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Sustainable transport strategies and their implementation barriers in Addis Ababa, Ethiopia

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Emerging cities like Addis Ababa are now facing rapid urbanization and motorization, which results in an increasing urban mobility challenges. Despite the global advancements in sustainable mobility, these cities are struggling with limited public transport that largely relies on informal and low-capacity transport modes and automobile use, causing traffic congestion, road traffic fatalities, noise pollution, and vehicle emission-related challenges. This paper aims to identify the sustainable transport strategies and key barriers to the implementation of these strategies, taking Addis Ababa as a case study. The study is based on empirical evidence from residents' and experts' perspectives, with the support of desk reviews. The analysis was done using descriptive analysis and ordinal logistic regression. The result revealed that the transport strategies in the study city emphasized promoting non-motorized and public transport, mobility management, planning considerations for land use and transport integration, adoption of technological solutions, institutional reforms, and awareness campaigns. It was found that most of the strategies are on paper without effective implementation, and the prevalence of pressing mobility challenges characterizes the city. The findings also indicated that the implementations of various ambitious sustainable transport strategies are constrained by financial shortage, and poor institutional quality with bad governance and management systems, together with weak coordination among institutions. Additionally, a lack of guiding framework for sustainable urban mobility, a lack of political commitment and leadership towards sustainable transport solutions, limited technological adoption, and socio-cultural attitude towards car use with limited alternative mobility options influenced the implementation of the stated strategies. This study suggests addressing the barriers comprehensively and the need for adopting a cost-effective strategy tailored to the study city context in Addis Ababa that helps with the transition toward sustainable mobility and livability.

KEYWORDS

sustainable mobility, public transport, non-motorized transport, mobility management, integration, technological solutions, institutional quality, awareness campaign

1 Introduction

Sustainable transport systems have significant positive impacts in achieving sustainable socio-economic development, social justice, and quality of life in cities. It is particularly important for fast-growing cities in Sub-Saharan Africa, which have been experiencing rapid urbanization and motorization. A well-designed urban transport system effectively facilitates socio-economic development and environmental sustainability (Sdoukopoulos

et al., 2019). However, with the growing number of automobiles, urban transport challenges such as traffic congestion, accidents, pollution, energy depletion, and limited public transport accessibility have become a defining feature of many emerging cities in Sub-Saharan Africa (Kenworthy, 2017; Knowles et al., 2020; Wiedmann et al., 2014). Furthermore, lengthy and unsafe travel, long waiting times, and costly trips in uncomfortable and unsafe vehicles impede the ability of many urban residents to enjoy healthy and productive lives, especially in these emerging cities. These urban transport challenges impact not only the urban poor who use walking, cycling, and public transport but also middle-class car owners and affluent car users.

Over the next three decades, cities are projected to gain an additional 2.5 billion people, with more than 90% of this growth occurring in Asia and Africa, regions where significant economic development is still anticipated (Beard et al., 2016). At the same time, many emerging cities across the world are now experiencing rapid growth in private car ownership with rising income (Wadud, 2020). The challenges are getting worse with increasing motorization through car-oriented development, investing in road infrastructure while overlooking other alternative modes of transport, including public transit, walking, and cycling (Acheampong and Asabere, 2022).

To achieve sustainable urban mobility (SUM), which prioritizes reducing environmental impacts, promoting social equity, and ensuring economic efficiency, a wide range of initiatives have been implemented worldwide. Some of these sustainable urban transport strategies (SUTS) include improving urban transport infrastructure (McLean et al., 2016; Melkonyan et al., 2022; Prus and Sikora, 2021); promoting public transport (Ceder, 2021; Oeschger et al., 2020); encouraging active mobility modes such as walking and cycling (Mansoor et al., 2022; Zhu and Diao, 2016); integrating land use and transport planning (Boitor, 2014); managing mobility demands (Diao, 2019); adopting technological solutions (Paiva et al., 2021); and strengthening the institutional and legal framework (Canitez et al., 2019; Stead, 2016). At the same time, the transition toward SUM has gained increasing attention in many cities worldwide.

Despite the growing recognition of sustainable transport policies and strategies in these fast-growing cities, their implementation remains inadequate due to various implementation barriers. Different researchers identified several barriers to the implementation of such strategies, including financial, institutional, legal, political, social, cultural, and technological challenges (Banister, 2005; May et al., 2006). However, many of the previous studies focused on cities in developed countries, overlooking the unique socio-economic and governance contexts of emerging cities like Addis Ababa. This research thus addresses the gap in addressing sustainable transport strategies by examining the specific barriers that hinder the implementation and will contribute to developing more effective policy recommendations tailored to the context of emerging cities. By examining the barriers to sustainable transport in Addis Ababa, this research aims to inform policymakers, urban planners, and transport authorities in designing more effective, context-specific solutions that can enhance sustainable mobility.

This paper is organized into seven sections. Following this introduction, Section 2 presents a review of the literature. Section 3 presents materials and methods used for this study. Section 4 presents the results of the study, while Section 5 presents a discussion of the results. Section 6 presents the limitations and policy implications of the study, while the final section presents the conclusion.

2 Literature review

Many cities in Sub-Saharan Africa are facing a wide range of urban transport challenges, including severe traffic congestion, high rates of road traffic fatalities, air and noise pollution, and inadequate public transport. These challenges are exacerbated by the absence of comprehensive urban mobility plans, limited funding, weak governance, and poor institutional quality. Despite the presence of various urban transport policies and strategies on paper, the effectiveness of these strategies continued to remain challenging. The subsequent section outlines the major sustainable urban transport strategies and the implementation barriers.

2.1 Sustainable transport strategies

Recent research highlights various strategies for attaining sustainable urban mobility in fast-growing cities, including road infrastructure improvements, efficient public transit development, promotion of non-motorized transport (NMT), and the introduction of pricing mechanisms as well as land-use regulations (Sietchiping et al., 2012). Some of these strategies are particularly relevant to emerging cities in Sub-Saharan Africa, are discussed in this literature review. The first most effective strategy is the NMT-oriented strategy, as the large majority of the population uses walking and cycling in their daily activities (Mansoor et al., 2022). However, despite the crucial roles of walking and cycling, urban planning efforts and policy decisions often neglect these modes of transport. Policy makers, often driven by the vision for modernization and economic growth, perceived such modes of transport as inferior and have given less attention (Bebber et al., 2021; Nogueira, 2022). This disconnect between policy decisions and the reality of urban mobility disproportionately affects the low-income communities that heavily rely on NMT. The absence of adequate infrastructures for pedestrians and cyclists makes urban mobility in cities of the developing world more challenging (Basil and Nyachieo, 2023). Addressing these issues requires a paradigm shift in urban transport planning and policy decisions that should consider NMT as a vital component of sustainable urban mobility in these cities.

The second broad alternative strategy is promoting public transport. Measures in this regard include infrastructure expansion, busses, and trams (light rail) systems that have been introduced in some of the large cities in Sub-Saharan Africa, including Addis Ababa. In this regard, the adoption of dedicated bus lanes and bus rapid transit (BRT) systems serves as an affordable alternative compared to the rail transit systems in these emerging cities with financial limitations (Racehorse et al., 2015). Although light rail transit (LRT) offers better capability than BRT, its high capital and operational costs make it an impractical solution for most cities in developing countries (Pojani and Stead, 2015). This underscores the urgent need for cost-effective and context-specific public transport alternatives that can enhance urban mobility while remaining financially feasible.

The third category of the sustainable transport strategy involves the integration of transport and land use planning. The land use

density, diversity, and design play a crucial role in enhancing urban efficiency and promoting sustainable transport systems in cities (Kodukula, 2018). High-density and mixed-use developments encourage walking and cycling while also strengthening the viability of public transport by creating a built environment that supports active mobility. A more structured form of transport and land use integration through transit-oriented development (TOD) is now getting recognition as a viable option for congestion reduction in many cities (Suzuki et al., 2013). However, the implementation of such strategies in emerging cities is challenging due to fragmentation among the many planning authorities with overlapping responsibilities and poor coordination. This lack of coordination often results in haphazard urban expansion and inefficient transport systems that weaken efforts toward achieving sustainable urban mobility.

Adoption of emerging technologies also has the potential to address some of the most pressing urban transport challenges, such as congestion, traffic accidents, and environmental pollution (Bajpai, 2016). In this regard, electric and biofuel vehicles offer promising solutions for reducing carbon emissions and dependency on fossil fuels. Almatar (2023) highlights the role of expanding electric vehicle (EV) infrastructure in promoting the use of renewable energy within urban transport systems that can reduce congestion and vehicle emission-related challenges. Additionally, the adoption of intelligent transport systems (ITS) technologies also helps in managing traffic congestion situations and traffic fatalities (Vijayalakshmi and Raj, 2019). However, the adoption of such technologies in emerging cities of Sub-Saharan Africa remains limited due to various financial and institutional challenges. Addressing these challenges requires targeted policy interventions, investment in supportive infrastructure, and capacity-building initiatives (See Figure 1).

2.2 Barriers to the implementation of sustainable transport strategies

Barriers can be defined as impediments that hinder the implementation of various urban transport policies and strategies. Several studies have explored the barriers to implementing sustainable transport initiatives. For instance, Vigar (2000) identified four broad types of barriers that include financial, organizational, cultural, and political. He stated that cultural and political barriers were the most significant. Similarly, Banister (2005) identified six categories of barriers that include resource-related, institutional and policy-related, social and cultural, legal, and physical impediments. Among these six barriers, Banister (2005) found that resource, institutional and policy, and social and cultural barriers were the most critical challenges. May et al. (2006) also identified four categories of barriers: legal and institutional, financial, political, cultural, and technological.

Based on the review of various studies, the researchers grouped the major barriers of effective implementation of sustainable transport strategies in for emerging cities context into seven groups. The first category of the barrier is financial barriers,

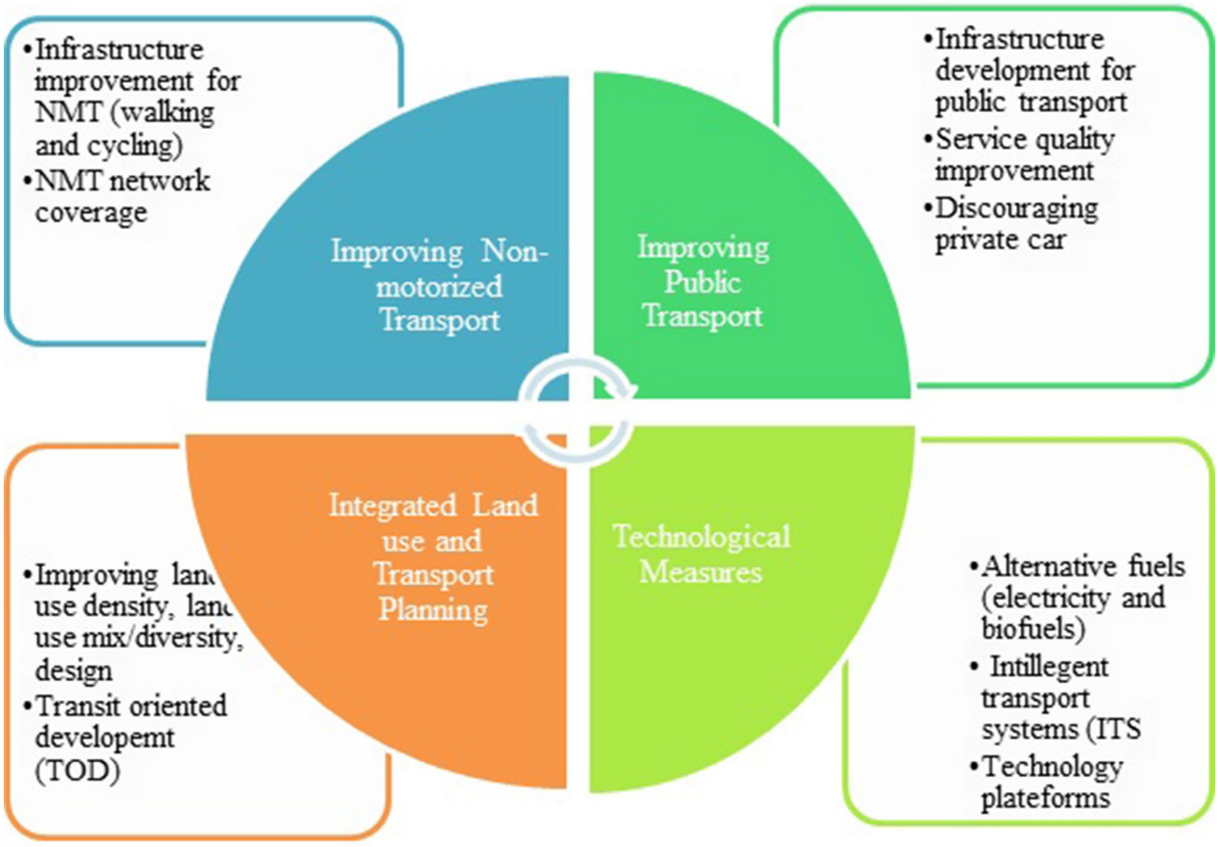

FIGURE 1
Four broad categories of sustainable transport strategies.

where many of the Sub-Saharan African cities struggle with insufficient budgets for urban transport infrastructure projects and heavy reliance on donor funding. Evidence indicates that while there is an acknowledgment of the need for sustainable transport, limited financial resources often result in project delays, diminished scale of efforts, and dependence on cost-saving strategies that undermine the quality and efficiency of urban transport solutions [Sub-Saharan Africa Transport Policy Program (SSATP), 2018].

The second barrier is political, or governance-related, that directly shapes the policies and decisions on urban transport systems. The lack of political will, lack of transparency and accountability, and absence of strong leadership can impair any transport initiative (Ceder, 2021). Given the complex political environments in many Sub-Saharan African cities, frequent changes in leadership, poor governance, and lack of stable political systems are the most significant barriers to the consistent implementation of various sustainable transport strategies.

The third barrier is institutional quality and capacity related that stems from a lack of responsible organizations. In many emerging cities, fragmented institutional structures, overlapping mandates, and weak coordination between different government agencies create significant challenges for the implementation of such strategies. The lack of capable institutions and skilled professionals often hinders the development of strong and long-term transport solutions.

The fourth barrier is the legal and policy framework. Outdated and inappropriate legal and policy frameworks with poor enforcement also hinder the implementation of sustainable transport initiatives. In many cases, legal issues arise from the absence of forward-thinking that aligns with sustainable transport goals (Prus and Sikora, 2021). However, they tend to be easier to address once political support and institutional capacity are strengthened, though they still require urgent attention.

The fifth barrier is limited technological adoption due to difficulties associated with embracing new technologies and the absence of contemporary transport technologies, including intelligent traffic management systems, smart infrastructure, and electric vehicle adoption. Technological limitations can compound other problems and prevent cities from modernizing their transport infrastructure (Paiva et al., 2021).

The sixth barrier is socio-cultural behavior, including the attitudes toward non-motorized transport options; public transport and private car ownership determine the transition to more sustainable mobility systems (Vanderschuren et al., 2022). Overcoming cultural norms and behavioral attitudes is thus essential for fostering broader societal support for sustainable transport initiatives.

The seventh barrier is related to physical or topographic constraints that pose significant challenges for non-motorized travel. While these barriers can be significant in specific areas, they can be addressed through targeted infrastructure solutions.

3 Materials and methods

3.1 Study area

This study was conducted in Addis Ababa, the capital city of Ethiopia. The city of Addis Ababa has a total area of 540 km^2 (Weldegebriel et al., 2021), and it is the most populous urban center in Ethiopia, both in terms of population. The city's population is now projected to reach above 5 million as of 2024 (World Population Review, 2023). The rate of motorization in the city is also increasing rapidly, accounting for 54% of the nation's registered vehicular traffic [Federal Transport Authority (FTA), 2020]. The city is estimated to have a total of around 721,180 registered vehicles by 2021 [Addis Ababa Driver and Vehicle Licensing and Inspection Authority (AADVLIA), 2022] (See Figure 2).

In the city of Addis Ababa, walking and public transport are the primary modes of travel together account for more than 80% of the trip; however, private cars account for 15% of the trip and dominate a disproportionate amount of space (60%), while pedestrians account for 54% of the trip, are confined to only 12% of the area. Public transport, which accounts for 31% of the trip, occupies only 28% of the road space [Addis Ababa Transport Bureau (AATB), 2018] (See Figure 3).

The case city, Addis Ababa, is selected due to the rapid urbanization and motorization, with pressing urban transport challenges. Over the past few decades, the city has experienced rapid population growth accompanied by a surge in car ownership. This has placed immense pressure on the existing transport infrastructures, leading to severe traffic congestion, rising road traffic fatalities, and an increasing level of air pollution from vehicle emissions. Despite the efforts to improve the urban transport systems with the introduction

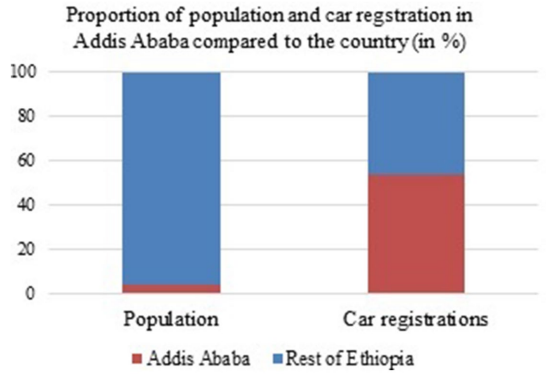

FIGURE 2
Proportion of population and vehicle registration (Source: Federal Transport Authority (FTA), 2020; World Population Review, 2023).

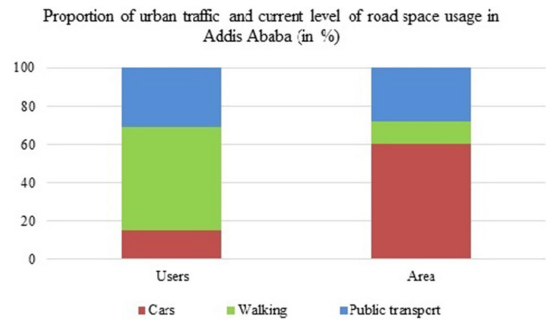

FIGURE 3
Proportion of traffic and road space usage (Source: Addis Ababa Transport Bureau (AATB), 2018).

of LRT, ongoing BRT construction, and current corridor development, the city continues to struggle with inefficient and unsustainable urban mobility challenges.

This situation presents a critical opportunity to assess the effectiveness of these interventions and identify the barriers impeding their success. Furthermore, Addis Ababa can serve as a representative case for other emerging cities in Sub-Saharan Africa that face similar urban transport challenges. Many cities in the region are undergoing comparable patterns of urbanization and economic growth, leading to similar transport challenges. Therefore, the findings from this study can provide valuable insights that may apply to other cities, contributing to the broader discourse on sustainable urban transport strategies in emerging cities.

3.2 Survey design

This study employed mixed methods that include a desk review, interviews, and a survey questionnaire. First, the existing sustainable transport strategies, their level of implementation, and the barriers to the implementation of such strategies in the study city context were identified using a desk review of various transport policies, strategies, and transport planning documents. The desk review provided a foundation for further analysis of these transport strategies and associated implementation barriers from the perspective of the residents and experts.

Following the document review, consultations were held with experts from diverse fields in the sector, including urban and transport planners, economists, sociologists, and environmentalists. The expert interview provided valuable insights into the existing urban transport policies and strategies, the level of implementation of such strategies, and the key barriers to the implementation of these strategies. Their perspectives were essential in refining the research framework and ensuring that all relevant factors influencing the implementation of various sustainable transport strategies in the city were considered.

Based on the desk review and expert interview, the residents' perspectives were addressed using a survey questionnaire. A total of 900 questionnaires were distributed to the respondents, and 720 complete and appropriately filled responses were used for analysis. The survey questions were tailored to the respondents' level of understanding for clarity and relevance. To ensure that a pilot test was conducted and the questionnaires were modified accordingly.

To make the sample representative, the sampling framework was designed to cover all parts of the city by dividing the city into three district categories: inner/central, intermediate/middle, and outer/peripheral zones. The respondents were thus distributed among these three zones. The stratification was crucial in capturing variations across different urban settings in the city. To refine the sample selection, all the respondents were required to be at least 18 years old and have lived at least 2 years in the city, which allows them to be more familiar with the city's transport challenges and the implementation of various strategies on the ground. These conditions were clearly outlined in the introduction of the questionnaire to ensure that only informed and relevant participants contributed to the study.

Finally, the study employed descriptive analysis and ordinal logistic regression. The ordinal logit regression model was used to examine the magnitude of influence of each barrier on the implementation of various transport strategies. Given that the dependent variable has more than two categories with ordinal responses, the researchers used an ordinal regression model. The ordinal logistic regression model is parameterized as:

$$\log\left(\frac{p(y \le j)}{1-p(y \le j)}\right) = \alpha_i + \beta_1\beta x_1 + \beta_2\beta x_2 + \beta_p\beta x_p; j = 1,\ldots j-1$$

It is also possible to compute the predicted probabilities using:

$$p(y \le j) = \frac{e^{\alpha j} + \beta_1\beta x_1 + \beta_2\beta x_2 + \ldots\ \beta_p\beta x_p}{1 + e^{\alpha j} + \beta_1\beta x_1 + \beta_2\beta x_2 + \ldots\ \beta_p\beta x_p}$$

Following the theoretical models described above, the specifications of the models considered in this study are given below.

$$P(y \le k) = \pi_1 + \pi_2 \ldots + \pi_k = \frac{\exp(\theta_k + x\beta)}{1 + \exp(\theta_k + x\beta)}$$

Where πk represents the probabilities for k = 1, 2, 3, …., θk is a constant; β is a vector of coefficients from the logit equation, and x is a vector of predictor variables.

The dependent variable is the perceived level of implementation of sustainable transport strategies represented by 'Y'. The independent variables were the barriers, including socio-cultural barriers, financial constraints, institutional capability, political barriers, legal barriers, technological barriers, and physical barriers. The dependent variable 'Y' is an ordinal response variable with 5 ordered categories, denoted as 1, 2, 3, 4, 5. Higher values correspond to a greater perceived level of implementation, while lower values correspond to a lower level of implementation, as illustrated below.

Y = Perceived level of implementation of sustainable transport strategies
- 1 = Very low
- 2 = Low
- 3 = Medium
- 4 = High
- 5 = Very high.

4 Results

4.1 Respondents' socio-demographic profile

Table 1 presents the socio-demographic characteristics of the respondents, and the majority of the respondents were male (76.8%). This may reflect the traditionally male-dominated participation of households in various affairs in many developing cities. In terms of age distribution, the sample seems to be well

TABLE 1 Socio-demographic characteristics of the respondents.

Variables	Classification	Frequency	Percentage
Gender	Female	167	23.2
	Male	553	76.8
Age	18–24	17	2.4
	25–34	107	14.9
	35–44	195	27.1
	45–54	236	32.8
	55 and above	165	22.9
Education	No formal education	18	2.5
	Primary education	138	19.2
	Secondary education	180	25.0
	TVET/Diploma	191	26.5
	Degree and above	193	26.8
Occupation	Full-time	310	43.1
	Part-time	104	14.4
	Unemployed	127	17.6
	Retired	94	13.1
	Other	85	11.8
Monthly income	Less than $90	114	15.8
	$90.1–180	199	27.6
	$180.1–360	169	23.5
	$360.1–540	160	22.2
	More than $540	78	10.8

$1 = ETB 56 during data collection in December 2023.

distributed across different age groups, with the 45–54 age range accounting for the largest share (32.8%), closely followed by those in the 35–44 age range (27.1%). This indicates that a significant portion of the households are led by old and middle-aged individuals, who often have stable employment and established commuting patterns. The education level of the respondents was distributed quite evenly, with a significant percentage having completed secondary school (25.0%) and a comparable percentage holding TVET/Diploma (26.5%). About 25% of the respondents have a degree or above (26.8%), which indicates the presence of a higher literacy rate that may influence their attitudes and actions within the research setting. The survey also shows the employment category with the majority having full-time employment (43.1%), followed by part-time jobs (14.4%) and retired adults (13.1%). These might be due to the fact that the survey was undertaken at the household level. The monthly income distribution also shows that 15.8% of the respondent household earning is less than 5000 Ethiopian Birr (ETB) or 96 US Dollar ($), which is below the average monthly household income of approximately $96 as of 2024 in Addis Ababa (Addis Ababa City Administration Plan and Development Bureau, 2023), at the current exchange rate before the recent exchange rate floating. Understanding the socio-demographic characteristics is relevant in designing and implementing various transport policies and strategies that address different demographic groups of the population for appropriate interventions.

4.2 Existing sustainable transport strategies in the case city

Based on a comprehensive review of transport planning and policy documents from various sources, the authors identified the key urban transport strategies proposed for the sustainable transport system in Addis Ababa. The review covered several policy and planning documents, including the Ministry of Transport, Federal Democratic Republic of Ethiopia (2011), Ministry of Transport and Logistics, Federal Democratic Republic of Ethiopia (2020), Addis Ababa City Planning Project Office (2017), Addis Ababa City Roads Authority & Addis Ababa City Road & Transport Bureau (2021), and Ministry of Transport and Logistics, Federal Democratic Republic of Ethiopia (2022). Additionally, other relevant municipal transport plans and strategies, including the public transport and NMT strategies, sectoral office reports and strategic documents, and reports from international organizations such as the UN-Habitat, were examined to provide a more comprehensive understanding of urban transport strategies in the case city. The review of these documents highlighted the presence of diverse urban transport strategies aimed at improving urban mobility and sustainability. Further analyses were done on the implementation of identified sustainable transport strategies and the potential barriers to implementation through experts' interviews and residents' opinion surveys. The survey questionnaires were designed to align with the respondents' general level of understanding. The details on residents' perceptions towards

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TABLE 2 Respondents' perception of the level of implementation of various transport strategies.

No	Strategies	Perceived level of implementation									
		VL		L		M		H		VH	
		N	%	N	%	N	%	N	%	N	%
1	Non-motorized transport (NMT) strategy	222	30.8	333	46.2	84	11.7	62	8.6	20	2.7
a.	Availability of adequate, safe pedestrian walkways and crossing facilities	221	30.7	318	44.2	92	12.8	64	8.9	25	3.5
b.	Availability of a dedicated bike lane	236	32.8	370	51.4	55	7.6	43	6.0	16	2.2
c.	Incentives for cycling and walking (e.g., subsidies)	208	28.9	310	43.1	105	14.6	79	11.0	18	2.5
2	Public transport strategy	196	27.2	308	42.8	114	15.8	73	10.2	29	4.1
a.	Availability of adequate public transport facilities	210	29.2	300	41.7	113	15.7	70	9.7	27	3.8
b.	Priority measures for public transport	198	27.5	289	40.1	122	16.9	79	11.0	32	4.5
c.	Public transport service quality, such as safety and comfort	215	29.9	346	48.1	79	11.0	58	8.1	22	3.1
d.	Subsidies for an affordable public transport service	160	22.2	298	41.4	140	19.4	86	11.9	36	5.0
3	Integrated transport and land use planning	209	29.1	303	42.1	97	13.5	74	10.3	36	5.0
a.	Settlement density and compactness	211	29.3	312	43.3	95	13.2	67	9.3	35	4.9
b.	Proximity of various social services and activities	197	27.4	305	42.4	108	15.0	80	11.1	30	4.2
c.	Ease of access to PT within a short walking distance	220	30.6	292	40.6	89	12.4	76	10.6	43	6.0
4	Demand or mobility management measures	198	27.5	258	35.8	124	17.2	88	12.2	53	7.3
a.	Parking control	219	30.4	297	41.3	109	15.1	57	7.9	38	5.3
b.	Traffic calming with speed bumps and others	199	27.6	231	32.1	130	18.1	101	14.0	59	8.2
c.	Vehicle and fuel tax measures	180	25.0	245	34.0	140	19.4	87	12.1	68	9.4
d.	Traffic signalization and marking	195	27.1	258	35.8	116	16.1	105	14.6	46	6.4

(Continued)

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TABLE 2 (Continued)

No	Strategies	Perceived level of implementation									
		VL		L		M		H		VH	
		N	%	N	%	N	%	N	%	N	%
5	Alternative technologies	238	33.0	298	41.4	87	12.1	62	8.6	35	4.9
a.	Availability of alternative fuels and vehicles (AFVs)	218	30.3	301	41.8	94	13.1	62	8.6	45	6.3
b.	Availability of electric vehicle charging	230	31.9	303	42.1	85	11.8	70	9.7	32	4.4
c.	Strict vehicle emission standards	251	34.9	307	42.6	75	10.4	61	8.5	26	3.6
d.	Availability of ITS for traffic management, travel information, and smart technologies	220	30.5	296	41.1	95	13.2	67	9.3	42	5.9
6	Education and awareness campaign	231	32.1	314	43.6	74	10.3	66	9.2	35	4.9
a.	Sustainability consideration in formal education	233	32.4	280	38.9	92	12.8	75	10.4	40	5.6
b.	Capacity building for professionals and managers	195	27.1	294	40.8	119	16.5	60	8.3	52	7.2
c.	Community awareness campaigns through various media	217	30.1	325	45.1	64	8.9	73	10.2	41	5.7
7	Institutional and regulatory reforms	212	29.4	321	44.6	62	8.6	83	11.5	42	5.8
a.	The capability of institutions in enforcing regulations	254	35.3	298	41.4	75	10.4	64	8.9	29	4
b.	Coordination among various institutions and stakeholders	185	25.7	355	49.3	55	7.6	73	10.1	52	7.2
c.	Accountability and transparency of institutions	222	30.8	333	46.2	84	11.7	62	8.6	20	2.7

VL, Very low; L, Low; M, Medium; H, High; VH, Very high.

the level of implementation of various transport strategies in the case city are presented in Table 2.

The findings indicate that the NMT strategy, which aimed at the expansion of adequate infrastructure for walking and cycling, is perceived as a low (46.2%) or very low (30.8%) level of implementation. Specific strategies such as the provision of adequate and safe pedestrian facilities and dedicated bike lanes, and incentives for NMT described with low or very low implementation, highlighting significant gaps in implementation. Similarly, the respondents rated the public transport strategies as inadequately implemented. A considerable number of the respondents rated the implementation as low (42.8%) or very low (27.2%). This perception extends to sub-specific strategies such as the provision of adequate public transport facilities, priority measures for public transport, improvement in public transport service quality, and public transport fare subsidies. The transport and land use integration also has a comparably low level of implementation, with the majority of planning initiatives, such as dense and compact land use

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TABLE 3 Barriers to the implementation of sustainable transport strategies in the case city.

Category of barriers	Labels	Responses on the extent of influence	*N*	%
Social and cultural barriers (SoCB)	1	VL	56	7.8
	2	L	97	13.5
	3	M	122	16.9
	4	H	289	40.2
	5	VH	156	21.6
Political barriers (PoB)	1	VL	31	4.3
	2	L	62	8.6
	3	M	84	11.7
	4	H	325	45.2
	5	VH	217	30.2
Financial barriers (FiB)	1	VL	25	3.5
	2	L	54	7.5
	3	M	50	6.9
	4	H	385	53.5
	5	VH	206	28.6
Institutional barriers (InB)	1	VL	27	3.8
	2	L	55	7.6
	3	M	68	9.4
	4	H	349	48.5
	5	VH	221	30.7
Legal barriers (LegB)	1	VL	57	7.9
	2	L	71	9.8
	3	M	112	15.6
	4	H	314	43.6
	5	VH	166	23.1
Technological barriers (TecB)	1	VL	62	8.6
	2	L	89	12.4
	3	M	109	15.2
	4	H	300	41.7
	5	VH	159	22.1
Physical barriers (PyB)	1	VL	90	12.5
	2	L	161	22.3
	3	M	63	8.8
	4	H	238	33.1
	5	VH	168	23.3

VL, Very low; L, Low; M, Medium; H, High; VH, Very high.

development and mixity of various land use activities, having a low (42.1%) or very low (29.1%) level of implementation.

The response on the level of implementation of various mobility management measures, such as parking control and traffic calming interventions, is also perceived as inadequately implemented, with 35.8% of respondents rating them as low and 27.5% as very low, respectively. Similarly, the initiatives for alternative technologies, such as the adoption of electric vehicles and vehicle emission regulations, were rated as low (41.4%) or very low (33.0%). Additionally, education and awareness campaigns about sustainable mobility show almost similar perception, with 41.1% of the respondents rated as low and 30.5% as very low. The perception of institutional and regulatory reforms also indicates the low and very low level of implementation (45.1 and 30.1%), respectively, with weak institutional capability, lack of accountability, inadequacy of

human and material resources, and poor coordination among various institutions.

4.3 Implementation barriers for sustainable transport strategies in the case city

Following the extensive review of various transport planning and policy documents, the researchers identified a wide range of barriers that influence the effective implementation of urban transport strategies in the context of the case city. Table 3 presents the respondents' perspective on the extent of influence of these key barriers on the effective implementation of sustainable transport strategies in the case city. Each of the categories encompasses details of specific elements, and here are the average values of the extensive lists of the barriers addressed.

The result revealed that, among the seven sets of barriers investigated, financial and institutional barriers were seen to be the most critical impediments to the implementation of sustainable urban transport strategies in the study city. Specifically, 82.1 and 79.2% of the respondents rated high or very high for the impact of financial constraints, pointing to the severity of the issue of funding. In spite of the city having proposed strategies to encourage public transport (PT) and non-motorized transport (NMT), the actual implementation has been constrained by underfunding, with over-reliance on donor funding and poor budgetary allocations from the government towards sustainable transport programs. On the institutional side, bad governance, such as poor leadership, weak management systems, and poor coordination between various government institutions, further impede progress. These are compounded by conflicting mandates, poor institutional capacity, and slow bureaucratic procedures, all of which result in inefficiency and delay. As a result, efforts at implementation of sustainable transport initiatives are typically disjointed, with a number of agencies working in silos, leading to duplicity of effort, service delivery gaps, and overall lack of program coherence in implementation. The absence of effective inter-agency coordination greatly undermines the effective implementation of sustainable transport strategies in the city.

The political, legal framework for sustainable transport, and technological adoption-related challenges also hinder the implementation of sustainable transport initiatives in the study city, with 75.4, 66.7, and 63.8% of respondents rating high or very high, respectively. The political barriers are characterized by a lack of political commitment and weak leadership that influenced the practical implementation of various transport initiatives in the city. The legal framework related barriers, characterized by outdated and inappropriate regulations and a lack of a guiding urban mobility plan, together with a lack of strict enforcement, also hindered the effective implementation of sustainable transport strategies. Technological barriers, such as limited adoption of advanced transport technology, such as Intelligent Transport Systems (ITS), alternative electric vehicles (EVs), and biofuel technology, also constrained the intended level of implementation. Despite the government's emphasis on adopting electric vehicles (EVs) and other alternative sustainable transport solutions, the implementation remains limited and requires significant attention.

The social and cultural barriers, with 61.8% of the respondents rated as high or very high influence, may also hinder the implementation to a certain level. The attitudes towards car ownership and the lack of interest in public transit, with perceived inconvenience and lack of adequate infrastructure for alternative sustainable transport options like bicycles, impede the adoption of alternative sustainable transport options. While there has been recent progress in bike facilities under Addis Ababa's Corridor Development Program, bicycle use remains low. This may be caused by a lack of cycling culture, unavailability of bicycles, and their high cost, which requires more public awareness and special incentives to promote bicycle use.

The physical or topographic barriers were perceived as having a relatively lower impact compared to other barriers, with just 22.3 and 12.5% of the respondents rating them as having a high or very high impact, respectively. Despite this relatively lower rating, physical constraints such as steep ground, uneven terrain, and broken-up urban layouts are still visible issues for non-motorized transport such

TABLE 4 Model fit summary.

Model fit	−2 Log likelihood	Chi-square	df	Sig.
Intercept only	3152.34			
Final	2432.51	435.63	78	0.00

Goodness of fit	Chi-square	df	Sig.
Pearson	246.15	719	1.00
Deviance	110.08	719	1.00

Pseudo R^2	R^2
Cox and Snell	0.622
Negelkerke	0.830
McFadden	0.763

Test of parallel lines	−2 Log likelihood	Chi-square	df	Sig.
Null Hypothesis	4.628			
General	3.15	1.92	78	0.65

as walking and cycling. They could also hinder the efficient expansion of the city's public transport network within areas of the urban region, thereby decreasing accessibility and connectivity to users of topographically constrained neighborhoods. Although not one of the most critical challenges from a respondent's perspective, physical and topographic constraints are thus important elements to be taken into account in sustainable mobility planning in the future.

4.4 Ordinal logit model

Before examining the individual predictor variables in the ordinal logistic regression model, it is essential to evaluate the model's fitness as presented in Table 4. The Chi-square statistic for model fit demonstrates a substantial improvement of the model compared to the baseline intercept-only model, which indicates that the model's predictions are good enough. The goodness of fit also displays Pearson and Deviance chi-square statistics to determine whether the observed data is in agreement with the model fit. Since the significance values for these statistics are greater than 0.05, it indicates that we have a strong model. The coefficient of determination for ordinal logistic regression with categorical data can be determined using Cox and Snell, Nagelkerke, and McFadden, and the Cox and Snell R^2 measure is computed by comparing the log-likelihood of the model with the log-likelihood of a baseline model. When working with categorical outcomes, the maximum possible value is always less than 1, even for a model that is deemed to be sound. The Nagelkerke R^2 is a modified version of the Cox and Snell statistic, which adjusts the scale of the statistic to include the whole range from 0 to 1. McFadden R^2 is an alternative form that uses the log-likelihood kernels of both the intercept-only model and the fully estimated model. The model with the highest statistical values is deemed the "optimal" choice, and thus the model is a good fit according to these criteria. Finally, the test of parallel lines was also used to assess the credibility of the parameters across all categories in the models. This test compares the performance of a model that uses the same set of coefficients for all categories against a model that uses different sets of coefficients for each category. The test of parallel lines provides evidence that supports the reasonableness of the assumption in this case, based on the considerable degree of significance shown. The null hypothesis states that the location parameters demonstrate homogeneity across various response categories.

The parameter estimates given in Table 5 below also provide a brief overview of the effects of each predictor variable. The positive coefficients imply a positive association between predictors and the result, whereas negative coefficients suggest an inverse relationship. A predictor variable with a positive coefficient indicates that when its value increases, the likelihood of belonging to one of the "higher" cumulative outcome categories also increases. The sign of a coefficient for a factor level depends on the influence of that factor level compared to the reference categories. Accordingly, the findings indicate that among the seven groups of barriers (independent variables), financial, institutional, political, legal, technological, and socio-cultural barriers have a significant influence on the overall level of implementation (dependent variable). Only the physical barriers have an insignificant influence value.

The result revealed that financial constraint, with a parameter estimate of (β) −4.166 and a p-value of 0.000, is the first dominant barrier to implementation of the proposed strategies. The substantial negative estimate of the financial barrier indicates a strong and highly significant negative impact of financial barriers on the level of implementation of various sustainable transport strategies. Similarly, the institutional barriers also have an estimated value of −3.358 with a significance value of 0.000. The estimate for political barriers is −2.225, with a p-value of 0.012 also indicates their significant influence. This negative estimate indicates that political barriers are significantly associated with a lower level of implementation.

Furthermore, the estimates for legal, socio-cultural, and technological barriers with parameter estimates of −1.235, −1.127, −0.931 and p-values of 0.000, 0.025, and 0.032 also indicated a negative association with the overall level of implementation, respectively. Although statistically significant, the effect size for socio-cultural and technological barriers is smaller compared to the other barriers, making it a less influential factor, but still relevant. On the other hand, physical barriers with a p-value of 0.568 do not significantly affect the level of implementation.

5 Discussion

In this study, we have identified several urban transport strategies initiated in the study city and categorized these strategies into seven broad groups for further analysis. The first strategy is PT improvement that focuses on enhancing the efficiency and reliability of public transit systems through the expansion of bus networks, increasing the number of busses, PT priority lanes, expanding the existing LRT lines further, and introducing BRT systems in selected corridors. The second is the NMT strategy, which emphasizes the expansion of infrastructure for pedestrian walkways, dedicated bike lanes in selected corridors, improving pedestrian crossing facilities, and safe road re-designing that prioritizes NMT users. The third is integrated transport and land use planning considerations to ensure that the transport infrastructure aligns with the spatial development pattern, encouraging dense, mixed-use, and transit-oriented corridor development. Particularly, the corridor development, which was started in Addis Ababa recently, contains expansion of the existing roads with adequate spaces for PT, bike, and pedestrian, with integrated greenery and other relevant facilities. The fourth is mobility management, which aims at optimizing the performance of the urban transport systems through various traffic calming, parking control, traffic signal improvement, and other traffic management measures. The fifth strategy is focused on the adoption of technological solutions that aim to enhance efficiency, reduce emissions, and improve mobility, encompassing the use of EVs and biofuel vehicles, ITS, and other smart mobility solutions. The seventh is institutional and regulatory reforms, which emphasize strengthening human and material resources, updating old regulations, effective enforcement of existing regulations, and improving coordination among various government institutions and other stakeholders. The seventh is education and awareness campaigns with the aim of behavioral change through public education initiatives on road safety and sustainable mobility, including walking and cycling.

The results are in line with the findings of several other studies carried out in emerging cities of developing countries. For instance, the findings on PT improvement strategies are well aligned with a study conducted by various researchers who identified the relevance of enhancing the public transport system through service quality improvement and infrastructure expansion in fast-growing cities like Addis Ababa (Dejene, 2019; Suzuki et al., 2013; Tazzie et al., 2024). The importance of safe and pleasant

TABLE 5 Parameter estimates of explanatory variables associated with implementation based on an ordinal logistic regression model.

Explanatory variables		Estimate	Std. error	Wald	df	Sig.	95% CI	
							Lower bound	Upper bound
Threshold	[STSOLI = VL]	−3.211	0.223	109.430	1	0.000	−2.649	−1.774
	[STSOLI = L]	−2.696	0.220	28.063	1	0.002	1.266	1.127
	[STSOLI = M]	0.539	0.230	7.877	1	0.000	1.089	1.989
	[STSOLI = H]	0.178	0.352	3.889	1	0.000	0.987	0.368
	[STSOLI = VH]	0[a]			0			
Location	[SoCB = VL]	−0.355	1.047	0.115	1	0.529	−2.407	1.698
	[SoCB = L]	−1.004	0.727	1.906	1	0.167	−2.430	0.422
	[SoCB = M]	−0.341	0.388	0.772	1	0.037	−1.102	0.420
	[SoCB = H]	−1.127	0.269	1.177	1	0.025	−0.926	0.130
	[SoCB = VH]	0[a]			0			
	[PoB = VL]	−0.690	1.639	0.064	1	0.342	−4.901	1.521
	[PoB = L]	−0.374	0.748	0.249	1	0.617	−1.093	1.840
	[PoB = M]	−1.207	0.466	1.196	1	0.043	−1.121	0.707
	[PoB = H]	−2.225	0.337	1.193	1	0.012	−0.293	1.029
	[PoB = VH]	0[a]			0			
	[FiB = VL]	−0.283	2.330	0.960	1	0.327	−6.849	2.283
	[FiB = L]	0.189	0.920	0.042	1	0.838	−1.615	1.993
	[FiB = M]	−1.638	0.497	1.006	1	0.039	−0.935	1.011
	[FiB = H]	−4.166	0.342	3.237	1	0.000	−0.837	0.504
	[FiB = VH]	0[a]			0			
	[InB = VL]	0.587	2.568	0.191	1	0.074	−0.446	9.620
	[InB = L]	0.663	0.901	0.403	1	0.065	−0.104	3.429
	[InB = M]	−1.146	0.553	1.287	1	0.038	0.061	2.231
	[InB = H]	−3.358	0.427	4.703	1	0.000	−0.479	1.195
	[InB = VH]	0[a]			0			
	[LegB = VL]	0.158	1.771	0.427	1	0.513	−2.313	4.629
	[LegB = L]	0.493	0.755	0.426	1	0.514	−1.972	0.987
	[LegB = M]	−0.153	0.499	0.094	1	0.008	−1.131	0.825
	[LegB = H]	−1.235	0.325	0.067	1	0.000	−0.553	0.722
	[LegB = VH]	0[a]			0			
	[TecB = VL]	0.548	1.488	0.935	1	0.087	−5.464	0.367
	[TecB = L]	−0.152	0.750	0.358	1	0.125	−2.622	0.318
	[TecB = M]	−0.769	0.549	1.964	1	0.526	−1.845	0.307
	[TecB = H]	−0.931	0.430	1.003	1	0.032	−1.274	0.412
	[TecB = VH]	0[a]			0			
	[PyB = VL]	0.221	0.614	0.130	1	0.719	−0.982	1.424
	[PyB = H]	−0.180	0.423	0.181	1	0.671	−1.008	0.649
	[PyB = M]	−0.251	0.374	0.449	1	0.923	−0.984	0.483
	[PyB = H]	−0.568	0.340	0.788	1	0.729	−1.020	0.312
	[PyB = VH]	0[a]			0			

Link function: Logit.

VL, Very low; L, Low; M, Moderate; H, High; VH, Very high.

[a]This parameter is set to zero because it is redundant. The reference for all the explanatory variables is VH.

walking and cycling infrastructure expansion as an alternative option for sustainable urban transport systems in emerging cities like Addis Ababa was also proposed by various researchers (Basil and Nyachieo, 2023; Tazzie et al., 2024; Tulu et al., 2019). Furthermore, our findings on transport and land use integration, as a strategy for sustainable transport planning, are consistent with the studies by Cervero (2013) and Kodukula (2018). Additionally, the role of ITS, such as smartphones, electronic ticketing, and traveler information systems, in enhancing safety, reducing traffic congestion, and improving environmental quality aligns with the research findings of other previous research (Rahman et al., 2013; Siuhi and Mwakalonge, 2016; Tazzie et al., 2024).

It was found that the level of implementation of these strategies has been low, where many of the strategies are proposed on paper but fail to be effectively implemented due to various reasons or factors. These barriers are categorized into seven main groups, each with distinct indicators: (i) social and cultural barriers; (ii) political barriers; (iii) financial barriers; (iv) institutional barriers; (v) legal barriers; (vi) technological barriers; and (vii) physical barriers. Among these barriers, the most hindering barriers for the effective implementations of various sustainable transport strategies are financial and institutional constraints followed by poor governance with lack of political commitment, and lack of appropriate legal and policy framework, as well as limited technological adoption, and social and cultural barriers related to the attitude towards car ownership and sustainable mobility options. The findings of the present study are aligned with the findings of Banister's (2005), which indicated that the most prevalent barriers were linked to limitations for financial resources, institutional restrictions, and policy-related constraints, followed by social and cultural barriers. Similarly, May et al. (2006) and Vigar (2000) identified a wide range of barriers, including institutional or organizational, financial, legal, political, cultural, and technical barriers, further reinforcing the findings of this study. Almatar (2024). This study also identified the implementation challenges for sustainable transport, such as limited resources, inadequate regulatory frameworks, and a lack of skilled personnel, requiring coordinated policy strategies and stakeholder collaboration that aligned with the current study.

Understanding these barriers carries practical significance. Addis Ababa is at a crucial juncture where failure to act decisively on sustainable transport could have long-term social and economic consequences. Commuters already face significant delays, reducing productivity, while the city's road safety record is among the worst in Africa. Public health is also at risk due to escalating air pollution and traffic-related stress. Moreover, the burden of poor transport planning falls disproportionately on low-income groups who rely most heavily on walking and public transport. This highlights the need to view sustainable transport not just as an environmental concern, but also as an issue of public health, economic efficiency, and social equity.

Identifying the strategies and implementation barriers has a practical significance for developing a context-specific strategy tailored to the study city for effective implementation. Given the existing urban mobility challenges, including significant delays in traffic that reduce productivity, worsening road traffic safety, public health risks related to vehicle emissions and pollution, this paper highlights the need to consider designing feasible solutions that are practical to the study cities context and effective implementation of the existing strategies not only just as from environmental sustainability perspective, but also from public health, economic efficiency and social equity concern. Accordingly, the combination of several key strategies, including funding prioritization with diversified options such as congestion pricing, and public-private partnerships to support investment in PT and NMT infrastructure; strengthening institutional capacity and coordination, enhancing a participatory approach to planning; and behavioral change through awareness campaigns are crucial for shifting the attitudes towards sustainable mobility options in the study city context.

6 Limitations and implications for further research

This paper is based on desk reviews, expert interviews, and a survey questionnaire. Given the critical role of the residents' perspective in assessing the actual implementation of various transport strategies, the study effectively addressed the residents' viewpoints using a quantitative approach. However, for the broader applicability of the findings, further research should be conducted in other comparable urban contexts in Sub-Saharan Africa. Additionally, as the study primarily relies on survey data, future research would benefit from in-depth qualitative investigations. A more detailed evaluation of specific sustainable transport plans and project implementations could provide deeper insights into the challenges and opportunities for effective implementation of various strategies.

7 Conclusion

Emerging cities like Addis Ababa, particularly those experiencing fast urbanization and motorization, have far outpaced in the development of a sustainable transport system that results in increasing traffic congestion, air and noise pollution, and road traffic fatalities. While these trends are also observed in other cities of the developing countries, the situation in Addis Ababa is exacerbated by various factors, including limited infrastructure development, lack of land use and transport integration, poor management systems, and others. Addressing the challenges and constraints by adopting cost-effective and practical solutions tailored to the growth trajectory of the city can enhance sustainable urban mobility.

The Addis Ababa city administration has undertaken various sustainable transport initiatives, including encouraging walking and cycling through infrastructure expansion; promoting public transport through the expansion of the transit network, transit priority lanes, and increasing the number of busses; furthermore, integrated transport and land use development, and various mobility management measures. The result also found that alternative technological solutions, such as the promotion of electric vehicles and technological platforms, have been proposed. Additionally, awareness-raising campaigns and reforms of institutional and regulatory frameworks have been proposed to enhance the sustainability of the transport systems.

Despite the efforts to introduce various sustainable transport strategies, the implementation has been low. The reasons for this low level of implementation are attributed to various groups of and the most significant barriers in the study city context were financial constraints and institutional capacity limitations. Additionally, lack of political commitment and poor governance, ineffective regulatory and policy

frameworks, as well as limited adoption of technological solutions, and socio-cultural barriers, particularly the emotional attachment to car use, and the status symbol for car ownership, further limited the effective implementation of these strategies, which are critical insight for designing effective policy responses.

It is thus essential to effectively implement a combination of context-specific and cost-effective strategies. This study provides a comprehensive review of sustainable transport strategies and the implementation barriers in Addis Ababa, offering valuable insights for emerging cities in Sub-Saharan Africa. This study bridges the knowledge gap on the practical challenges of implementing sustainable transport strategies in fast-growing cities, integrating empirical evidence to provide a framework that aligns ambitious strategies with local contexts. Unlike many studies that focus solely on policy recommendations, this study highlights governance limitations, infrastructure deficits, and behavioral barriers influencing the adoption of various transport strategies, making the findings more applicable to similar urban contexts. To advance sustainable mobility, future research should focus on targeted interventions that enhance institutional capacity, financial sustainability, and community engagement.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

This study was conducted in accordance with ethical standards for research involving human participants. Written informed consent was obtained from all participants before their inclusion in the study, ensuring that they were fully informed of the study's objectives, methods, potential risks, and benefits. Participants were made aware that their involvement was voluntary, with the option to withdraw at any time without consequence. The consent process also included provisions for data privacy, emphasizing that all collected information would be anonymized and used solely for research purposes.

Author contributions

YT: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. DA: Conceptualization, Resources, Supervision, Validation, Visualization, Writing – review & editing. BW: Conceptualization, Resources, Supervision, Validation, Writing – review & editing.

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