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Sustainable road transport practices and challenges in Ethiopia: Sidama National Regional State

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Abstract: *Purpose*: To investigate sustainable road transport practices and the challenges facing Sidama Region, Ethiopia, in the context of national development goals. *Methodology*: The study uses a qualitative approach, including focus group discussions, key informant interviews, and document analysis, analyzed thematically with NVivo software and grounded in theories of accessibility, mobility, and sustainability. *Results*: The research identifies significant challenges: policy fragmentation, underdeveloped infrastructure, limited adoption of intelligent transport solutions, weak stakeholder engagement, and environmental sustainability gaps. *Theoretical Contribution*: The study applies and tests established transport theories in a new regional context, highlighting the gap between policy aspirations and practical outcomes. *Practical Implications*: Recommendations include improved policy alignment, investment in infrastructure and human capital, stronger public-private partnerships, and adoption of green technologies to advance sustainable transport in Sidama.

Keywords: transport systems, sustainable road transport, socio-economic development, accessibility theory, mobility theory, sustainability theory, Ethiopia

Sustainable Development Goals (SDGs): SDG 3: Good Health and Well-being; **SDG 9:** Industry, Innovation and Infrastructure; **SDG 10:** Reduced Inequalities; **SDG 11:** Sustainable Cities and Communities; **SDG 13**: Climate Action

1. Introduction

Transportation systems are pivotal to the development of nations, serving as a backbone for socio-economic growth and community development (ERA, 2023; Dappe et al., 2022; Arumugam et al., 2019). Sustainable road transport infrastructure is critical in reducing isolation, improving accessibility, and fostering economic activities (Klaus, 2024; World Bank Group, 2024). As global efforts emphasize environmental sustainability and inclusive development, the Road Transport and Logistics Sector (RTLS) has emerged as a vital component in achieving these objectives (Butkus et al., 2023; Mulat, 2024; de Rus et al., 2022). Strong institutions and efficient transportation systems are essential for

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maintaining national competitiveness and advancing social well-being, reducing poverty, and promoting regional integration (Han et al., 2021; Sénquiz-Díaz, 2021). This research builds on these principles, exploring sustainable road transport practices and challenges in the context of broader socio-economic and environmental progress.

Investments in rural transport infrastructure directly contribute to 72% of Sustainable Development Goals (SDGs), improving isolation (Badada et al., 2023; Kaiser & Barstow, 2022a). According to the International Transport Forum (2022), the global transportation sector is worth $12 trillion and employs over 50 million people, demonstrating its immense socio-economic influence. Sustainable Road Transport and Logistics Sector (SRTLS) practices must address and enhance social and economic competitiveness by reducing operating costs and increasing productivity (Luke & Walters, 2022; Patier & Routhier, 2020). However, in many developing countries, more than one billion people live more than 2 km away from all-weather roads, limiting social and economic participation (Asher & Novosad, 2020; Kaiser & Barstow, 2022).

In Africa, RTLS is critical for economic growth, yet the region faces persistent challenges with inadequate road quality, limited accessibility, and high costs (Kuteyi & Winkler, 2022). Sub-Saharan Africa, including Ethiopia, also needs strategic infrastructure investments to bridge rural-urban disparities and promote sustainable logistics and mobility (Akinshipe & Aigbavboa, 2020; Dappe et al., 2022). However, insufficient institutional capacity, financial constraints, and unequal infrastructure access hinder these efforts (Saidi et al., 2020; Tucho, 2022). According to the (Forum, I. T. 2023), inadequate transport and logistics connectivity restricts territorial integration, economic growth, and access to opportunities. Ethiopia, with its fast-growing population of 133,444,313 as of November 2024, based on the latest Worldometer (2024), is projected to surpass 149 million by 2030 and 170 million by 2037. This demographic surge highlights significant opportunities and challenges for sustainable road transportation development.

The Ethiopian Road Sector Development Program (ERSDP) has substantially enhanced road infrastructure, increasing road density and rural connectivity through investments totaling over ETB (National Currency) 685.9 billion during the past 25 years (ERA, 2023). However, the Sidama Region still struggles with low project delivery, poor maintenance, lack of periodic upgrades, low road density, poor safety, and insufficient funding, stalling progress (Tucho, 2022; ERA, 2023; African Development Bank, 2021; UN Economic Commission for Africa, 2022). According to Badada et al. (2023), transport infrastructure indicates an 81% annual adjustment rate towards long-term goals, which attracts Foreign Direct Investment (FDI) to Ethiopia. However, the Region faces challenges like inadequate road density, logistical inefficiencies, and misaligned policies, particularly in rural areas. The challenges seem like low road density, poor project delivery, lack of periodic maintenance, insufficient qualified contractors and skilled labor, and inadequate funding (Pizzinini et al., 2024). The reliance on motorbikes for smallholder farming and a lack of affordable, sustainable logistical services underscores systemic challenges in the Sidama Region (Yohannes et al., 2020). As a result, thorough inquiry fails to address the underlying causes of inefficiency.

Previous studies have focused on highway, corridor, and multi-modal transportation intent for macro-economy development (Abebe et al., 2022; UNCTAD, 2019). Pizzinini et al. (2024) and Yohannes et al. (2020) argued that the Sidama Region relies heavily on motor bicycles for smallholder farmers due to a lack of essential transportation and logistics services, posing significant challenges in their supply and value chains. Kambata (2023) and Dangisso (2023) claimed that the region faces a high burden of human death due to road traffic accidents. Degwale et al. (2018) depicted a high shortage of transport and logistics supply and mismanagement, while (Ethiopian Institution of Ombudsman, 2022) survey highlights the negative impact of unadjusted demand and supply in the transport and logistics sector in the Region. Many studies have explored this area, but none have fully addressed the existing practices and challenges of the sustainable road transportation and logistics sector.

2. General objective of the study

This study explores practices and the challenges of sustainable road transportation in the Sidama region, characterized by a population exceeding five million and significant transport needs.

2.1. Specific objectives

1. To evaluate federal and regional policy coordination and governance challenges.
2. To analyze the state of road infrastructure, focusing on maintenance and Intermediate Means of Transport (IMT).
3. To examine environmental sustainability and road safety integration in transport planning.
4. To assess stakeholder partnerships, workforce skills, and financial resources in transport logistics.
5. To investigate the adoption of ICT and green technologies for transport efficiency and sustainability.

3. Methods

The study employed a qualitative approach, including focus group discussions (FGDs), key informant interviews (KIIs), and document analysis using dual thematic and content analysis to identify patterns in policy frameworks, strategic plans, infrastructure development, and stakeholder dynamics within the Sidama region. A total of 21 key informant participants representing government officials, transport operators, and business owners provided diverse perspectives. The collected information was analyzed using NVivo software to identify patterns across thematic categories, including infrastructure, connectivity, road safety, and technology adaptation. The analysis is grounded in multiple theoretical frameworks, including the theory of accessibility, which emphasizes equitable transport systems; mobility theory, which explores the movement of people and goods; and sustainability and environmental impact theory, which evaluates the long-term viability of infrastructure investments and their ecological implications. Together, these theoretical perspectives provide a comprehensive lens to assess policies and strategies to foster community development and sustainable growth in the Sidama Region.

3.1. Data collection

To address the specific objectives, the study gathered necessary information through FGDs, KIIs, and document analysis. FGDs were conducted to encourage interactive dialogue and capture diverse perspectives on the challenges and practices within the transport and logistics sector. KIIs provided in-depth insights from individuals with specialized knowledge and direct experience in the field, allowing for a deeper understanding of policy implementation and operational dynamics. Document analysis complemented these methods by examining existing policy documents, strategic plans, and reports to provide a contextual and evidence-based foundation for the findings.

Participants included government officials, transport operators, and representatives from private and public transport cooperatives, ensuring a balanced representation of stakeholders involved in the sector. A total of 21 individuals were carefully selected, representing various sectors and levels of expertise, to capture a wide range of viewpoints and experiences critical for comprehensive analysis. This diverse representation ensured that the study accounted for the complexities and nuances of the Sidama Region's road transport and logistics system.

Table 1: Characteristics of the FGD participants and KII

PID Code	Sex	Age	Organization	Experience Years	Educational Level	Position
fgp1	Male	30	BoTRD	5	Degree	Operational Staff
fgp2	Male	32	BoTRD	4	Master's Degree	Operational staff
fgp3	Male	34	BoTRD	6	Degree	Technical Expert
fgp4	Male	40	BoTRD	8	Master's Degree	Logistics officer
fgp5	Female	40	SRA	12	Degree	Operational staff
fgp6	Female	31	SRA	5	Master's Degree	Planner
fgp7	Male	35	SRA	7	Master's Degree	Senior Technical expert
fgp8	Male	30	SRA	4	Master's Degree	Logistics officer
fgp9	Female	33	Privat public transport Coop.	9	Degree	Customer Engagement Officer
fgp10	Male	38	Privat Public transport Coop	14	Degree	Field Operations Specialist
fgp11	Female	35	Privat freight transport Coop	12	Degree	Administrative Coordinator
fgp12	Male	27	Privat freight transport Coop	3	Degree	Transport Logistics Specialist
KII1	Male	35	BoTRD	5	Master's Degree	Policy Expert
KII2	Male	40	BoTRD	10	Master's Degree	Logistics Analyst
KII3	Female	32	BoTRD	8	Degree	Transport Planner
KII4	Male	40	SRA	12	Master's Degree	Infrastructure officer
KII5	Female	30	SRA	5	Degree	Road Safety Engineer
KII6	Male	34	Garage Owner	10	Degree	Garage Operation Leader
KII7	Female	32	Public passengers' Transport org.	6	Degree	Cooperative Manager
KII8	Male	30	Private passengers' Transport Coop.	5	Degree	Cooperative Manager
KII9	Male	33	Freight Transport Operators Coop.	4	Degree	Cooperative Planner

Source: Survey Data, (2024)

Table 2: Individual Information and Collective Characteristics

Category	Individual Characteristics	Collective Characteristics
Sex	Males =14 Females = 9	61% 39%
Age	Range from 27-40 years	Most common 30 - 34 years, mid-career professionals
Organization	BoTRD=6, SRA=5 Private/Public Cooperatives=7 Other=2	Strong focus on logistics, transport planning, and cooperatives
Experience Years	Range from 3–14 years Most common: 5–8 years	Moderate to high experience levels 6 have 10+ years
Educational Level	15 with bachelor's Degrees 8 with master's Degrees	Bachelor's=35% Master's degree= 65%
Position	Operational Staff, Technical Experts, and Managers	Mix of operational, technical, and managerial roles

Sources: Survey Data, (2024)

The provided data reveals a male group of individuals focusing on mid-career professionals aged between 27 and 40. Most are affiliated with BoTRD, but diverse affiliations like Sidama Road Authority (SRA) and various transport cooperatives are also represented. The group boasts an elevated level of education, with the majority having at least a bachelor's degree and a range of experience from three to fourteen years. Furthermore, the roles within the group are varied, encompassing operational staff, technical experts, planning officers, and managerial positions.

3.2. Analytical approach

The data analysis encompasses the effectiveness of federal and regional policy implementation, infrastructure development progress, and approaches to address sustainability in transport infrastructure and services, including Environmental Impact Assessments (EIAs) and deforestation during road construction and maintenance, resource and capacity constraints, stakeholder engagement, and the efficiency of transportation provision system and governance, information and technological solutions, promotion of IMT, transportation practices and challenges based on theoretical bases such as theory accessibility, mobility theory, sustainability and environmental impact theory in Sidama Region.

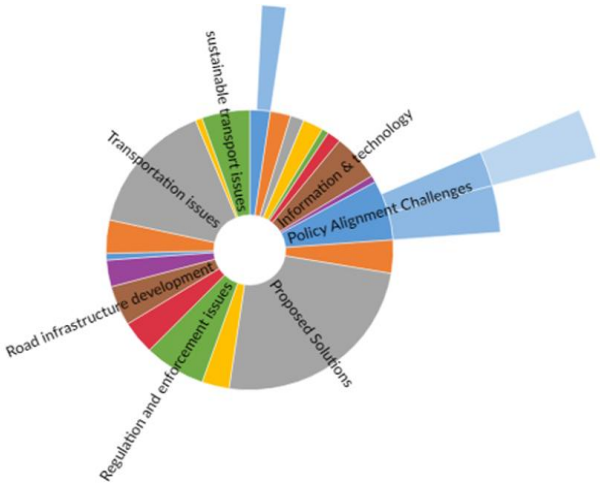
The following sections align with the study objectives, offering insights into the present situation and potential future directions for regional transportation development, aligning with the stated goals. The Ethiopian Federal Transport and Logistics Ministry's Ten Years Strategic Plan (Ministry of Transport and Logistics, 2023), (Ethiopian Transport Master Plan, 2022), the Ministry of Development and plan, (2022), and the Sidama Region Transport and Road Development Bureau's (BoTRD). The Ten-year Strategic Plan (BoTRD, 2023) is among the regional and federal strategic documents that serve as benchmarks for analyzing practices.

Thematic analysis was employed to identify the qualitative data's recurring patterns and key themes. Using NVivo software, the data organized and coded into thematic categories, including sustainable transport infrastructure, rural-urban connectivity, road safety, IMT, and technology adaptation. This analytical approach enabled a structured exploration of the underlying issues and the development of actionable solutions.

3.3. Relevance to research objectives

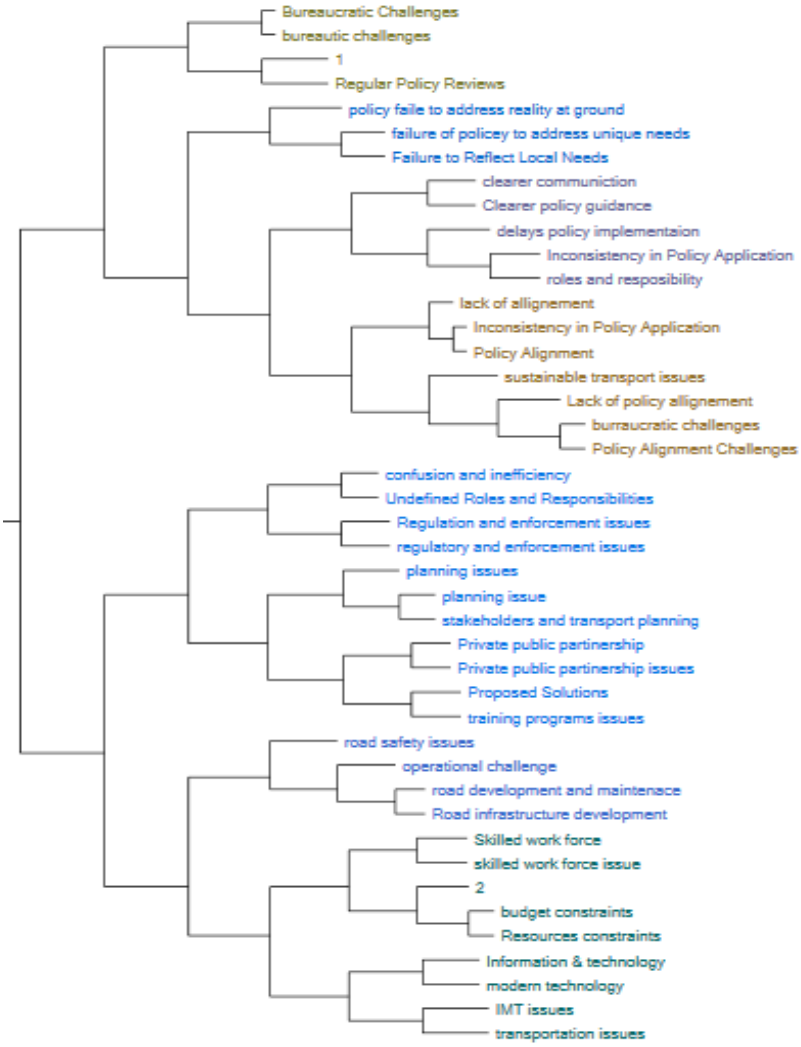
The demographic and professional composition of the FGD and KII participants aligns closely with the research aims, ensuring a well-rounded exploration of sustainable road transportation practices and challenges at Sidama National Region State (SNRS). The chosen method and participant profile aligns closely with the study's objectives, ensuring a balanced perspective on operational inefficiencies, policy gaps, and sustainability challenges. The combination of grassroots insights and strategic viewpoints provides a nuanced understanding of the transport issues in SNRS.

Figure 1: Themes compared by number of coding references



Source: Data analysis by Nvivo (2024)

Figure 2: Items clustered by theme



Source: Results from Nvivo (2024)

4. Results and descriptions

4.1. Practices of sustainable road transportation and logistics

The Sidama National Regional Transport and Road Development Bureau, established in 2020, organizes and governs the institutions and leads the efforts to solve the regional transportation challenges (Sidama Council, 2020). It administers public and freight transit, driver and vehicle competency, road safety, Universal Rural Road Access Projects (URRAP), and the Regional Road Authority (RRA). The regional ten-year strategy (2020–2030) coincides with the sustainable development goals of the National Transport Policy, aiming at economic, social, and environmental goals (BoTRD, 2023). It prioritizes institutional capacity, infrastructure, and equitable transit to boost connectedness and growth.

The responsibility declared to the bureau is to address safety, efficiency, and sustainability while enhancing mobility for both urban and rural communities, envisioning "a modern, safe, and high-quality transport system accessible to all by 2030". The significance of this strategic goal is to strengthen sustainable infrastructure, regulatory capacity, driver and vehicle competency, rural accessibility, and sustainable transportation. To meet long-term regional demands, the strategic plan is dedicated to strengthening economic development, enhancing quality of life, and establishing a resilient transport network utilizing a people-centered approach and values like adaptability and integrity for the Sidama Region.

4.1.1. Coordination between the Ministry of Transport and Logistics (MoTL) and Regional Transport and Road Development Bureau (BoTRD) Policies

Federal and regional transport policies and strategies have stronger governance frameworks and cohesive implementation directions. Federal MoTL supports in the form of funding and technical guidance to harmonize with local priorities, such as improving rural-urban connectivity and enhancing road safety.

4.1.2. Road Infrastructure and Intermediate Means of Transport (IMT)

Upgrading existing roads and constructing new ones, particularly in remote areas, is essential for facilitating market access and reducing transportation costs. Furthermore, the adoption of Intermediate Means of Transport, such as motorcycles, bicycles, and animal-drawn carts, was considered vital for addressing mobility needs in rural areas. On the other hand, the Ethiopian Road Sector Development Program aims to enhance road infrastructure, increasing road density and rural connectivity through investments of over 685.9 billion ETB during the past 25 years (ERA, 2023). The Sidama National Regional State has made significant strides in developing road infrastructure through initiatives like the Road Sector Development Program and the Universal Rural Road Access Program. These programs aim to expand rural connectivity, reduce transportation costs, and foster economic growth. Efforts include road expansion, rehabilitation, and creating resilient, all-weather networks. Community collaboration and direct budget allocations by the regional government are vital to mobilizing resources and encouraging local ownership of projects.

Accordingly, after emerging as a regional state, the Sidama Regional Transport and Road Development Bureau (BoTRD), between 2020 and 2024, invested in road development, constructing 1,400 kilometers by Sidama Road Authority (SRA) and 1,500 kilometers of Universal Rural Road Access Projects for gravel roads. However, the lack of effective coordination reflected in logistical inefficiencies and delayed infrastructure projects like Tula- Arbegona- Worancha, mitigated by creating joint task forces and establishing clear roles for federal and regional authorities (at the time of data collection).

4.1.3. Environmental sustainability and road safety

To address the environmental sustainability measures, such as the adoption of hybrid buses and pedestrian-friendly infrastructure, have been advocated in the policies but remain mostly unexecuted.

The sustainable transport provision strategy, which advocates for mass transit systems such as buses and potential Bus Rapid Transit (BRT) in rapidly expanding cities like Hawassa, significantly enhances urban transportation; however, it is not planned or executed in practice. Given the importance of environmental sustainability, efforts must be increased by funding bike lanes, walkways for walkers, and energy-efficient vehicles like hybrid or electric buses. There is still no resolution to the mass transit and environmental challenges in the transportation system mentioned in the plans and strategies. Furthermore, although Intelligent Transportation Systems (ITS) have been regarded as revolutionary for transport efficiency, financing and technical capacity limitations have delayed their implementation.

Essential elements of road safety that have been incorporated into the region's operating strategy but have not yet been shown to be remarkably successful include enforcing traffic laws, training drivers, and raising public knowledge of safe driving habits. To address safety concerns, the regional plan does, however, proactively prepare for speed limit establishment and improved signage, notably in metropolitan areas. These challenges are listed, though, and they need to be addressed locally. Likewise, sound regulatory frameworks and behavioral change initiatives are necessary for developing a safer and more disciplined road environment in the Sidama Region prioritized in the strategy document. Systematic traffic laws and enforcement, with penalties for speeding and parking violations addressed. In addition, public initiatives to enhance knowledge about road safety and the combined responsibility of drivers, bike riders, and pedestrians are recognized in the plans. Inclusive road designs that accommodate all users, including those with special needs, will ensure equal access and safety for everyone.

Road safety remains a top focus for the Regional Transport and Logistics Bureau, with efforts such as enforcing driver qualification criteria, conducting frequent vehicle inspections, and launching public education programs to decrease accidents. However, road traffic accidents are continuing and cause significant loss of life, serious injuries, and property damage. The reports from BoTRD show that between 2020 and 2024, 291 road traffic accidents were recorded, resulting in 136 fatalities, 118 serious injuries, 20 minor injuries, and property damage in seventeen cases. While reductions in accident rates are reported as an achievement, these figures underscore the persistent challenges in road safety. Contrastingly, emergency response mechanisms have upgraded, with over 2,616 casualties treated between 2023 and 2024. However, the Department of Road Traffic Safety recorded only 132 cases. This discrepancy illustrates a fundamental flaw: the absence of an integrated data collection framework and management and inadequate inter-agency communication. Without accurate data, policymakers lack the evidence to allocate resources, prioritize interventions, and track progress effectively.

4.1.4. Role of stakeholders in transport and logistics services

The strategic plans recommend that stakeholders actively participate in providing sustainable transportation. Since it is essential for sustainable road transportation, the local community, business sector participants, and government agencies are all mentioned in the strategic problems. Government organizations must lead in creating regulations, assigning funds, and upholding the law, even while private companies can invest in fleet modernization and Intelligent Transport Solution (ITS) technologies. Local communities should be involved in infrastructure maintenance and transportation priorities, particularly in rural areas. The intention is that public-private partnerships could be crucial for funding large-scale projects and enhancing service delivery. This guarantees inclusive transportation options that meet the diverse requirements of the area. Practically speaking, the corporate sector that runs public transportation ignores modernization and sustainability issues in favor of a traditional approach to revenue collection.

Transport services in SNRS are evolving to address societal mobility needs in the private sector. There are 1,553 medium buses and seventeen publicly owned buses running in the region, although the system relies on outdated vehicles like Bajaj (three-wheelers) and minivans. Freight transport is regulated by work permits issued based on ability, with efforts underway to diversify services and modernize the sector to accommodate growing demands. These practices aim to improve accessibility and service quality while fostering competition among various transport modes.

4.1.5. Workforce skills, institutional capacity, and financial resources

The policy articulated that the sustainable transportation system requires workforce skill development, institutional capacity building, and funding, as outlined in strategic plans and policies. Key strategies include aligning workforce development with the national human resource agenda, expanding transport-related disciplines in Ethiopian universities to produce skilled professionals, and establishing a transport training institute to standardize and support training programs. Additionally, fostering partnerships with international transport universities aims to facilitate knowledge transfer, scholarships, and capacity-building initiatives. These efforts seek to close skill gaps, build technical competence, and equip workers to plan and manage sustainable transport systems effectively. The strategy also proposed creating an Ethiopian Transport Research Institute (ETRI) to lead research and development across transport sub-sectors, establish a transport research fund, and develop partnerships with local and international institutions. Furthermore, a national transport database plan is outlined.

However, despite policy emphasis, ineffective implementation has led to significant gaps. Fragmented institutional coordination, skill shortages, resource constraints, and limited information technology (IT) adoption hinder progress. In addition, the transport sector faces challenges due to inadequate training infrastructure and weak links between higher education and the sector. Investments in workforce training and institutional capacity are unrealized, highlighting the need for stronger governance, resource mobilization, and accountability.

4.1.6. Role of Intelligent Transportation Solutions (ITS) and green technologies

The intention for integrating Intelligent Transportation Solutions (ITS) is to provide transformative opportunities for public transportation. GPS-enabled real-time passenger information systems also pointed out the need to eliminate uncertainty and wait times by delivering precise updates on bus arrivals and departures. Automated fare collection systems that use mobile payment platforms to speed transactions and improve transparency are not yet realistic in the strategy, except for the recently implemented e-ticketing origin from Hawassa for highway transportation. Passenger counting systems can optimize route design by detecting high-demand locations, allowing for more effective allocation of resources that have yet to be solved. Further, ITS systems can increase safety by monitoring cars in real-time and responding quickly to problems, resulting in a more reliable and user-friendly transportation network.

While the national policy emphasizes the transformative potential of Intelligent Transportation Solutions to improve public transportation, significant gaps remain in the Sidama Region, preventing these strategies from being realized. The deployment of ITS technologies, such as GPS-enabled real-time passenger information systems, automated fare collection, and passenger counting systems, remains under implementation. The recently introduced e-ticketing system for highway transportation originating from Hawassa is the only notable progress, highlighting the region's limited achievements compared to national goals. The lack of necessary infrastructure and technical capacity further hampers the adoption of ITS, as advanced technologies like real-time monitoring and mobile payment platforms require significant financial investment, which has not been allocated. Additionally, the shortage of skilled workforce capable of managing and maintaining ITS technologies exacerbates the issue, as existing training programs fail to address ITS-specific skills. Moreover, passenger counting systems that could optimize route design by identifying high-demand areas have yet to be introduced, resulting in inefficient allocation of resources. Safety monitoring through real-time vehicle tracking, another key component of ITS, remains absent, leaving gaps in incident response and compliance with safety standards. These challenges underscore the disparity between the ambitious strategies outlined in the national policy and the region’s practical realities, which are hindered by resource constraints, institutional limitations, and insufficient technical capacity. Addressing these gaps requires targeted investments, improved governance, and workforce development to bridge the divide and enable the successful implementation of ITS in the Sidama Region.

4.1.7. Planning and management for urban and rural connectivity

The strategies outlined in the national policy emphasize the need for an integrated transport system to address the Sidama Region's distinct urban and rural demands. Key initiatives include optimizing urban transport, particularly in Hawassa, improving rural-urban connectivity to support agricultural producers, enhancing road infrastructure, and introducing multimodal hubs to streamline transport services. The policy also underscores the role of digital tools like route mapping and integrated ticketing systems and highlights the importance of regular infrastructure maintenance to ensure reliability, especially during challenging conditions like the rainy season.

While the national strategy offers an unobstructed vision for sustainable and integrated transport, the Sidama Region struggles with gaps in implementation. Urban transport systems remain inefficient, rural-urban connectivity weak, and road maintenance inconsistent. The lack of multimodal hubs, digital tools, and stakeholder-driven planning has also hindered efforts to improve accessibility and economic integration. These gaps highlight the need for better governance, targeted resource mobilization, and stronger institutional coordination to bridge the divide between strategy and practice effectively.

4.1.8. Data-driven transport management

The strategic plan addressed modernizing transport management in Sidama, achieved through a data-driven approach. Passenger flow analysis can identify peak demand periods, allowing for dynamic adjustments in service frequencies. Vehicle performance monitoring using telematics can optimize fuel efficiency and reduce operational costs. Customer feedback systems will provide insights into passenger satisfaction, ensuring continuous improvements. These practices will help to create a more adaptive and efficient transport system that meets the region's evolving needs.

However, the region lacks the infrastructure to collect, analyze, and utilize data for passenger flow and vehicle performance. Without proper data collection systems, such as advanced telematics and passenger tracking tools, it is not easy to implement the proposed strategies for optimizing service frequencies or fuel efficiency. This technological gap hinders the ability to adopt a data-driven approach effectively. Even if data collection mechanisms are established, there may be a shortage of skilled personnel to interpret and act on the data. The region may lack the data analytics and telematics expertise needed to manage vehicle performance monitoring and customer feedback systems. Additionally, integrating such technologies into existing systems may be technically challenging without proper workforce training. This could delay or hinder the successful adoption of strategies like dynamic service adjustments or telematics-based vehicle monitoring.

To sum up, the gap in Sidama lies in the inadequate technological infrastructure, lack of skilled personnel, financial constraints, fragmented coordination, and the absence of effective mechanisms to gather and act on customer feedback. These limitations hinder the region’s ability to fully implement the data-driven strategies outlined in the national policy for modernizing transport management.

4.2. Challenges of sustainable road transport and logistics

4.2.1. Policy governance and enforcement

Systemic governance issues remain significant obstacles, including inadequate planning, integration, and coordination. Weak institutional frameworks, unclear role definitions, and poor communication among agencies hinder the effective implementation of strategies. Capacity-building initiatives and transparent communication are vital to address these challenges. Policy enforcement faces challenges due to weak regulatory mechanisms, misalignment, and mismatching interests and situations at the grassroots level.

Policy failures and alignment gaps stem from various interconnected issues: insufficient local participation in federal policy design, limited regional capacity for implementation, conflicting priorities between levels of government, and inadequate monitoring and evaluation mechanisms. These issues result in policies ill-suited to local needs and a lack of coordinated effort. However, opportunities exist for improvement.

4.2.2. Workforce and resources development

A shortage of skilled professionals and inadequate training programs severely hinder the effectiveness of road transportation, including infrastructure projects, leading to delays and substandard outcomes. The lack of sector-specific training institutes and collaboration between the transport sector and higher education institutions prevents the alignment of academic training with industry needs. Limited investments in modern training facilities and technologies further stagnate workforce development, restricting the adoption of advanced methodologies. To build a cohesive and sustainable transportation system, addressing these challenges requires comprehensive reforms, including improved workforce training, IT integration, and institutional coordination.

4.2.3. Road Infrastructure Development

Road infrastructure development issues include insufficient ability to execute institutions, poor-quality and delayed construction projects caused by a lack of workforce, equipment, insufficient funds, and incomplete projects compounded by poor contractor performance, lack of timely payments, and quality concerns that increase costs due to liquidation. Maintenance plans are often not periodical, and insufficient resources lead to subpar repairs and rapid road deterioration. The absence of housing for workers and logistical challenges at remote sites disrupt schedules. Public participation is limited, with poor coordination among stakeholders and resistance to land acquisition. Addressing these systemic issues requires better governance, stakeholder engagement, and sustainable practices to align infrastructure projects with community and ecological needs.

4.2.4. Public and freight transport

The public transport sector in SNRS struggles with outdated vehicles, fragmented management, and weak regulatory enforcement, while freight transport faces inefficiencies like inadequate warehousing, hygiene facilities, outdated practices, and limited ICT use. These challenges raise costs and reduce reliability, hampering economic activities. To address this, SNRS should develop cooperative frameworks with freight companies, explore alternative funding, and invest in modern technology and ICT systems. Phasing out outdated vehicles and building critical infrastructure like transport hubs can enhance reliability, reduce costs, and boost economic growth.

4.2.5. Road traffic safety and regulation

Road safety challenges persist due to insufficient enforcement of regulations, such as those against overloading and speeding. Poor road signage, lack of traffic control measures, and outdated infrastructure further worsen the problem, creating unsafe conditions for road users. Improvements in driver training and public awareness campaigns were noted, reflecting progress in addressing road safety concerns. However, challenges persist in implementing essential safety measures such as traffic controls and signs, radars, and speed breakers, managing outdated vehicle fleets, and expanding emergency response systems. These gaps continue to undermine the region's effectiveness of road safety initiatives.

4.2.6. Inadequate Intelligent Transportation Solutions (ITS) adoption

The regional transportation sector faces significant challenges due to the limited adoption of Intelligent Transportation Solutions, which hampers operational efficiency and service quality. The Ethiopian Transport Master Plan (ETMP) (2022-2052) highlighted the underutilization of critical technologies such as GPS-based fleet management, digital ticketing, and real-time tracking. This technological gap adversely impacts the freight and public transportation sectors, making coordinating logistics and providing reliable services difficult. For example, the absence of GPS tracking and real-time monitoring restricts freight optimization, while the lack of digital ticketing diminishes convenience and accountability for public transport users.

4.2.7. Environment-friendly transportation

Environmental challenges include inadequate Environmental Impact Assessments (EIAs), delayed quarry rehabilitation, unchecked erosion, and insufficient policies to phase out high-emission vehicles. Rural road networks are still underdeveloped, limiting access to essential services and perpetuating inequalities. While sustainability measures such as afforestation, soil erosion mitigation, and dust control are prioritized, enforcement gaps and resource constraints hinder progress. To ensure environmental sustainability, the region must adopt cleaner technologies, strengthen EIA practices, and improve quarry rehabilitation efforts. In addition, a resilient approach to integrating ecological responsibility into transportation planning is critical to achieve long-term sustainability goals.

4.2.8. Intermediate Means of Transport (IMT) Promotion

Intermediate Means of Transportation are crucial in enabling better access to essential services and markets in improving rural and urban connectivity. Transitioning to modern, cost-effective IMT options, such as handcarts, bicycles, motorbikes, three-wheeler vehicles, and durable carts, can save time, reduce travel burdens, and enhance agricultural productivity. Improved road access and tailored solutions that address local conditions, like better internal roads and affordable transport options, can significantly enhance quality of life and economic activity. The Accessibility Theory underscores that addressing these challenges is key to unlocking IMTs potential to improve living standards and support sustainable development.

5. Key findings

5.1. Policy reforms and strategic strategy alignment

The absence of a robust framework capable of addressing systemic and interconnected transport issues comprehensively remains a significant challenge. Policy missed addressing all relevant aspects of the root problem and its interconnected elements that are comprehensive and practical. Local stakeholders have limited involvement in policy design, resulting in strategies that do not reflect the region's unique needs. Weak coordination between federal and regional entities further complicates the implementation of cohesive policies. Moreover, the lack of regular evaluations and monitoring frameworks prevents policies from adapting to changing circumstances or identifying unintended consequences, hindering their long-term effectiveness.

5.2. Infrastructure and resource development

The development of infrastructure and resources faces critical obstacles. The region’s road network remains underdeveloped, creating persistent bottlenecks in logistics. Insufficient investments in road construction and maintenance further exacerbate these issues. Adopting modern technologies, such as traffic management systems, is limited, reducing operational efficiency and safety. A significant shortage of skilled personnel adds to these challenges, while resource constraints impede efforts to effectively address infrastructure gaps.

5.3. Partnerships and stakeholder engagement

Collaboration between the public and private sectors is weak, leading to underutilized resources and missed opportunities for innovation. Community involvement in transport planning and decision-making processes is minimal, resulting in systems that fail to meet local needs. Vulnerable populations, particularly those in rural areas, are often excluded, perpetuating inequalities in accessibility and service delivery. This lack of inclusivity undermines the sustainability and equity of the transport systems.

5.4. Safety and regulation

Transport safety and regulatory measures face considerable challenges. Ineffective enforcement mechanisms, such as weak inspection protocols and lenient penalties for violations, contribute to unsafe practices and non-compliance. Public awareness of road safety remains limited, with many individuals unaware of essential practices like using seat belts or avoiding distracted driving. These factors and inadequate safety measures result in high accident rates and an unsafe transportation environment.

5.5. Adoption of Intelligent Transportation Solutions (ITS)

The adoption of intelligent transportation solutions has been slow, impeding modernization efforts. Minimal integration of ICT systems for route optimization and real-time tracking contributes to inefficiencies within the sector. Additionally, a reliance on traditional vehicles increases environmental impacts due to high carbon emissions, as cleaner technologies like electric or hybrid vehicles are not widely adopted. This lack of modernization leaves the region struggling to compete effectively in regional and global markets

5.6. Accessibility challenges

The Accessibility Theory underlines the transformative potential of improved transport networks for economic development, as seen in region's URRAP initiative. While the program aims to reduce rural isolation, connect communities to essential services, and lower transportation costs, several critical challenges persist. Maintenance delays and limited access to essential machinery constrain the program's effectiveness, undermining its potential to drive accessibility-driven poverty reduction. These constraints highlight a significant gap between theoretical aspirations and practical implementation.

5.7. Mobility impediments

The Mobility Theory stresses the importance of transportation systems that enhance individual and collective mobility. Regional initiatives, including driver training programs, vehicle inspections, and public awareness campaigns, align with this theoretical framework. However, outdated vehicle fleets and financial constraints prevent these initiatives from achieving the desired mobility standards. These systemic limitations create barriers to realizing improved mobility outcomes, limiting the broader impact of transportation investments.

5.8. Environmental sustainability gaps

The Sustainability and Environmental Impact Theory emphasizes balancing transportation and logistics development with environmental stewardship. While SNRS adheres to environmental sustainability principles, implementation gaps are evident. Weak enforcement of Environmental Impact Assessments (EIAs) and inadequate quarry rehabilitation practices lead to significant environmental degradation. These shortcomings underscore the need for more rigorous measures to mitigate the environmental consequences of road transport and logistics projects.

6. Discussion

The findings revealed the multifaceted challenges of achieving sustainable road transportation in the SNRS. These challenges reflect a complex interplay of socio-economic, environmental, and institutional factors consistent with patterns seen in other low-income and geographically dispersed regions. A convergence of economic, environmental, and social constraints, with poor infrastructure quality and limited access to quality modes of transportation, hinders fair mobility and connectivity. The fragmented regulatory framework, inadequate warehousing, and terminal inefficiencies worsened the transport system in the region.

These findings mirror global challenges documented by Musselwhite (2023), Wan et al. (2024), and Fan et al. (2023), who emphasize the environmental degradation and socio-economic limitations posed by inadequate transport systems. In the SNRS context, geographic dispersal also intensifies logistical challenges, with rural isolation reducing access to essential services and markets, as Asher and Novosad (2020) highlighted. On the other hand, stakeholder engagement is central to transforming the transport and logistics sector. Inclusive policy formulation and implementation approaches can help address socio-economic disparities and foster collaboration. As suggested by the World Bank (2018), government and non-governmental support for IMTs and road infrastructure investments can facilitate rural access and improve socio-economic outcomes. Furthermore, collaborative frameworks incorporating the local community's voices can promote culturally proper solutions, addressing issues such as gender-based mobility access.

IMTs provide an essential bridge between non-motorized and motorized transportation, particularly in rural and peri-urban areas. Their accessibility and affordability make them indispensable in low-income regions like SNRS. Kaiser and Barstow (2022) and Sieber and Allen (2016) emphasized that cost-effective IMTs such as bicycles and animal-drawn carts can significantly enhance mobility. However, infrastructure quality remains a critical determinant of their effectiveness. Poor road conditions in SNRS often limit the usability of IMTs, which need targeted investments in maintenance and upgrades. IMTs also hold potential as environmentally sustainable solutions. Given SNRS' vulnerability to climate change, promoting IMTs as alternatives to fuel-dependent transport aligns with global sustainability goals. Policies incentivizing IMT adoption, such as tax exemptions and microfinancing, can bridge the affordability gap while fostering environmental resilience.

The broader goal of achieving sustainable road transportation in SNRS necessitates a multi-pronged strategy. Kaspi et al. (2022) underscore the need for clean fuels, optimized routes, and vehicle efficiency to reduce emissions and environmental impacts. In SNRS, this translates into investing in renewable energy sources and green freight initiatives that align with the region's socio-economic realities. Additionally, integrating advanced planning technologies such as GPS tracking can enhance operational efficiency (Sadaf et al., 2023). Investments in urban infrastructure planning consolidation and non-motorized transport promotion can create a balanced and sustainable transport ecosystem (Nieuwenhuijsen, 2020). Addressing non-motorized, green transport, and traffic safety through well-designed systems is a crucial consideration for SNRS, given its high accident rates and inadequate sustainable and safety management systems.

The road transport sector's potential to drive community and economic development is evident in its ability to connect isolated regions, facilitate trade, and improve access to essential services. Mohan et al. (2020) noted the sector's critical role in boosting market expansion and social cohesion. In SNRS, targeted investments in road infrastructure can stimulate local economies by linking producers to markets and reducing transportation costs. Moreover, addressing logistical challenges can enhance supply chain efficiency, enabling timely delivery of goods and services. As Zhang et al. (2023) and Badada et al. (2023) assert, efficient logistics systems contribute to regional competitiveness and economic diversification, outcomes particularly relevant to the underserved communities of SNRS. While the potential benefits are significant, achieving sustainable transport in SNRS requires overcoming persistent challenges. Limited financial resources, institutional weaknesses, and socio-economic instability impede progress. The findings by Nitsche (2021) highlighted that the argument related to high transport costs and volatile transport timeliness affects the productivity of transport users. Therefore, these challenges also present opportunities for innovation and reform. By tailoring international best practices to local conditions, SNRS can create a resilient transport system that supports community development.

Advancements in modern technologies, including Information and Communication Technology (ICT) systems, present opportunities to address some challenges (Santos, 2017). Route optimization and real-time tracking are critical in enhancing decision-making processes (EPA, 2022; Yedla, 2015). One such technology is Intelligent Transportation Systems (ITS), which integrates advanced technologies to improve transportation systems planning, management, and operation (Sadaf et al., 2023). By improving the efficiency and reliability of transportation operations, ICT systems contribute to better resource utilization and reduced environmental impacts (H. Zhang et al., 2022). These improvements make ITS a critical tool for achieving environmental sustainability and operational

efficiency in transportation. Like other developing areas, the Sidama Region stands to gain substantial benefits from adopting ITS in its local transportation systems. Consequently, ITS represents a valuable investment for regions aiming to modernize their transportation systems while aligning with global sustainability goals.

Policy misalignment and weak regulatory frameworks amplify these challenges. The absence of cohesive strategies between federal and regional authorities hinders effective implementation. Moreover, limited stakeholder engagement reduces the inclusivity and responsiveness of transport initiatives. Despite these challenges, the study finds significant opportunities for transformative change. Leveraging partnerships with private entities and local communities, fostering innovation in transport technologies, and enhancing policy enforcement can drive progress toward a sustainable transport system in SNRS. These initiatives must prioritize environmental sustainability, inclusivity, and resilience to align with global development goals and Ethiopia's national strategies.

6.2. Theoretical analysis

The theoretical frameworks of Accessibility, Mobility, and Sustainability provide a comprehensive lens to evaluate the challenges and gaps in SNRS's transportation and logistics initiatives. The ***Accessibility Theory*** highlights the critical role of transport networks in reducing rural isolation and promoting economic development, and systemic inefficiencies hinder the practical implementation of these ideals in SNRS. In line with this theory, SNRS's URRAP initiative also seems to be the development of the transportation sector. This initiative aims to reduce rural isolation and connect communities to critical services while reducing transportation costs and supporting poverty reduction. However, constraints like maintenance delays and limited machinery access limit the potential of URRAP to satisfy accessibility-driven poverty reduction and access to essential services fully.

Similarly, the ***Mobility Theory*** stresses the importance of transportation systems that enhance movement and connectivity. SNRS's initiatives also follow the theory focusing on driver training, vehicle inspections, and public awareness programs. However, systemic impediments, such as outdated fleets and financial restrictions, hinder the fulfillment of high mobility standards. This reflects a broader systemic issue of underinvestment in the transport sector, undermining efforts to improve mobility.

The ***Sustainability and Environmental Impact Theory*** underscores the importance of balancing infrastructure development with environmental responsibility and aligning it with environmental sustainability ideas. While SNRS recognizes these principles, insufficient enforcement of Environmental Impact Assessments and poor rehabilitation of quarries lead to significant environmental damage. This gap between policy and practice suggests more stringent oversight mechanisms and innovative approaches to integrate environmental sustainability into transport development. This paradigm advocates for more rigorous Environmental Impact Assessments and enhanced quarry rehabilitation techniques to prevent severe environmental damage.

7. Conclusion and recommendations

7.1. Conclusion

Addressing barriers like policy fragmentation, infrastructure quality, stakeholder engagement, investment in IMTs, and green economy practices are critical to using the transport sector for socio-economic progress in SNRS. Addressing these gaps requires a multifaceted approach that combines improved funding mechanisms, enhanced stakeholder collaboration, and the integration of innovative technologies. The theoretical findings also highlight significant gaps between the aspirations of Accessibility, Mobility, and Sustainability theories and their practical application. Ultimately, bridging these gaps will align SNRS's transport and logistics initiatives with theoretical ideals and ensure that these initiatives contribute meaningfully to economic development, enhanced mobility, and environmental sustainability in the country. Future research should focus on harmonizing federal and regional policies, gender inclusiveness, adopting environment-friendly road practices, perfecting coordination through ICT, improving safety and compliance, and ensuring fair access for all, focus on

creating a holistic strategy that incorporates these theories into actionable, context-specific policies and practices.

7.2. Recommendations

Based on the findings, the following suggestions are forwarded in different dimensions

Policy and Governance

- Establishing clear roles and responsibilities for federal and regional authorities to improve policy implementation is essential.
- Regular policy reviews are crucial to ensure alignment with regional needs and ground realities**.**

Infrastructure Development

- Increasing investments in road construction and maintenance is mandatory to address connectivity gaps.
- Integrating modern technologies, such as traffic management systems and fleet monitoring, enhances operational efficiency.

Capacity Building

- To address skill gaps and improve project delivery quality, launching workforce development programs is essential.
- Promoting advanced education opportunities for professionals in transport planning is to be considered.

Environmental Sustainability

- Phasing out high-emission vehicles and incentivizing the adoption of clean technologies is crucial.
- Strengthening enforcement mechanisms for Environmental Impact Assessments (EIAs) in transport projects are essential.

Community and Stakeholder Engagement

- Fostering public-private partnerships to mobilize resources and drive innovation to be given attention.
- Actively involve local communities in planning and decision-making processes to ensure inclusivity and cultural relevance.

Road Safety and Regulation

- Enhancing the regulatory ability to enforce safety and operational standards is crucial.
- Implementing public awareness campaigns focused on road safety and sustainable transport practices is essential.

Adoption of ITS

- Developing ITS-related policies and ensuring they align with national and regional integration goals should be given attention.
- Leveraging PPPs and international funding opportunities to reduce reliance on public budgets to be explored.
- Increasing awareness about the advantages of ITS among stakeholders to foster broader acceptance is mandatory.

Gender inclusive policy

- Integrate gender-sensitive perspectives in the transportation infrastructure design, ensuring accessibility, safety, and affordability for all.
- Promote gender equity in the transport sector workforce and employment opportunities for women in logistics, operations, and leadership roles.

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support of various stakeholders, including government officials, transport operators, and representatives from both public and private transport cooperatives.

Ethical Considerations

This study adheres to academic integrity, ensuring informed consent and confidentiality for all participants. The research avoids conflicts of interest and provides unbiased analysis.

Contributions

The findings offer actionable insights for policymakers and stakeholders, bridging the gap between policy aspirations and on-the-ground realities. This research addresses identified challenges and creates adaptive and sustainable transport systems that drive regional development.

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Conflicts of Interest

The authors declare no conflict of interest.

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