the sprawling urban landscape in search of economic opportunities and access to essential amenities [2, 9]. Recognizing the need to address this growing transport demand, cities have sought to develop and enhance their transportation systems and infrastructure, with a particular emphasis on roadways as the primary mode of urban transit to facilitate the mobility of their residents [10]. Transportation systems must be developed with an understanding of the socio-economic factors influencing urban mobility, ensuring that they accommodate the diverse needs of all citizens while promoting inclusivity and accessibility to essential services [11].

The development of transport systems directly contributes to the transformation of urban settlements [12, 13]. Settlement systems play an important role in shaping the social and economic mobility of actors in different communities. Changes in institutional arrangements within the housing system have been shown to affect social integration, which in turn affects social and economic development [14].

Individual mobility is an integration of socio-economic and cultural diffusion flows, including information technology that has experienced a phase of shifting individual mobility in spatial interactions, this is characterized by scenarios of changes in household income and increased ownership of private vehicles as a catalyst for individual mobility [15]. Moreover, social and economic mobility is not only determined by the housing system but also by interactions with industrialization, social mobility, and access to resources, as seen in rural areas [16]. Sustainable urban development

requires a delicate balance between settlement patterns and transportation systems [17]. Mobility as a Service (MaaS) is shifting the paradigm from ownership-based transport to access-based transport and is now gaining ground in the context of urban mobility [18]. The urban environment and the quality of urban space are strongly influenced by various forms of mobility [19]. This concept has not been effectively applied to medium-sized cities in Indonesia due to the dominant use of private vehicles, where the concept of individual mobility based on flow integration [15] is a reality scenario in urban characteristics in Indonesia.

In summary, settlement systems are integral to the social and economic mobility of actors, affecting social integration, health services, and community cohesion. However, their impact is not uniform and can result in both positive social and economic outcomes and undesirable exclusivity, depending on the nature of the housing and its interaction with other social and economic factors. The complexity of these dynamics highlights the need for policies that consider the multifaceted impact of housing systems on social and economic mobility [14, 16, 20-22].

There is much research on settlement systems in general, but understanding of how settlement systems influence movement actors, especially in the context of dynamic causality, is limited. There is a gap in the literature that explores the direct relationship between settlement systems (e.g., spatial distribution, accessibility, and public amenities) and the socio-economics of the travelers in the destination of the travelers. This research aims to address this gap by examining how the interaction between settlement systems and socio-economic factors influences the movement patterns of individual actors, particularly in the developing urban fabric of the Palopo city center. As such, it contributes to a deeper understanding of the complex relationships between settlement systems, socio-economic activities, and individual travel decision-making in the context of a developing country's medium-sized cities.

The transport system as a service center is a multifaceted concept that integrates various subsystems to improve the efficiency and quality of service within the transport center system [23]. Transport systems are evolving into service center systems that require adaptive hierarchical control mechanisms and integrated information services to meet complex user demands [23, 24]. Addressing the challenge of optimizing and expanding the scope of transport hubs to include city functions is critical to the development of an effective service hub system [25]. The integration of these elements contributes to the overall efficiency and effectiveness of transport as a service center system. Settlement systems in developing countries and medium-sized cities are strongly influenced by socio-economic factors and transport systems. In medium-sized cities, the development of urban transport systems is influenced by factors such as technology costs, functional needs, and economic considerations [26].

The relationship between settlement patterns and the socio-economic systems of migrants is multifaceted, as justified by a variety of findings. The complexity of socio-economic systems and the potential for modeling agents in the movement of goods and people do not directly link to settlement patterns [27, 28]. Collective justifications show that settlement patterns are closely linked to the socio-economic systems of the movers, with factors such as local production, livelihood changes, environmental suitability, and technology adoption playing an important role. However, the relationship is complex and varies depending on the specific socio-economic context and the type of movement actors involved. The papers provide an understanding that settlement patterns are not only determined by geographical or environmental factors but are also shaped by the socio-economic dynamics of the community and the individuals within it [29-34].

Palopo City, one of the three autonomous cities in South Sulawesi province with an area of 269.23 km^2, consists of 9 sub-districts and 48 villages. Based on Government Regulation No. 26 of 2008, Palopo is designated as a regional activity center (PKW) to serve the provincial scale and several surrounding districts, including Luwu, North Luwu, and East Luwu. The main service centers are in Tompotikka and Salekoe villages, with sub-service centers in several villages in the districts of Telluwanua, Bara, Wara Selatan, Sendana, and Wara Barat. In addition, environmental centers for economic and social services are located in various wards within the municipal area [35].

Analysis of the centrality index in Palopo City shows an imbalance in the distribution of service functions and facilities between districts. Although Wara and Wara Timur districts serve as the city service centers with the highest centrality scores, they lack access to adequate educational facilities and infrastructure. In contrast, the districts of Wara Utara and Mungkajang, although they have a smaller role, actually have better access [36]. This imbalance reflects the inequality in regional planning, which if left unchecked can worsen the gap in development and service center systems between sub-regions in Palopo City.

Palopo City has specific challenges and opportunities in urban development and transport systems, which are closely related to its role as the center of regional activities and the distribution of service facilities across its sub-districts. Challenges include the unbalanced distribution of facilities in settlement centers, suboptimal mobility and accessibility management, and limited infrastructure to support a dispersed spatial structure. On the other hand, there are opportunities to strengthen the function of services at the area and neighborhood level to support regional service centers. In addition, there is great potential for developing an integrated transport system that can improve connectivity and mobility between service centers in the city.

This research aims to fill the knowledge gap regarding the relationship between settlement systems and socio-economic dynamics in medium-sized cities, particularly Palopo City. Although many previous studies address the relationship between settlement patterns and socio-economic mobility, most of them focus on large cities and pay less attention to the role of transport systems in influencing mobility. This research adopts an integrative approach by considering the interaction between settlement patterns, accessibility, and transport systems to provide new insights into how socioeconomic factors shape movement patterns in developing cities. The theory of paradigm shifts in individual mobility [15] and the concept of MaaS form the basis for contextualizing this research [18].

The research highlights the significant complexity in the relationship between the settlement system and the socio-economic dynamics of movement. In this context, both the settlement system and the socio-economic characteristics of movement actors play crucial roles in shaping mobility patterns. Consequently, different contexts may develop distinct patterns, underscoring the need for in-depth empirical analysis in specific cases. This analysis should focus on urban

areas and community groups, examining the interactions between the socioeconomic dynamics of movement actors, the settlement system, and the characteristics of the transportation system.

Your research introduces a novel approach by integrating the analysis of settlement systems, socio-economic factors, and transport system characteristics within Palopo's service center system. This focused perspective highlights how socio-economic factors influence both movement actors and the transport system, offering new insights into local dynamics often overlooked in broader studies of transport and settlement.

Based on the research problems above, research development is needed based on the construction of theoretical reality testing. This research intends to answer the following research questions:

1. How do the settlement system and social and economic actors of the movement affect the actors of the movement?
2. How do the settlement system, social, and economic systems on the characteristics of the transportation system?
3. How to model the service center system in Palopo City?

This research is essential to addressing the theoretical gap in previous studies. Therefore, it is necessary to employ Structural Equation Modeling (SEM-PLS) to analyze the case of the Activity Center in Palopo City.

2. MATERIAL AND METHOD

2.1 Research approach

This study employs a quantitative approach to analyze the interactions between settlement systems, socio and economic factors, movement actors, and their impact on the transportation system within Palopo City. The research focuses on key locations, including the City Service Center (PPK), Environmental Service Center (PPL), and Sub City Service Center (SPPL). By examining these key service centers, the study aims to understand how various levels of service hubs influence the optimization of the city's transportation infrastructure and the broader socioeconomic dynamics.

2.2 Data collection

In this study, a sample was drawn from 21 administrative villages across three clusters: the City Service Center (PPK), Sub-City Service Center (SPPK), and Environmental Service Center (PPL) in Palopo City. The selection of a study area that includes city service centers (PPK), sub-city service centers (SPPK), and neighborhood service centers (PPL) in Palopo City (see Figure 1). There were 200 respondents in this study, with 9 to 12 respondents per administrative village, ensuring comprehensive representation and reliability of the research data. The use of this sample size follows a simple model [37]. The selection of these respondents was based on the inclusion criteria of people living in the area for more than one year and actively using transport modes, both public and private. This selection aims to obtain a sample that represents a variety of socio-economic characteristics and mobility patterns.

Data collection was conducted on Mondays, Fridays, and Sundays to cover variations in activity and holiday times. Monday and Friday represent weekdays with high mobility, while Sunday represents weekend travel patterns. Each area represents various settlement systems as the distribution of settlement infrastructure and neighborhood scale service centers, socio-economic characteristics of movers, e.g., income, vehicle ownership, and public transport users; movers, e.g., destination, trip time and length; and transport system characteristics, e.g., cost and level of service. The proportional sampling of between 9 and 12 respondents per ward reflects demographic diversity and allows for in-depth analysis of settlement systems, socio-economics, movement patterns, and relationships within movement and transport systems in the realization of an urban service system model. As such, this research can provide a more accurate and holistic picture of the modeled relationships for more inclusive and sustainable urban planning.

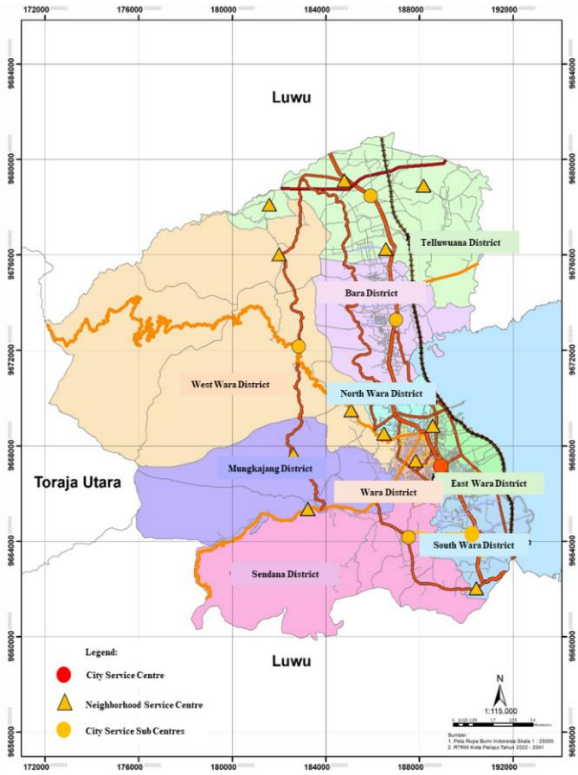

Figure 1. Research area
Source: Author elaboration

Data sources for this study include surveys, observations, and documentation. Surveys were conducted through questionnaires to collect data on movement characteristics, social and economic conditions, and the condition of settlement facilities and infrastructure. Observations were conducted at each service center (PPK, SPPK, PPL) to observe and describe the characteristics of the settlement system, as well as the social and economic conditions of movement actors. Documentation was conducted by collecting information related to policies, regulations, and reports related to settlement and transport infrastructure in Palopo City. In measuring the indicators in this study using a Likert scale, with responses ranging from: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, to (5) strongly agree. This scale allows for a more nuanced assessment of respondents' views on various aspects of the settlement system and associated factors.

2.3 Data analysis method

The analysis method uses a structural equation model from

survey data collected from questionnaires, which are then examined and integrated into Smart-PLS 3.0 software. Path analysis in structural equation modeling (SEM) is to analyze the relationship between variables in the research model. Using this approach, we were able to understand how the settlement system relationship model, social, and economic systems affect the actors of movement, as well as their impact on the characteristics and optimization of the transport system. Path analysis in SEM allows us to decipher the complex relationships between these variables, including the cumulative interactions that occur. SEM provides the ability to account for measurement errors through latent variables, which is an important advantage in transport studies where measurement errors are often significant [38, 39]. Thus, the use of SEM in this study ensures more robust and accurate results to provide deeper insights into the dynamics of the relationship between settlement and socio-economic systems of movement actors in the characteristics of the transport system, as well as contributing to the conceptual model of activity service systems in the characteristics of medium-sized cities such as the case of Palopo City.

Variables in this study are the settlement system (X_1), social and economic actors movement (X_2) as an independent variable or exogenous, actors movement (Y_1) as an intervening variable, and the characteristics of the transportation system (Y_2) as a dependent variable or endogenous as for the concept of equality as follows:

$$Y_1 = \beta_1 X_1 + \beta_2 X_2 + e \quad (1)$$

$$Y_2 = \beta_1 X_1 + \beta_2 X_2 + \beta_3 Y_1 + e \quad (2)$$

3. RESULT AND DISCUSSION

3.1 Determinants of movement factors and transport system characteristics

3.1.1 Measurement model analysis (Outer model)

The coefficient of determination on the direct path with R^2 is 0.869, indicating that the traveler variable explains about 86.9% of the path variation. Furthermore, the determination of the other path with R^2 is 0.912, indicating that the transport system characteristics variable is able to explain about 91.2% of the path variation.

3.1.2 Structural model analysis (Inner model)

This path analysis explores the relationships between settlement systems, socio-economic factors, travelers, and transport system characteristics. The results show that settlement systems affect movement actors (T-statistic = 8.509, p-value = 0.000), and affect transport system characteristics (T-statistic = 3.632, p-value = 0.000). In addition, socio-economic factors affect movement actors (T-statistic = 6.354, p-value = 0.000) and transport system characteristics (T-statistic = 5.032, p-value = 0.000). However, the direct effect of movement actors on transport system characteristics is weak and not statistically significant (T-statistic = 1.730, p-value = 0.084). These results indicate that although the settlement system and socio-economic conditions are key determinants in shaping transport dynamics, the direct influence of movement actors on the transport system is small. The results of the path coefficient show that of the three hypotheses proposed, all are acceptable (see Table 1).

Table 1. Path coefficient

Path	T-statistics	p-values
Settlement system →actors of the movement	8.509	0.000
Settlement system → characteristics of the transport system	3.632	0.000
Social and economic actors of the movement → actors of the movement	6.354	0.000
Social and economic actors of the movement → characteristics of the transport system	5.032	0.000
Actors of the movement → characteristics of the transport system	1.730	0.084

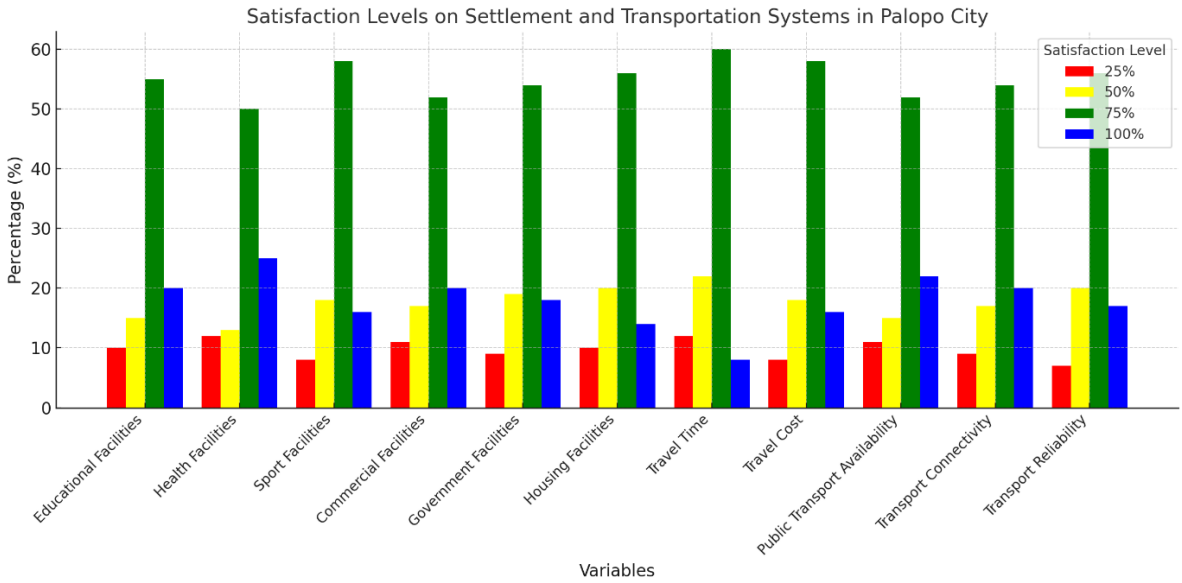

Figure 2. Distribution of respondents as actors in mobility toward transport system characteristics
Source: Author's elaboration

In Figure 2, the survey results on various aspects of the settlement and transportation systems in Palopo City reveal a generally high level of satisfaction among respondents. A significant majority expressed approval, with 40% agreeing and 41% strongly agreeing with the availability of educational facilities. Similarly, 58% agreed, and 17% strongly agreed on the adequacy of religious facilities. For commercial facilities, 48% agreed and 34% strongly agreed, indicating high satisfaction. Sports facilities received the highest approval, 68% agreeing and 10% strongly agreeing. Government facilities were also well-received, with 58% agreeing and 18% strongly agreeing. Healthcare facilities garnered 57% agreement and 26% strong agreement. Regarding transportation, 51% of respondents agreed that travel time is adequate, with 24% strongly agreeing, while 58% agreed and 21% strongly agreed that travel costs are reasonable. Public transport availability and comfort received 53% agreement and 22% strong agreement. Lastly, 49% of respondents agreed, and 26% strongly agreed on the reliability of the transportation system. These percentages indicate that the public perceives the city's infrastructure and services as well-developed and effective.

3.2 Relationship of settlement, socio-economic systems with travellers, and transport systems

The analysis shows that the settlement system significantly influences movement actors and transport system characteristics. This suggests that the spatial distribution, accessibility, and public facilities in the settlement system strongly influence how people move within the city and how the transport system is designed. This finding is consistent with the theory that settlement systems are integral to the social and economic mobility of actors. As outlined by the study [12], settlement systems shape social and economic mobility, which in turn affects social integration and community cohesion. Keller et al. [14] also point out that changes in institutional arrangements in housing systems can affect social and economic development, further reinforcing the importance of settlement systems in the context of transport.

Socio-economics was found to have a significant influence on the actors and the characteristics of the transport system. This finding suggests that socio-economic conditions, such as income, employment, and access to services, play an important role in determining mobility patterns and transport demand. This finding is in line with the literature that suggests that transport systems should be developed with an in-depth understanding of the socio-economic factors that influence urban mobility [40]. In addition, the concept that social and economic mobility is influenced by interactions with industrialization and access to resources, as discussed by the study [16], provides a framework for understanding the complex relationship between socio-economic conditions and transport system characteristics.

The findings in this study show that socio-economic factors have a significant influence on movement actors and transport system characteristics. Socio-economic conditions, such as income, employment, and access to services, play an important role in determining mobility patterns and transport demand. This is in line with the literature that emphasises that transport systems should be developed with an in-depth understanding of the socio-economic factors that influence travelers [40]. In addition, this finding also supports the concept of integrating individual mobility in influencing spatial interaction patterns, which indicates that changes in socio-economic conditions can directly affect the dynamics of individual movement in urban spaces [15]. These two findings illustrate that the development of an effective transport system should consider local socio-economic conditions as well as individual mobility dynamics in a spatial context.

The direct influence of movers on transport system characteristics is weak and not statistically significant. This suggests that while movers are an important element in transport dynamics, their influence on transport system characteristics is not as great as that of settlement systems or socio-economic factors. This finding highlights the complexity of the transport system as a service center that includes various subsystems, as described by Zhang et al. [23]. Although displacement actors are important, they do not directly influence transport system characteristics. This suggests the need for a more comprehensive approach that considers a range of factors, including the socio-economic conditions of the movers who perceive access and connectivity within the service center to be close enough to be a weak link to transport system characteristics.

The results of this study reinforce the understanding that the settlement system and socio-economic factors are the main determinants in shaping the transport system characteristics of Palopo City. Although mobility actors play a role in transport system characteristics, their influence on these system characteristics is not as great as that of the settlement system and socio-economic conditions. This weak relationship is due to the access and connectivity of actors in terms of affordable mobility to reach the city's service centers. Therefore, urban planning policies should consider the multifaceted impact of the settlement system and socio-economic factors in an effort to develop an efficient and sustainable transport system. This analysis demonstrates the importance of a holistic approach in urban planning that integrates various aspects of social, economic, access, and connectivity of movement actors and spatial destinations within urban service centers as an integration in establishing spatial structures and patterns for sustainable and inclusive urban development.

In the comparison between existing theories and survey results regarding accessibility to urban service centers, several discrepancies or potential contradictions can be identified. Firstly, the theories proposed by studies [1, 3], emphasize that sustainable urban development requires a complex balance between settlement patterns and transport systems. While the survey shows that physical accessibility to service centers is quite good, the theory suggests that this balance depends not only on geographical proximity but also on the quality of connectivity and regularity of the transport system. Therefore, if the survey does not consider these aspects, the ideal balance expected in the theory may not be achieved, creating a potential mismatch between the theory and the survey findings.

Second, the theory proposed by studies [4, 5], states that effective transport systems play an important role in improving socio-economic well-being in city centers. If accessibility to service centers is rated as good in surveys, this may indicate that people have good access to economic opportunities and essential services. However, this theory also underlines that a disorganized transport system can encourage the use of private vehicles, which has a negative impact on the environment and increases congestion. If the survey only assesses physical accessibility without considering the

unevenness of the transport system on private vehicle use and congestion, then the survey findings may contradict the theory on the impact of socio-economic well-being and the transport system.

3.3 Urban service center system model

Urban service system models that involve interactions between settlement systems, socio-economic factors, and movement actors play a key role in optimizing transport systems. A well-integrated settlement system can improve accessibility to urban service centers, while supportive socio-economic factors can strengthen mobility and access to services. On the other hand, travelers, although their direct influence is limited, still have an important role to play in ensuring the transport system functions properly to fulfill daily mobility needs. To achieve transport system optimization in Palopo City, urban planning policies need to consider the multifaceted impacts of settlement systems and socio-economic factors. Holistic and integrated planning, which includes spatial aspects, accessibility, and connectivity of movement actors and spatial destinations within urban service centers, will support the development of sustainable and inclusive spatial structures and patterns. This approach is essential to ensuring an adaptive, efficient transport system that can support urban growth and the city's long-term mobility needs.

The findings of this study provide significant practical implications for urban planning and transport system optimization in Palopo City and similar cities. Based on the insights gained, possible strategies include the development of integrated transport infrastructure, linking settlements to important service centers such as markets and health facilities, and improving transport access for low-income groups living in informal settlements. In addition, spatial planning that optimizes public facilities such as bus stops and transport service centers in residential areas, as well as sustainable transport policies that support bicycle lanes and green public transport, can reduce dependence on private vehicles and congestion. A holistic approach that considers socio-economic factors in urban planning is also essential to creating an inclusive, effective, and sustainable transport system that supports more balanced urban development and is adaptive to socio-economic change.

A number of limitations are acknowledged in this study to assist contextualize its findings and lay the groundwork for further research. First off, the dynamics present in other urban locations with distinct socioeconomic or physical contexts might not be well captured by the focus on Palopo City. Second, the analysis of long-term changes in mobility patterns and the changing effects of settlement and transportation networks is hampered by the lack of longitudinal data. Furthermore, there are methodological difficulties in precisely quantifying socioeconomic variables like income inequality and service accessibility, which may restrict wider applicability. Notwithstanding these limitations, the study offers insightful information for communities dealing with related problems, like the need for inclusive transportation options and the rate of urbanization. Mid-sized cities with comparable circumstances can benefit from strategies like improving access for underserved communities and connecting transportation with important metropolitan service centers. This study emphasizes that thorough transportation planning is crucial for promoting fair and sustainable urban expansion by re-connecting with the issues of urbanization, sustainability, and integrated transport systems previously discussed.

4. CONCLUSIONS

Settlement systems and socio-economic factors influence mobility dynamics and transport characteristics in Palopo City. Factors such as spatial distribution, accessibility, and public facilities in the settlement system play a role in determining movement patterns, while socio-economic conditions, such as income and access to services, influence transport demand. While the direct influence of movement actors on the transport system is limited, their role remains important, requiring a comprehensive approach that considers access and mobility to urban service centers.

This study emphasizes the importance of integrating settlement systems, socio-economic factors, and mobility patterns to develop a model of an urban service center system based on transport systems. A holistic approach that encompasses the distribution of spatial service centers, mobility, and widespread dispersal of activities supported by socio-economic drivers is essential to creating a polycentric, inclusive spatial structure.

ACKNOWLEDGMENT

We would like to thank Andi Jemma University and the government and community of Palopo City, as well as the Postgraduate Programme of Bosowa University Makassar, for helping in the collaboration of writing this research as one of the requirements in pursuing a doctoral education in the Regional and Urban Planning Doctoral Study Programme.

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