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Research Article

Effectiveness of Road Transportation Strategies and Accessibility in the Sidama National Region, Ethiopia: A Multilevel Analysis

Siquarie Shudda Dangisso[1]*, Dayanandan R.[2], and Wogene Markos Dumo[3]

[1]Department of Cooperatives, College of Business and Economics, Hawassa University, Ethiopia
[2]Department of Cooperatives, College of Business and Economics, Hawassa University, Ethiopia,
[3]Department of Economics, College of Business and Economics, Hawassa University, Ethiopia

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CORRESPONDING EMAIL
* siquarie@gmail.com

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Abstract

The study examines the effectiveness of the road transport services strategies using service reliability, accessibility, and system integration indicators and multilevel modeling to capture both individual and kebele-level variations in the Sidama Region, Ethiopia. A cross-sectional survey was conducted with 379 households to measure perceptions of service reliability characterized by availability, accessibility, affordability, and integration in the sample kebeles in the study area. Data indices are composed of 32 Likert-scale items, and a multilevel linear model described for clustering at the kebele level (ICC = 0.538). The results showed that service availability (β = 0.42, p < 0.001), accessibility to essential services (β = 0.36, p < 0.001), and integration and efficiency (β = 0.31, p = 0.001) are the strongest predictors of perceived transport services' effectiveness. The income of respondents positively influenced the perceptions of respondents, while household size presented limited effects. The substantial variation in kebele level was observed, which implies the importance of logistics infrastructure and institutionalization and governance at localized interventions. The findings advocate optimizing availability, access, and service coverage and system integrity; consolidating modal integration to users' satisfaction; and progressing toward Sustainable Development Goals, particularly SDG 9, SDG 10, and SDG 11. The study significantly contributes empirical evidence and a validated multi-dimensional framework to transport strategies in developing and localized service-oriented interventions over transport planning and equitable services provision.

1 Introduction

Road transport is pivotal to bringing about socio-economic development across both high-income and developing countries. Transport strategies such as infrastructure expansion, service integration, and regulatory frameworks play a central role in shaping the outcomes of services' quality and accessibility (Du et al., 2022; Khan & Khan, 2022). Focusing on inclusive infrastructure, equitable access to services, and endorsing sustainable settlements, the effectiveness of integrated transport systems is critical for supporting local development strategies and realizing the sustainable development goals (SDGs), SDG 9, SDG 10, and SDG 11, which (Butkus et al., 2023; Kaiser & Barstow, 2022).

Efficient and integrated transport services uplift competence to address the needs for mobility (Alola et al., 2025; Khan & Khan, 2022). Improving reliability and access to all modes of transport services is critical to sustaining transport services ("Dynamic linkages between transport, logistics, foreign direct Investment, and economic growth: Empirical evidence from developing countries," 2020; Ngyah & Ngusulugh, 2021; Onokala & Olajide, 2020). However, the service system remains uneven and ineffective. Therefore, it fails to meet the needs of the community in many low- and middle-income countries (LMICs), markedly across Sub-Saharan Africa. Asher and Novosad (2020) argued that more than one billion people globally lack essential services, highlighting determined infrastructure shortages and service gaps.

The United Nations, in its sustainable development goals, includes the development of resilient, inclusive, and sustainable infrastructure, particularly in the transport sector (United Nations, 2024). Recent studies underline that sustainable transport systems require an integrated multimodal approach supported by data-driven evaluation frameworks (Nitwal et al., 2025; Zhang et al., 2024). However, challenges are pertained to such as infrastructure gaps, weak institutional coordination, and inequality in access persist, particularly in developing cities (Ngcobo et al., n.d.; Tazzie et al., 2025). These findings reinforce the need for coordinated transport strategies that align with SDG 10 and SDG 11 by promoting inclusive, efficient, and well-integrated transport systems.

The provision of transport services and its administration in many LMICs is characterized by fragmentation, limited access, and poor integration, which contribute to rising business costs and increased journey times, which exacerbates socio-economic inequalities (Kaiser & Barstow, 2022; Khan & Khan, 2022; Netirith & Ji, 2022). Weak institutional frameworks limited multimodal integration, and overall ineffectiveness hindered mobility, economic opportunities, and social inclusion (Alola et al., 2025; United Nations Economic Commission for Africa, 2022). Hence, improving network integration, service quality, and operational efficiency is critical to enhance mobility, decrease transport costs, and foster regional development.

To improve transportation service in Ethiopia, the national Road Sector Development Program (RSDP) has made significant investments in infrastructure expansion, with road transport accounting for 90% of passengers and freight services in the country (Ministry of Transport, 2020). To translate this effort into equitable service delivery, there are bottlenecks, including uneven access, weak multimodal integration, and fragmented regulatory and institutional coordination (Ethiopian Roads Administration, 2023; Ministry of Transport, 2020). As Alemayehu and Delina (2024) explained, weak regulatory mechanisms continue to determine reliability, competitiveness, and overall system performance. This demands that the provision of affordable, reliable, inclusive, and demand-driven transport services does not meet its goal and demand for interventions that integrate infrastructure, operations, and governance.

In Sidama National Regional State (NRS), road transport services management is facing the problem of reaching an integrated system of road-based mobility and goods distribution across urban and rural areas. This includes passenger transport services as well as freight and logistics services. Passenger transport services referring to formal public transport modes such as public buses, minibuses, and three-wheeled vehicles (commonly known as Bajaj). While these services are behind mobility for work, education, healthcare access, trade, and social interaction, thereby contributing to socio-economic integration and accessibility. Therefore, commuters' services are directly contributing to community satisfaction aligned with SDG 9, SDG 10, and SDG 11.

The institutional mandates of governance of transport services in the Sidama NRS are structured around public regulatory bodies and privately owned transport service operators (unpublished regional proclamation, 2020). The transport and road development bureau (BoTRD) is a government authority responsible for transport policy implementation at the Sidama NRS. The bureau offers services such as licensing, regulating operators, route and fare allocation, regulation, coordination, and monitoring compliance with service standards. Private Sector Operators (PSOs) provide services commenced by private actors, with registered private-owned bus operators' associations, minibus and taxi unions, and Bajaj operators. Privately owned transport operators and public authorities do not have integrated and coordinative approaches.

Previous studies were constrained to addressing the strategies to enhance transport service effectiveness that influence satisfying users' perceptions in Ethiopia. Takele et al. (2023) also argued that the urban bias deprives peripheral areas of equitable connectivity. Sisay (2024) added the emphasis that the urban bias and top-down decision-making in Ethiopian transport development aggravated the problem. Studies by Solomon et al. (2025) examined public transport in Addis Ababa through the lens of a centralized transport authority. In addition, national-level studies by Sisay (2024) often prioritize macroeconomic frameworks and high-volume infrastructure. As Girma (2023), mobility aspects in evolving regional cities are still not explored. The same scenario is behaving in the emerging regional state, Sidama NRS, due to the lack of attention given to addressing this problem.

The extent to which determinant factors, such as availability, accessibility, integration, and affordability, shape users' perceptions at the community level is not yet examined. These challenges rigorously limit access to progress toward SDGs 9 and 11. Therefore, the analysis of the study connects with transport accessibility theory ("Accessibility evaluation of land-use and transport strategies: review and research directions," 2004; W. G. Hansen, 1959) to explore transport service outcome indicators to perceived transport service effectiveness (PTSE), addressing the service delivery dimensions that span from individual users to kebeles to identify factors. Further, the findings are used to generate policy-relevant insight aimed at improving transport service provision and aligning user needs with broader development goals, particularly SDG 9, SDG 10, and SDG 11 in the Sidama National Regional State.

1.1 Theoretical and Empirical Background

1.1.1 Theoretical Foundation of Road Transport Service Effectiveness

The effectiveness of road transport services relies on the extent to which transport systems are reliable, affordable, and well-integrated with mobility. It enables users to access essential services and opportunities efficiently. In connection with accessibility theory (P. Hansen et al., n.d.), road transport services value a means to connect individuals to essential services. On the other hand, mobility theory (Sheller & Urry, 2006) underlines the role of both individual and collective mobility in facilitating access to opportunities and fostering social connections to support social and economic activities (Sheller & Urry, 2006). Mobility is defined as an integrated system that coordinates public and private transport that enables services to address users' demands .

Real-time connectivity is the modern engine of transport efficiency (Eltved et al., 2021). Enhancing access in urban and peri-urban mobility lowers travel costs (Medina-Tapia et al., 2021). Transport effectiveness is a system that facilitates access and realizes integration, thereby strengthening public and private operations across all modes of transport services (Litman, 2007; Masrournejad et al., 2021). Accessibility is multidimensional and includes service availability, affordability, travel time, reliability, and spatial connectivity (Freiria et al., 2022). System integration refers to the coordination of modes, fares, information, and infrastructure to provide seamless mobility (Onokala & Olajide, 2020).

1.1.2 Empirical Evidence on Road Transport Service Effectiveness

Accessibility is referred to as a key benefit of transportation networks, with low accessibility associated with poverty, unemployment, and social marginalization (Adhvaryu & Mudhol, 2021; Malhotra et al., 2021). Transport cost is a major barrier for low-income households, limiting their ability to access transport services even when available (Mutiganda et al., 2023). Improvements in public transport systems show that better coverage and connectivity increase access to opportunities and improve social equity (Bocarejo & Urrego, 2022).

Improved service coverage, connectivity, and increased accessibility that incorporate both schedule- and frequency-based services represent a better passenger perception (Eltved et al., 2021). Mobility as a Service (MaaS) seeks an effective strategy to unify public and private transport services via a single application . Integrated transport systems (e.g., coordinated services, multimodal connections, and unified fare systems) improve outcomes of mobility by reducing fragmentation and increasing ease of travel (Mutiganda et al., 2023; Soares et al., 2022).

As mentioned by Cedillo-Campos et al. (2022) and Fobosi and Malima (2024), inadequate infrastructure and weak regulatory frameworks impede transport strategies that determine the effectiveness of service availability, accessibility, affordability, and system integration, particularly in LMICs. In Ethiopia, the difficulty arose from structural challenges, including inadequate infrastructure and weak regulatory frameworks that restrict the effectiveness of transport initiatives (Ministry of Transport, 2020). The road transport service effectiveness in regions like Sidama relies on contextual synthesis, aiming to blend high-tech data with low-tech inclusivity to address socioeconomic realities of rural accessibility.

2 Objectives

1. To assess household perceptions of the effectiveness of transport services strategies focusing on key drivers, such as availability, reliability, affordability, and connectivity.
2. To examine how multilevel contextual attributes and socio-demographic factors influence the perceived effectiveness of transport service, employing multilevel modeling.
3. To estimate the extent of the perceived transport service effectiveness in the geographic variation across kebeles and quantity between-kebele variation in perceived transport service effectiveness.
4. To provide relevant policy evidence for improving transport services provision and user-centered transport strategies in Sidama NRS.

3 Hypotheses

Hypothesis (H1): A higher level of perceived determinants of transport service, such as availability, reliability, affordability, connectivity, and system integration, positively influences perceived transport service effectiveness (PTSE).

Hypothesis (H2): Greater accessibility to essential services (education, healthcare, commerce, and employment) positively affects PTSE.

Hypothesis (H3): A higher household income level is positively associated with PTSE.

Hypothesis (H4): Travel-related factors (distance and trip frequency) significantly influence PTSE.

Hypothesis (H5): Socio-demographic-related characteristics (household size, occupation, and location) significantly affect PTSE.

4 Methods and Materials

4.1 Study Area Description

This study was carried out in Sidama Region, Ethiopia. The region emerged as a regional state in 2020 after a referendum. The capital, Hawassa, is situated 275 km south of Addis Ababa. The region covers 6,992.24 km^2 and lies between latitudes 6°14′ N and 7°18′ N, and longitudes 38°20′ E and 39°20′ E. It is bordered by the Oromia region, Gedeo zone, and Wolaita zone, with an average elevation of 2,068 meters. The region has various agro-ecological zones, including temperate Middle land (45.3%), Highland (27.2%), Lowland (24.2%), and alpine (3.4%). As of the plan and development bureau (2024) (unpublished report), the population is 4.8 million across 991,000 households, organized administratively into 30 woredas [1] (districts) and six city administrations (Hawassa administration with eight sub-cities), and a total of 658 kebeles[2]. Regarding the Infrastructure, 4,422.43 km of roads and 60 complete bridges, though poor road quality and connectivity remain issues, especially in remote areas (unpublished report). The spatial distribution of sampled administration is presented in Figure 1.

4.2 Research Design and Approach

This study applied a quantitative cross-sectional survey design to examine the effectiveness of transport service strategies in responding to commuter needs in the Sidama NRS. The analysis focuses on the perception of users on the transport services effectiveness (PTSE) through key predictors, such as services accessibility and operational-effectiveness dimensions on a household level. For the hierarchical structure data, a multi-level modeling framework is employed, where individual households (Level 1) are nested within kebeles (level 2). The approach helps the analysis to capture respondents who are within the same kebele and are likely to share similar contextual characteristics, such as transport infrastructure conditions, service availability, and local governance, which potentially lead to intra-group correlation. In this way, a two-level model is specified to estimate both

[1] Woreda: Refers to an administrative division after zones in Sidama NRS. They are responsible for delivering essential services and implementing national polices at community level.

[2] Kebele: The smallest administrative unit in Ethiopia, operate at the community level, handling local governance, civil registration, and grassroots service delivery.

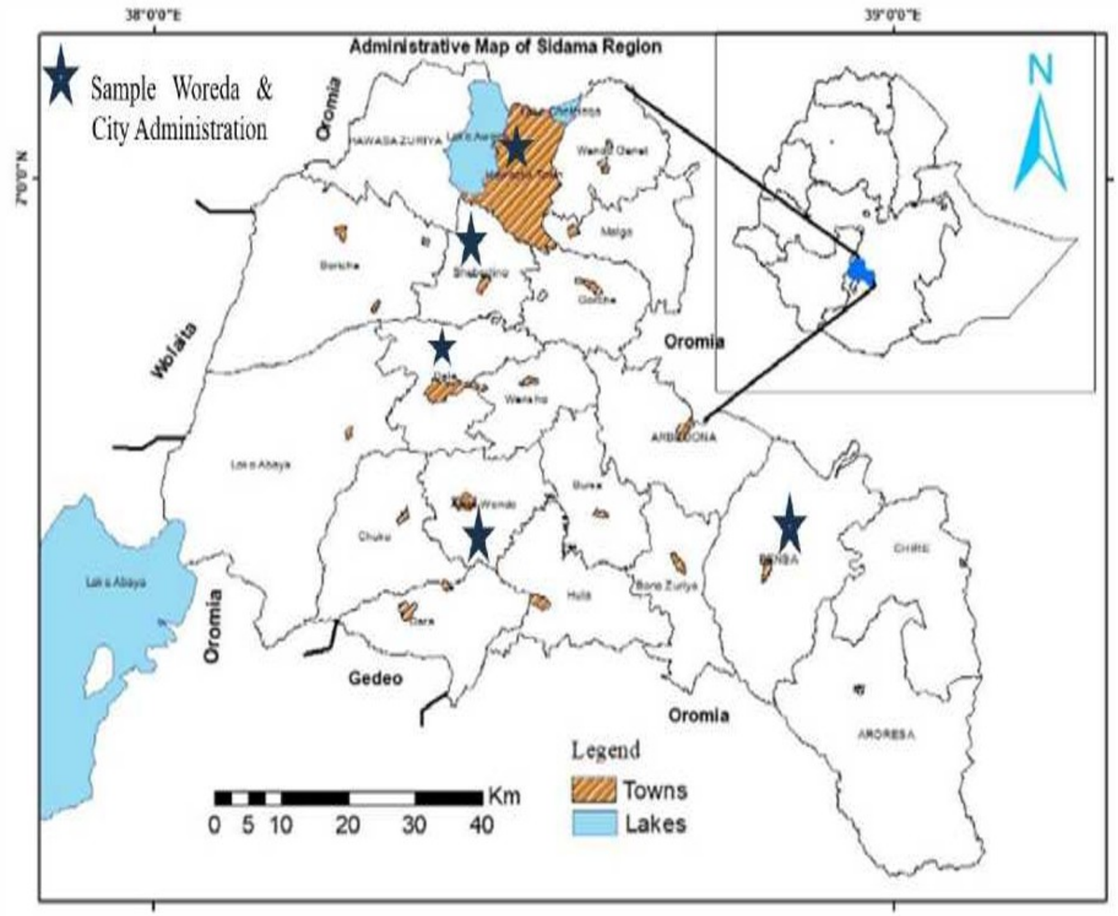

Figure 1: Map of the Study Area (Sidama National Regional State, Ethiopia)

individual-level determinants of PTSE and kebele- level variation is assessed using the intraclass correlation coefficient (ICC), while random intercepts are included to account for unobserved heterogeneity across kebeles. This hierarchical modeling approach ensures stronger and more reliable parameter estimates.

4.3 Data Collection Method

A structured questionnaire was administered to collect the information on these dimensions to compare respondents and kebeles across them. The household survey was managed by trained enumerators, and they were given two days of training to cover the study objectives, ethical procedures, content of the questionnaire, and exploitation of digital data collection tools. The questionnaire was coded using Kobo Toolbox and processed through face-to-face interviews using smart mobile devices (tablets/smartphones). The method was chosen because it improves data accuracy, reduces entry errors, and allows real-time consistency checks. The questionnaires were translated into local language during interviews to ensure clarity and comprehension. All participants were informed to obtain consent prior to the interview.

4.4 Sampling and Sample Size Determination

The target population comprises households residing in ten kebeles in the Sidama National Regional State (NRS). The regional state is purposely selected due to the Federal House of Representatives and the Regional Transport and Road Development Bureau (BoRTD) reports, which note these current structural challenges and advocate to see new solutions and take actions to improve road transportation quality and service effectiveness in the Sidama Region on April 20, 2024.

First, all five Zones were included in the study to ensure full geographic coverage in the region. Therefore, no sampling was applied at the zone level. Within each zone, a multistage random sampling procedure was implemented. First, woredas are selected from each zone, based on population size and number of kebeles they cover. Accordingly, one woreda (district) was selected from each Zone. Subsequently, two kebeles were randomly sampled from each selected woreda (district), resulting in a total of ten kebeles.

Within these kebeles, households were selected using proportional systematic random sampling based on the kebele household registry, with the help of the Kobo Toolbox. A total sample of 379 households was proportionally allocated from a population of 24,551 (Regional Development and Plan Bureau, 2024). Household members aged 18 and above were eligible to participate.

Sample size was calculated using Cochran's formula (Cochran, 1977) with a finite population adjustment. First, the initial sample size for an infinite population was calculated as:

$$n_0 = \frac{Z^2 p(1-p)}{e^2}$$

Where $Z = 1.96$ (95% confidence level), $p = 0.5$ (maximum variability), and $e = 0.05$ (margin of error). This gives:

$$n_0 = \frac{(1.96)^2 \times 0.5(1-0.5)}{(0.05)^2} = 384$$

Since the population is finite ($N = 24,551$), the adjusted sample size was computed using:

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}} = 379$$

Thus, the final sample size is 379. A design effect (Deff) of 1.0 was assumed due to minimal intra-cluster correlation.

Survey data, which measures perceived strategy effectiveness, service availability, accessibility, reliability, affordability, comfort, and system integration, reflects how well road transport services meet the daily mobility needs of a diverse community. Data were collected using structured Likert-scale items. In addition, socio-demographic factors, such as occupation, income, and location were also collected to control individual-level perceptions.

4.5 Data Analysis Method

This study employed a multilevel modeling approach to account for the hierarchical structure of the data, where households are nested within kebeles, in order to investigate the effectiveness of the strategies in road transport service delivery. The approach enables the decomposition of total variance into within- and between-kebele components, thereby allowing the estimation of the intra-class correlation (ICC) and examination of how geographic context influences PTSE. The analysis investigates how the key transport service dimensions and accessibility factors shape household experience in PTSE, grounded in transport accessibility and mobility theory (W. G. Hansen, 1959; Sheller & Urry, 2006). The hierarchical nature of data, within the same kebele are likely to share similar contextual characteristics, such as infrastructure quality, service availability, and local governance, thus violating the independence assumptions of conventional regression models.

To address hierarchy data in structure, a two-level linear mixed-effects model with random intercepts was applied (Raudenbush & Bryk, 2002). This helps to establish a baseline to vary kebeles while estimating the fixed effects of key predictors, including service availability, accessibility to essential services, integration system efficiency, and sociodemographic characteristics. In this way, the dependent variable, PTSE, was constructed as a composite index derived from multiple Likert scale items capturing key dimensions, such as affordability, reliability, and accessibility, and user experiences. Therefore, the multilevel modeling approach provides more accurate parameter estimates and standard errors by explicitly accounting for clustering effects, thereby offering a strong framework for analyzing the determinants for transport service effectiveness in a geographically structured context.

4.5.1 Definitions of Variables

Table 1 presents the definitions, measurements, and levels of all variables that are further used in the analysis. The dependent variable is a composite index that is derived from multiple Likert scale items, while the independent variables are service availability and socio-demographic characteristic-related dimensions. However, a variable travel time was incorporated as a contextual variable using secondary data from the Ethiopian Roads Administration (Ethiopian Roads Administration, 2023), representing average travel duration (in minutes). Table 1 also differentiates between individual-level and kebele-level variables used in the multilevel modeling framework.

4.5.2 Model Specification

The general model is specified as follows:

$$Y_{ij} = \beta_0 + \sum \beta_k X_{kij} + u_j + \epsilon_{ij}$$

Where Y_{ij} denotes the perceived transport service effectiveness score for individual i in kebele j; X_{kij} stands for individual-level predictors (service quality, perceptions, and socio-demographic characteristics); u_j is the kebele level random intercept capturing unobserved contextual variation; and ϵ_{ij} is the individual level error term.

Prior to model estimation, descriptive statistics and graphical diagnostics, including histograms and Q-Q plots, were used to test normal distribution, revealing only minor deviations acceptable under large sample conditions. A stepwise approach was taken, starting

Table 1: Variable Definition and Measurements

Variable	Definition	Measurement	Level
PTSE (Dependent Variable)	Perceived effectiveness of transport availability, accessibility, affordability, and system integration	Composite index (32-Likert items, sum (32–152))	Individual
Service Availability	Extent to which transport services are available and meet user needs across time periods	Composite index	Individual
Accessibility to Essential Services	Ease of healthcare, education, employment, and other key services	Composite index	Individual
Integration and Efficiency	Degree of coordination between transport modes and system performance	Composite index	Individual
Socioeconomic Support	Extent to which transport services facilitate commerce and provide affordable fare options	Composite index	Individual
Comfort / User Experience	Quality of travel experience across transport modes	Composite index	Individual
Income Level	Annual household income of respondents	Continuous variable (Ethiopian Birr, ETB)	Individual
Education Level	Highest educational attainment of respondent	Categorical	Individual
Household Size	Number of individuals in the household	Continuous (count)	Individual
Travel Time	Travel time for daily activities (e.g., work, school)	Continuous (km or categorized distance ranges)	Average
Kebele (Cluster Variable)	Administrative unit representing geographic clustering of respondents	Categorical (kebele identifier)	Kebele
Kebele-Level Effects (Random Effect)	Unobserved contextual factors	Random intercept in multilevel model	Kebele

Source: Authors' Compilation based on Household Survey Data (2025)

with a null model to calculate the interclass correlation coefficient (ICC) to assess kebele-level variance. Subsequent models included individual-level predictors, with likelihood ratio tests for model adequacy. Statistical reliability was ensured by using standard errors clustered at the kebele level to address intra-group correlations and heteroscedasticity.

5 Analysis and Results

The results of the study are presented under five sections. The first section describes the socio-demographic characteristics of the respondent. The second section presents descriptive statistics of the PTSE index. The third section discusses the construction and measurement of the PTSE variable in an analysis; the fourth section examines the influence of service quality, travel behavior, and socio-demographic factors using a multilevel modeling approach. The last section explores geographic variation and outlines kebeles' policy implications for improving transport services provision in the Sidama region.

5.1 Descriptive Statistics

As shown in Table 2, descriptive statistics indicate moderate variation across service-related dimensions. The composite PTSE score ranges from 32 to 152, with a mean of 85.72 (SD = 25.25), reflecting a moderate level of variability among respondents in perceived transport service effectiveness. A mean score for service availability is 2.68; integration and efficiency mean scores are 2.65, reflecting potential gaps in service frequency, coordination, and system reliability. A mean score of 2.82 for accessibility shows below optimal levels, implying gaps in accessing essential services. A mean of 252,354 ETB (SD = 291,241) for household income indicates a significant economic variation among respondents. This may relate to perceptions of affordability and access to transport services. The average household size mean is 3.75 (SD = 1.56), ranging from 2 to 10 members, implying a moderate household size with considerable variation across respondents.

Travel time is referred as a contextual variable incorporated using secondary data from the Ethiopian Road Administration (Ethiopian Roads Administration, 2023) (unpublished report), representing average travel duration (in minutes) in rural and peri-urban areas. These results imply that transport services provide basic functionality; improvements are needed in service reliability, accessibility, and system integration to enhance perceived effectiveness.

Table 2: Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
PTSE	85.72	25.25	0	152
Service Availability	2.68	1.06	1	5
Accessibility	2.82	1.16	1	5
Integration & Efficiency	2.65	1.03	1	5
Socioeconomic Support	3.02	1.23	1	5
Comfort / User Experience	2.70	1.10	1	5
Income (ETB/year)	252,354	291,241	100,000	2,500,000
Household Size	3.75	1.56	2	10
Travel Time	60	30	30	90

Source: Computed from household survey data ($N = 379$), 2025

5.2 Socio-Demographic Characteristics of the Respondents

Table 3 shows the result of the sample is male (71.2%), while females account for 28.2%, and 0.5% fall under unspecified categories. This implies participation differences rather than household headship. Likely, the age of respondents ranges from 18 to 78 years, with the majority (59.6%) falling within the economically active age group (30–45 years). Younger adults, ranging from 18 to 29 account for 17.2%; those aged between 46 and 60 represent 16.2%; and respondents above 60 years constitute about 7%. Therefore, the result indicates that the sample is composed of working-age individuals who are highly dependent on transport services.

Regarding the status of education, 32.2% of respondents hold a diploma or higher education, while 21.4% completed secondary education (9–12). However, 17.4% of respondents have no formal education. This indicates variation in educational attainment that may influence perception of service quality. Household income shows substantial variation, with a mean annual income of 252,354.21 ETB ranging from 100,000 ETB to 2,500,000 ETB (SD = 291,240.79). This dispersion indicates significant economic heterogeneity among respondents. This supports analyzing differences in perceived affordability, accessibility, and equity in transport services. Therefore, data captures a socially and economically diverse population and strengthens the findings to capture varied experiences with PTSE.

Table 3: Socio-Demographic Characteristics of Respondents ($N = 379$)

Variable	Category	Frequency (N)	Percentage (%)
Gender	Male	270	71.2
	Female	107	28.2
	Other/Unspecified	2	0.5
Age Group	18–29	65	17.2
	30–45	226	59.6
	46–60	61	16.2
	> 60	27	7.0
Education Level	Diploma and above	122	32.2
	Secondary school (9–12)	81	21.4
	Uneducated	66	17.4
	Senior secondary (7–8)	45	11.9
	TVET (1–4)	34	9.0
	Primary (1–6)	31	8.2

Income (ETB/year)	Metric	Value
	Mean (approx.)	252,354.21
	Minimum	100,000
	Maximum	2,500,000
	Std. Deviation	291,241.00

Source: Computed from household survey data ($N = 379$)

5.2.1 Distribution of PTSE

Table 4 presents distributional properties of the composite of PTSE scores. This index ranges from 0 to 152, reflecting substantial variability in respondents' perceptions, which has a mean of 85.72 (SD = 25.25) and a median of 86.00. This result indicates a symmetric distribution. The interquartile range ranges from 65 to 104, suggesting moderate dispersion, without evidence of floor or ceiling effects. Skewness (0.009) is negligible. While kurtosis (2.48) was slightly below the normal benchmark, which suggests minor deviation from normality and supports the suitability of the data for parametric analysis. A 95% confidence interval for the mean is [83.17, 88.27] (SE = 1.29), indicating a precise estimate of a population mean. These properties confirm that the PTSE index is continuous, symmetric, and suitable for parametric analysis.

Table 4: Distributional property of PTSE Score

Statistic	Value	Interpretation
Mean	85.72	Moderately high perceived effectiveness
Median (p50)	86.00	Close to mean; symmetric distribution
Min – Max	0 – 152	Wide variation in responses
Standard Deviation	25.25	Substantial variability
Skewness	0.009	Symmetric
Kurtosis	2.48	Mild deviation from normality
IQR (p25–p75)	65–104	Moderate dispersion
95% CI (Mean)	83.17–88.27	Precise estimate

Source: Computed by the author using `tabstat` in Stata 18 from household survey data ($N = 379$), 2025

5.3 Effectiveness of PTSE in the Study Area

A composite index for the dependent variable (PTSE) was constructed with data derived from 32 Likert-scale items across six thematic dimensions: service effectiveness, service availability, accessibility to essential services, socio-economic support, comfort and user experience, system integration, and efficiency. Each item was measured through a five-point scale, yielding a total index score ranging from 32 to 152.

The composite index is generated using the row-total procedure in Stata, which sums responses across all items to produce a continuous variable. The approach suggesting that aggregated Likert scale items can be treated as approximately interval-level data for parametric analysis establishes methodological guidance (Norman, 2010). The index helps to measure households' perceived transport system effectiveness in meeting daily mobility needs.

As presented in Table 5, the survey items represent key services outcomes dimensions, including accessibility, reliability, affordability, and user experience. These indicators form the basis for a composite index and subsequent regression analysis. Specifically, the index reflects service performance across different items of the day; accessibility to essential services such as health care, education, and employment; economic support (e.g., fare equity and commerce facilitation); comfort across transport modes; and the level of coordination and integration within the transport system.

Therefore, the constructed index provides a comprehensive and multidimensional measure of perceived PTSE across urban and peri-urban residents.

Table 5: Thematic Grouping for Transportation Effectiveness

Theme	Variables
Service Effectiveness	Morning, afternoon, evening commuter effectiveness; timeliness effectiveness; private bus effectiveness; public bus effectiveness; taxi commute effectiveness
Service Availability	Accessibility, service frequency, and alignment with user needs
Access to Essential Services	Access to healthcare (public/private), education (public/private), and work-related travel
Socioeconomic Support	Commerce support (public/private/taxi); fare equity (public/private/taxi)
Comfort / User Experience	Comfort levels in public buses, private buses, and taxis
Integration & Efficiency	Public-private coordination, system integration reliability, reduced waiting time, real-time information, customer feedback mechanisms

Source: Survey Instrument and Variable Coding (2025)

5.4 Normality Assessment

Figures 3-4 present the histogram with normal curve, Kernel Density Plot, and Q-Q Plot for PTSE index. Visual inspection highlights a symmetric and bell-shaped distribution, with only minor deviations in the tails. Visual inspection of plots suggests a symmetric, bell-shaped distribution of the PTSE index, with minor tail deviations. Despite a significant Shapiro–Wilk test ($p < 0.01$) due to the large sample size, the normality assumption is deemed satisfied for OLS estimation.

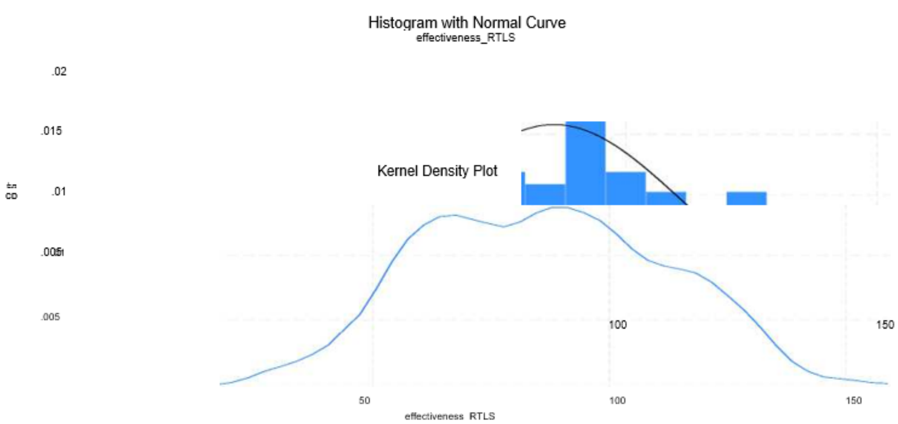

Figure 2: Figure 2: Histogram of PTSE Score (with Normal Curve) Source: Computed from household survey data (N = 379)

The Shapiro-Wilk test (Table 6) indicates a statistically significant departure from normality ($W = 0.988$, $p = 0.0028$). However, given the large sample size ($N = 379$), such tests are known to be extremely sensitive to minor deviations from normality.

Table 6: Shapiro–Wilk Test for Normality of PTSE Score

Variable	**Obs**	**W**	**V**	**z**	**Prob > z**
PTSE	379	0.98778	3.214	2.772	0.00279

Source: Computed from household survey ($N = 379$), 2025.

Source: Computed from household survey data (N = 379)

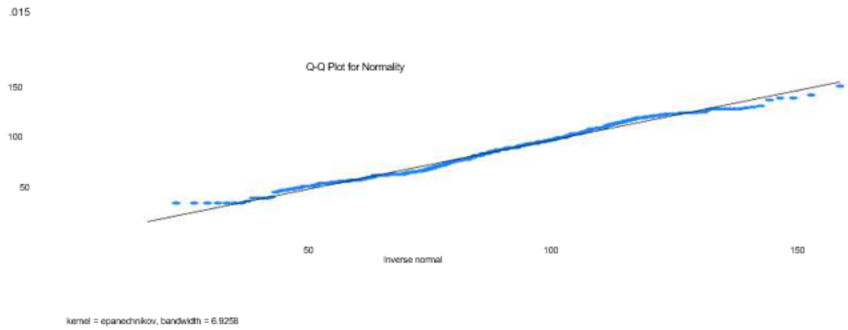

Figure 3: Figure 3: Kernel Density Plot of PTSE Source: Computed from household survey data (N = 379)

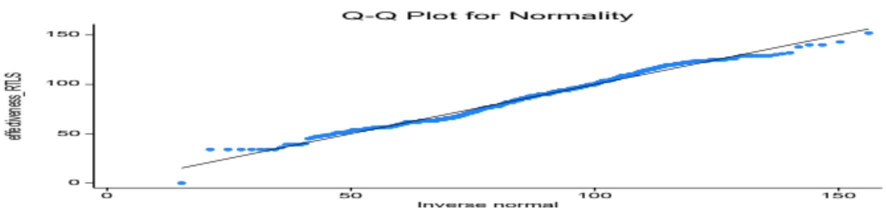

Figure 4: Figure 4: Q-Q Plot for PTSE Source: Computed from household survey data (N = 379)

As shown in Table 7, another test for normality was done based on skewness and kurtosis. The result showed skewness is not significant (p = 0.9403), while kurtosis is statistically significant (p = 0.0078), resulting in a significant joint test (p = 0.00322). This suggests that the distribution is symmetric but exhibits mild deviation in tail behavior. Therefore, graphical diagnostics indicate normal distribution. Thus, normality assumption is considered sufficiently satisfied for OLS regression analysis.

Table 7: Skewness and Kurtosis Test for Normality

Variable	**Obs**	**Pr (skewness)**	**Pr (kurtosis)**	**Joint test**	
				Adj chi^2 (2)	**Prob > chi^2**
PTSE	379	0.9403	0.0078	6.87	0.0322

Source: Computed from household survey ($N = 379$), 2025

5.4.1 Model Choice and Intraclass Correlation Coefficient (ICC) Analysis

As presented in Table 8, a multilevel ordinary least squares (OLS) regression model analyzes the effects of key determinants of transport service and socio-demographic factors on the PTSE, considering the hierarchical data structure of households within kebeles. A two-level linear mixed effects model with a random intercept was utilized to account for this structure. Multilevel modeling improves upon single-level regression by considering clustering effects, yielding accurate standard errors, and enabling the estimation of fixed and random effects at hierarchical levels.

The analysis of the null model estimating the intraclass correlation coefficient (ICC) revealed that about 54% of the variance in PTSE is due to differences between kebeles (ICC = 0.54, SE = 0.116; 95% CI: 0.318–0.745). Clustering effect supports the adoption of a multilevel modeling approach, emphasizing kebele-level contextual factors. Likely, the Likelihood ratio tests confirmed that the multilevel model fits the data significantly better than a single-level model (p < 0.001). As a result, robust standard errors clustered at the kebele level were applied, ensuring valid statistical results. Diagnostic checks indicated no major violations of assumptions concerning linearity, multicollinearity, or homoscedasticity, affirming the model's good fit and reliability for further analysis.

Table 8: Multilevel OLS Regression Results for PTSE

Fixed Effects	**Coefficient**	**SE**	**p-value**
Intercepts	42.15	4.32	< 0.001
Service availability	0.42	0.05	< 0.001
Accessibility to essential services	0.36	0.06	< 0.001
Integration and efficiency	0.31	0.08	0.001
Income level	0.27	0.09	0.003
Education	0.08	0.07	0.256
Household size	-0.06	0.05	0.232
Travel time	-0.11	0.06	0.068
Random Effect	**Variance**	**SD**	
Kebele_ID (Intercept)	292.40	17.10	
Residual (within kebele)	248.80	15.70	

Source: Computed from household survey ($N = 379$), 2025

5.4.2 *Model Justification and Validation*

The multilevel OLS regression model accounts for the continuous dependent variable and significant clustering at the kebele level. It applies diagnostic checks to affirm that key OLS assumptions, including linearity, homoscedasticity, and the absence of influential outliers, are satisfied. The hierarchical data, nesting households (Level 1) within kebeles (Level 2), which share transport services and infrastructure, challenge traditional regression assumptions. Individual and kebele-level factors affect perceived transport service effectiveness. Multilevel modeling estimates intra-class correlation (ICC) and quantifies perceived effectiveness differences across kebeles while providing reliable parameter estimates by addressing clustering and accommodating both fixed and random effects. The ICC was computed from the variance components of the null (empty) model as:

$$ICC = \frac{\hat{\sigma}^2_{between}}{\hat{\sigma}^2_{between} + \hat{\sigma}^2_{within}}$$

Substituting the estimated variance components:

$$ICC = \frac{292.41}{292.41 + 248.80} = \frac{292.41}{541.21} \approx 0.54$$

This indicates that 54% of the total variance in PTSE is attributable to differences between kebeles, while the remaining 46% is due to within-kebele (household-level) variation. The substantial clustering effect justifies the use of multilevel modeling.

To improve the strength of the statistical inference, it was adjusted using cluster-robust estimators at the kebele level to account for potential intra-cluster correlation and standard errors. This adjustment is important in hierarchical data structures, where observations within some kebele may not be independent. The standard errors accordingly correct the model, providing more reliable statistical inferences and reducing the risk of biased significance estimates (Colin Cameron & Miller, 2015; Wooldridge, 2023).

5.5 Multilevel Analysis of the PTSE

As demonstrated in Table 5, the determinants of PTSE in the multilevel model show both individual-level and contextual (kebele level) factors influencing PTSE. The intraclass correlation coefficient (ICC = 54%) confirms that a substantial proportion of the total variance is attributable to differences across kebeles. Therefore, the finding indicates the localized infrastructure conditions, service provision disparities, service provision, and governance effectiveness in shaping transportation outcomes.

5.5.1 Service Quality and Accessibility Factors

Service availability is a variable that emerges as the strongest predictor ($\beta = 0.42$, p < 0.001), indicating that frequent and reliable transport services significantly enhance perceived effectiveness. The accessibility ($\beta = 0.36$, p < 0.001), which is access to essential services, shows a strong positive effect. This highlights the critical role of transport systems enabling access to healthcare, education, and business activities. Integration and efficiency ($\beta = 0.31$, p = 0.001) also significantly improve perceived effectiveness by reducing travel time and enhancing system coordination.

5.5.2 Socio-Economic Characteristics

Household income is a significant socio-economic predictor ($\beta = 0.27$, p = 0.003), suggesting higher-income households perceive better transport effectiveness. In contrast, education ($\beta = 0.08$, p = 0.256) and household size ($\beta = -0.06$, p = 0.232) do not significantly impact perception of transport service effectiveness.

5.5.3 Effect of Travel Time

Travel time shows a negative but statistically marginal relationship ($\beta = -0.11$, p = 0.068), suggesting longer travel duration reduces perceived effectiveness. Although the effect of travel time is not at conventional levels of statistical significance. This result should therefore be interpreted with caution. From the policy perspective, the high ICC underlines strong spatial variations across kebeles, supporting the need for place-based transport interventions focusing on service frequency improvement, accessibility expansion, and integration of transport modes.

From a development perspective, improved transport service and accessibility promote inclusive mobility, boost economic productivity, and help to reduce inequalities, aligning with key global development goals such as SDG 11.2 which emphasizes access to safe, affordable, and sustainable transport systems; SDG 9 which focuses on building resilient infrastructure; and SDG 10 aimed at reducing inequalities.

To sum up, from a development perspective, improved transport service and accessibility promote inclusive mobility, boost economic productivity, and help to reduce inequalities, aligning with key global development goals such as SDG 11.2 which emphasizes access to safe, affordable, and sustainable transport systems; SDG 9 which focuses on building resilient infrastructure; and SDG 10 aimed at reducing inequalities.

5.6 Hypotheses Testing

This study examined the hypotheses supposed about the determinants of the PTSE. Each hypothesis is evaluated using the variable(s) contained in the multilevel regression model.

Hypothesis (H1) was testing the impact of PTSE. Drivers of transport service were operationalized using important dimensions such as service availability and system integration/efficiency. Results indicate that both service availability ($\beta = 0.42$, p < 0.001) and system integration/efficiency ($\beta = 0.31$, p = 0.001) have a favorable and statistically significant effect on PTSE. These findings suggest that improved service coverage and better coordination across transport modes enhance users' perception of transport effectiveness. Therefore, hypothesis H1 is supported.

Hypothesis (H2) is access to essential transport services (e.g., education, healthcare, commerce, and work) is positively associated with the strategy of the PTSE. The result confirms that accessibility to essential transport services ($\beta = 0.36$, p < 0.001) proved a significant positive relation with perceived strategy effectiveness. This variable is important in facilitating social and economic inclusion, as improved access directly enhances perceived performance. This hypothesis is supported by the results.

Hypothesis (H3) is that affordability and income level are the positive effects of income, but the absence of direct affordability metrics suggests that perceived effectiveness is linked to a reduced financial burden of transport costs. Higher income indicates a stronger link with area, as high-income households live in places with better services. Future research should disentangle this by including direct cost-to-income ratios.

Hypothesis (H4) is about travel-related behaviors, such as travel time sensitivity, frequency, and purpose of travel, significantly influencing perceptions of strategy effectiveness. Travel time ($\beta = -0.11$, p = 0.068) was found to be marginally significant and negatively related to perceived effectiveness. This suggests that some travel-related factors require further investigation. This hypothesis is partially supported.

Hypothesis (H5) examines whether socio-demographic characteristics (e.g., location, occupation, and household structure) significantly shaped PTSE. The results indicate that income level ($\beta = 0.27$, p = 0.003) remains a key predictor reinforcing its role as a key socioeconomic control variable, whereas household size (p = 0.232) was not significant. This indicates that household size shows limited influence, and economic capacity continues to play a dominant role in shaping PTSE. This hypothesis is partially supported.

6 Findings and Discussion

6.1 Findings

The results showed service availability, accessibility, and system integration across transport modes are the primary predictors of PTSE. Multilevel modeling further revealed the substantial clustering of responses at the kebele level (ICC = 0.54), explaining that more than half of the variation in perceived effectiveness arises from structural and service differences between kebeles rather than individual-level characteristics. This implies the critical role of spatial and infrastructure disparities in shaping transport service outcomes.

Access to essential services such as health, education, and administrative services positively influences the PTSE. System integration across public, private, and informal transport modes enhances perceived effectiveness through coordinated scheduling and connectivity. Furthermore, a household with high income correlates with greater PTSE, whereas household size does not have significant effect.

6.2 Discussion

The empirical findings of the study about the PTSE provide clear evidence that is strongly shaped by service quality, availability, accessibility to essential services, system integration, and household socioeconomic characteristics in Sidama region.

6.2.1 Service Availability

The result confirmed that service availability is a fundamental part of the transport services. It notes that enhanced service availability positively influences users' perceptions of reliability and satisfaction, corroborated by recent empirical research (Malhotra et al., 2021). In contrast, limited service availability hinders access to essential services, worsening spatial inequality and contributing to transport disadvantage and social exclusion, as evidenced by studies (Muttaqin, Herwangi, et al., 2021; Poku-Boansi, Asibey, et al., 2024).

6.2.2 Accessibility as a Key Predictor

In this study, accessibility was identified as both a transport provision and a key performance indicator that affects the perceived effectiveness of transportation strategies for commuters. The findings suggest that households with better access to transportation report higher satisfaction, indicating that transport systems are assessed by their capability to connect users to essential services such as healthcare, education, and employment. The empirical evidence supported that improved mobility enhances access to essential services, social inclusion, and opportunities in economic activities, particularly in low- and middle-income contexts (Fobosi & Malima, 2024; Ramírez-Saiz et al., 2025). This result is also supported by results from LMICs (Bwire & Ntamwiza, 2025; Ramírez-Saiz et al., 2025; Tao et al., 2024). In the Sidama Region, access to essential services should be prioritized to reduce spatial inequalities and foster equitable development, especially in underserved kebeles.

6.2.3 Integration and Operational Efficiency

Integration and operational efficiency significantly impact the integration across public, private, and informal operators. In this way, it can enhance the coordination of the transport services that enables reduced fragmentation, particularly in underserved areas. The result is also supported with empirical evidence from Olowosegun, Moyo, et al. (2021) and Rakhmatullah et al. (2024). Challenges continue with weak modal integration, which is leading to increased travel times and costs in the Sidama region. Strengthening institutional coordination, developing better interchanges, and encouraging private sector involvement are essential for enhancing transport performance and user satisfaction.

6.2.4 Socioeconomic Factors

In the study, socioeconomic status, particularly household income, was positively associated with the perceived effectiveness of the transport services strategies. The result showed that affordability constraints disproportionately affect lower-income households. However, another demographic factor, household size, showed insignificant influence, suggesting that improvements in service delivery are likely to benefit a broad range of commuters regardless of socioeconomic background. Household income was positively associated with PTSE, reflecting affordability constraints among low-income users, while household size had inadequate predictive power, suggesting that advances in service delivery would benefit commuters across socioeconomic groups.

6.2.5 Policy-Linked Implications

The finding also aligned with the policy of Minister of Transport and Logistics (MoTL) (Ministry of Transport, 2020). The result highlighted that fragmented regulation, outdated and aging vehicles, and insufficient terminal capacity are primary challenges in Sidama NRS. Therefore, integrated and coordinated resources use is vital to enhance service reliability and accessibility in passenger transport in Sidama NRS. In addition, developing integrated infrastructure, intelligent transport system solutions, and modernization of transportation can solve service quality. Further, expanding road networks, promoting sustainable transport modes, and supporting community participation enhance mobility and economic inclusion for commuters' transport (Litman, 2007).

6.2.6 Implications for SDGs

The study found that availability, accessibility, and integration directly support the attainment of SDGs 9, 10, and 11, by promoting inclusive and sustainable infrastructure (SDG 9), reducing spatial and socioeconomic inequalities (SDG 10), and supporting sustainable urban and rural mobility (SDG 11). In addition, place-based interventions that enhance equity, efficiency, and sustainability in Sidama NRS transport system should be given attention to addressing the variations among the kebele-level users.

In sum, the findings indicate that expanding transport services to underserved kebeles, enhancing availability, accessibility to essential services, and improving operational integration across transport modes represent the most effective levers for improving public satisfaction with PTSE strategies. Therefore, combine infrastructure investment with strengthened operational management, such as fare regulation, service standardization, and multimodal coordination seeking policy responses. Place-based interventions, which promote inclusive mobility, thereby accelerating progress toward SDGs 9 (industry, innovation, and infrastructure), 10 (reduced inequalities), and 11 (sustainable cities and communities) should be guided by kebele level to reduce variation and spatial inequalities.

7 Conclusion

The study analyzed PTSE on predictors such as service availability, accessibility, and system integration dimensions, while geographic variations at the kebele level are being considered. Key findings confirmed that PTSE is influenced by core dimensions of service delivery, including availability, accessibility to essential services, and system integration. The drivers of transport service and accessibility factors exert a stronger influence on perceived effectiveness than most socio-demographic characteristics, while household income shows a significant positive association, household size does not. Improving service provision generates broad benefits, but affordability constraints remain relevant for lower-income households.

The findings from the statistical data show that substantial geographic disparities in perceived effectiveness explained it at the kebele level (ICC $\approx$ 0.54). This indicates that the importance of localized infrastructure conditions, service availability, and institutional performance approaches that shape transport outcomes and uniform policy is insufficient to address spatial inequalities in service provision. Therefore, strengthening the side of provision and shifting governance strategies to decentralized and responsive are critical to improving the PTSE dimension such as enhancing service delivery, particularly in underserved areas, strengthening access to essential services, and improving coordination among transport modes and operators in the region.

Therefore, the study contributes empirical evidence by a multilevel modeling to capture both individual perceptions and spatial heterogeneity in transport service effectiveness, while the findings support the relevance of transport services in advancing broader development priorities, such as SDG 9, SDG 10, and SDG 11.

8 Recommendations

1. The data indicated that the high intra-class correlation (ICC) (54%) suggests substantial heterogeneity between kebeles, implying uniform regional approaches are insufficient. Regional authorities should execute decentralized and kebele-specific transport planning, emphasizing poorly performing areas through targeted investments in feeder roads, local route expansion, and service frequency increases to promote availability.
2. Since access to essential services (health, education, and markets) is a key driver of perceived effectiveness, transport planning should be beyond infrastructure expansion toward operational improvement. This should include developing systematic route scheduling systems, especially in peri-urban and underserved kebeles with the greatest reliability gaps.
3. The institutional and sectoral responsible body, particularly BoTRD, should advocate for a new funding approach that prioritizes equity-focused service expansion while ensuring that marginalized kebeles have adequate route coverage and service frequency; furthermore, it should be made to support robust and sustainable transportation systems, such as integration-enhancing infrastructure (e.g., multimodal hubs) and regulations that increase service reliability over time.
4. Regional governments should develop new formal coordination frameworks that include public, commercial, and informal transportation providers through unified scheduling platforms, shared terminals, standardized fare systems, and regulatory norms, which improve first- and last-mile connections while minimizing system fragmentation.
5. Regional government should conduct timely reviews on the transport services strategies, considering factors such as cost-to-income ratios, trip time, and accessibility to allow for evidence-based adjustments to kebele-level transportation initiatives.
6. A structured monitor and evaluation systems should be developed to track key performance indicators such as accessibility, reliability, service frequency, and user satisfaction to incorporate systems for collecting and integrating commuter feedback, ensuring that transportation policies stay responsive to changing user demands and mobility patterns.

9 Contribution of the Study

This study provides new empirical data on the efficiency of transport strategies in a developing economy and, particularly, a local community for the community and development practitioners.

In addition, it offers a new approach that highlights the importance of combining multilevel modeling for policy-relevant transport studies. Furthermore, the study offers empirical evidence that is derived from comprehension of SDGs 9, 10, and 11, analyzing them in concerns of whether they are met with their ultimate goal of service efficacy and inclusion.

This study has limitations in terms of, such as, the fact that it is based on self-reported perceptions and it is restricted to the Sidama Region. Also, it does not explicitly evaluate availability and accessibility of the transport service efficacy. Future research should investigate the long-term effects of infrastructure expenditures and expand to other geographical contexts to validate and generalize findings.

10 Ethical Considerations

The study adhered to strict ethical guidelines, and the Hawassa University College of Business and Economics Research Ethics Committee formally approved the study (Protocol No. 1; Approval: CBE_RTT-87/2024; issued December 11, 2024). In this accord, the participants were oriented and gave their written or verbal agreement to data collectors after being fully informed about the purpose of the study and their rights of the study. To guarantee proper community reactions, confidentiality and anonymity were maintained, while local customs and cultural sensitivity were honored.

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Data Availability

Data can be made available on the behavior of the request

Declaration of interests' statement

The author declare no competing interests.

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