

The Determinants of Truck Congestion Reduction In Tanzania Borders Crossing

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Abstract

This study involves the determinants of truck congestion reduction in Tanzania borders crossing. Guided by three objectives, it examines the effects of traffic management strategies, infrastructure upgrades, and digital clearance systems. Using a descriptive design and a mixed-methods approach, data were collected from a sample of 80 respondents. Findings indicate that traffic management measures, including designated truck lanes and revised scheduling protocols, have significantly reduced delays and bottlenecks. Infrastructure challenges particularly poor road conditions, limited signage, and outdated weighbridge facilities, were identified by 65% of respondents as major barriers to efficiency. Digital clearance systems were widely recognized for improving data accuracy and cutting truck processing times from over six hours to two to three hours. Despite these gains, respondents noted persistent gaps in staffing, technical training, and system reliability. The study concludes that sustained efficiency requires investment in both physical and soft infrastructure, stronger policy coordination, and continuous system evaluation. Given the modest sample size, further research with a broader respondent base is recommended to validate these findings.

Keywords: *Truck Congestion, Traffic Management Strategies, Infrastructure Improvements, Digital Clearance Technologies*

Introduction

Cross-border trade is essential for global economic development, with effective transportation systems crucial for the seamless movement of goods. Nonetheless, truck congestion at border crossings presents a major obstacle, leading to delays, heightened operational expenses, and inefficiencies within the supply chain. This traffic congestion is frequently linked to insufficient infrastructure, ineffective customs clearance procedures, and inadequate traffic management (World Bank, 2020). To combat these challenges, various regions have adopted advanced traffic management systems, modernized infrastructure, and digital clearance processes, resulting in enhanced transport efficiency and reduced congestion. For example, the European Union has implemented integrated border management strategies, including digitized customs systems, which have notably decreased delays and improved trade efficiency (OECD, 2021).

In Africa, border congestion continues to be a pressing concern, especially in landlocked and transit-dependent nations. Border crossings such as Beitbridge in Zimbabwe and Kasumbalesa in Zambia experience significant congestion due to outdated infrastructure, complex

customs procedures, and insufficient coordination among border agencies (AfDB, 2021). At Beitbridge, truck delays frequently range from 18 to 36 hours, while at Kasumbalesa, clearance backlogs have been reported to exceed 48 hours during peak trade seasons (COMESA, 2020). These inefficiencies elevate logistics costs, diminish competitiveness, and obstruct regional trade integration. To tackle these issues, initiatives like the African Continental Free Trade Area (AfCFTA) have highlighted the necessity for modernized infrastructure, digitized processes, and effective traffic management to enhance cross-border trade (UNCTAD, 2020). For instance, the introduction of the Single Window system in Rwanda has considerably decreased clearance times and improved trade efficiency (East African Business Council, 2022).

The Tunduma border, recognized as one of the most heavily trafficked border crossings in Tanzania, is crucial to the trade network of the Southern African Development Community (SADC). It serves as a vital link between Tanzania and Zambia, facilitating the movement of goods between East and Southern Africa. On average, 1,200–1,500 trucks pass through Tunduma daily, transporting goods ranging from fuel and construction materials to agricultural commodities (TRA, 2021). However, the border is plagued by significant truck congestion, with trucks often delayed between 12 to 24 hours on average, particularly during peak traffic periods. Although shorter compared to Kasumbalesa's multi-day queues, these delays remain a substantial barrier to trade efficiency within the region. The economic cost of these inefficiencies is also considerable: estimates suggest that each truck idle at the border incurs USD 200–400 per day in demurrage, fuel wastage, and lost time (World Bank, 2020). With over a thousand trucks delayed daily, this translates into potential losses exceeding USD 200,000 per day, undermining the competitiveness of regional trade corridors.

In recent years, Tanzania has initiated several measures aimed at alleviating truck congestion at the Tunduma border. Key priorities have included upgrading infrastructure, such as expanding border facilities and enhancing road networks, to improve capacity and minimize delays (Ministry of Works and Transport, Tanzania, 2022). Furthermore, the introduction of digital clearance systems and the streamlining of customs procedures have demonstrated potential to cut processing times and enhance efficiency. Despite these initiatives, truck congestion often stretching to half a day or more remains a significant challenge that continues to adversely impact trade and transport efficiency.

Literature Review

Truck Congestion

Truck congestion refers to the significant buildup of freight vehicles at border crossings, which is often caused by delays in customs processing, poor traffic management, or insufficient infrastructure (Awuni & Boateng, 2020). At the Tunduma border, this congestion results in longer waiting times, higher transportation costs, and decreased efficiency in trade logistics. As noted by UNECA (2021), the congestion at major African borders, including Tunduma, is worsened by a lack of coordination among customs agencies and a high volume of trucks compared to the available infrastructure.

In the context of this study, truck congestion underscores the operational difficulties encountered at Tunduma. It is vital to address this issue through integrated strategies, such as improved traffic management, infrastructure enhancements, and the implementation of digital systems, to facilitate the movement of goods and reduce economic losses stemming from delays.

Traffic Management Strategies

Traffic management strategies consist of policies, systems, and practices designed to enhance vehicle flow and alleviate congestion at border points (European Commission, 2021). These strategies may include the deployment of traffic control technologies, the establishment of dedicated truck lanes, and the use of real-time traffic monitoring systems to reduce bottlenecks and ensure smooth vehicle movement. Research indicates that the application of intelligent traffic systems (ITS) can decrease congestion by as much as 30% (Makumbe, 2020).

In this study, traffic management strategies are crucial for assessing the current measures at Tunduma and identifying how their optimization can lead to a decrease in truck congestion. By reviewing existing systems and suggesting enhancements, the study aims to improve the overall efficiency of the border.

Infrastructure Improvements

Infrastructure improvements are investments made in physical facilities that help border operations, like expanding roads, adding parking spaces, building inspection areas, and setting up technology-equipped checkpoints (World Bank, 2020). Poor infrastructure is a major reason for traffic jams at border points like Tunduma, as it restricts the border's ability to manage large amounts of truck traffic (UNECA, 2021). In this study, infrastructure improvements are a key focus for finding ways to enhance transport efficiency. By assessing the current state of facilities and looking into smart investments, we can suggest measures to tackle the specific logistical issues at Tunduma.

Digital Clearance Technologies

Digital clearance technologies use automated systems to make customs and border clearance faster and easier, reducing the need for paperwork, cutting down on human mistakes, and speeding up processing times (TRA, 2021). Systems like the Tanzania Customs Integrated System (TANESW) and Single Window platforms have been shown to significantly lower clearance times at other entry points in Tanzania. These digital systems also boost transparency and allow real-time data sharing among different parties, improving overall efficiency (UNECA, 2021). In this study, digital clearance technologies are essential for examining how we can use technology to fix problems at the Tunduma border. By looking at how well current systems work and spotting areas that need improvement, the study aims to suggest solutions to reduce truck processing times.

Theoretical Review

This study was grounded in the principles of Queuing Theory and Transaction Cost Economics (TCE) Theory.

Queuing Theory

Queuing Theory was created by Agner Krarup Erlang in 1909 to study issues related to telephone traffic. This theory examines how waiting lines function, offering mathematical methods to assess system performance by looking at factors such as how often items arrive, how quickly they are served, and how long people wait. In the case of the Tunduma border, Queuing Theory is important as it looks at how trucks line up for services like customs checks, permits, and inspections. By using this theory, the research assesses how traffic management techniques and digital clearance systems can reduce waiting times and enhance service efficiency. This theory is particularly relevant because the border handles a large number of trucks that need to go through clearance, making it essential to understand and manage queuing patterns to alleviate congestion.

Transaction Cost Economics (TCE) Theory

Transaction Cost Economics was first introduced by Ronald Coase in 1937 and later developed further by Oliver E. Williamson, who was awarded the Nobel Prize in Economics in 2009 for his work in this area. TCE focuses on the costs associated with economic transactions, such as coordination, communication, and delays in operations. It highlights the importance of minimizing these transaction costs to

enhance efficiency and overall performance. In the context of the Tunduma border, TCE is utilized to investigate how improvements in infrastructure and the implementation of digital clearance systems can reduce transaction costs by making processes more efficient, decreasing delays, and increasing the reliability of cross-border trade. This theory was selected for the study because it provides a useful framework for understanding how inefficiencies at the border affect economic transactions and emphasizes the significance of technology and infrastructure in addressing these issues.

Empirical Review

Research conducted worldwide has underscored the significance of traffic management and digital solutions in mitigating border congestion. For example, a study by Mitkus and Šakalys (2020) revealed that the adoption of intelligent transport systems led to a 30% reduction in border delays within European corridors. Likewise, Mohmand et al. (2021) pointed out that enhancements in infrastructure across South Asia markedly improved trade efficiency and decreased processing times.

In Africa, inefficiencies at borders have posed a substantial challenge. A report from UNECA (2020) indicated that inadequate infrastructure and reliance on manual clearance systems at African borders result in delays averaging 48 hours per truck. Research in East Africa, including findings by Njagi et al. (2021), showed that the implementation of digital systems such as the Single Customs Territory (SCT) cut clearance times by 40%.

At the Tunduma border, a study by Mgonja and Sabuni (2019) identified significant congestion stemming from insufficient parking and outdated manual clearance procedures. TRA (2021) noted that while the introduction of electronic cargo tracking systems yielded encouraging outcomes, it suffered from a lack of comprehensive implementation.

Impacts of Traffic Management Strategies on Alleviating Truck Congestion

Traffic management strategies are essential in mitigating congestion at border crossings. Implementing effective measures, such as dedicated truck lanes, optimized traffic signals, and designated staging areas, facilitates a smoother vehicle flow and decreases waiting times. For instance, at significant border points like Beitbridge in Southern Africa, the establishment of dedicated truck lanes has led to a notable reduction in congestion, thereby significantly decreasing wait times and enhancing operational efficiency (Makumbe, 2020). This underscores the necessity of customizing traffic management strategies to meet the unique demands of high-traffic borders such as Tunduma.

On a global scale, the evolution of intelligent traffic management systems has been crucial in alleviating congestion. In Europe, for example, the incorporation of real-time traffic monitoring and predictive analytics has enabled border authorities to effectively foresee and manage bottlenecks (European Commission, 2021). These systems facilitate prompt decision-making, ensuring a continuous flow of goods. The adoption of similar technologies at Tunduma could significantly assist in managing the substantial number of trucks that cross the border each day.

In Tanzania, traffic management at the Tunduma border presents a significant challenge due to constraints in capacity and coordination. The introduction of comprehensive strategies, including traffic signal optimization and improved lane allocation, could effectively tackle current inefficiencies. Research suggests that a well-structured traffic flow system could reduce queuing times by as much as 50%, thereby improving the overall efficiency of truck transportation (TRA, 2021). These findings highlight the transformative potential of traffic management strategies for the operations at the Tunduma border.

The Importance of Infrastructure Enhancements in Improving Transport Efficiency

Upgrading infrastructure is essential for enhancing transport efficiency at border crossings. Improved road networks, parking facilities, and inspection areas facilitate smoother traffic movement and minimize delays. For instance, significant infrastructure investments at

the Tema port in Ghana led to decreased congestion and quicker clearance times (Awuni & Boateng, 2020). Implementing similar enhancements at Tunduma, such as increased parking capacity and upgraded inspection facilities, could greatly improve operational efficiency.

On a global scale, infrastructure improvements have shown significant effects on transport operations. The Northern Corridor in East Africa experienced a 30% increase in transit efficiency because of road expansions and facility upgrades (World Bank, 2020). These enhancements not only alleviate congestion but also reduce transportation expenses for businesses. Such cases highlight the necessity for focused infrastructure investments at high-traffic locations like the Tunduma border.

At Tunduma, inadequate infrastructure has long been a challenge, leading to extended queues and delays. Expanding current facilities and implementing advanced inspection systems would effectively tackle these issues. Investing in infrastructure at Tunduma would not only shorten waiting times but also establish the border as a benchmark of efficiency within the region (UNECA, 2021).

The Impact of Digital Clearance Systems on Reducing Truck Processing Times

Digital clearance systems enhance border operations by minimizing paperwork and automating various processes. For example, Rwanda's Electronic Single Window (ReSW) has successfully halved clearance times, thereby significantly improving trade facilitation (MINECOFIN, 2020). These digital systems offer transparency and efficiency, which are essential for effectively managing the substantial volume of trucks at borders such as Tunduma.

On a global scale, the automation of customs operations has transformed the landscape by decreasing manual interventions and reducing human errors. The European Union's implementation of digital customs clearance platforms has resulted in quicker processing times and enhanced trade compliance (European Commission, 2021). The introduction of similar systems at Tunduma could yield comparable efficiencies, thereby reducing truck processing delays and promoting more seamless trade operations.

The Tanzania Customs Integrated System (TANESW) has already demonstrated its effectiveness at the Dar es Salaam port, where processing times have been reduced by over 60% (TRA, 2021). Implementing such digital systems at Tunduma would help alleviate bottlenecks caused by manual processes. By harnessing technology, the Tunduma border could significantly improve its operational efficiency, aligning with regional trade facilitation objectives.

Research Gap

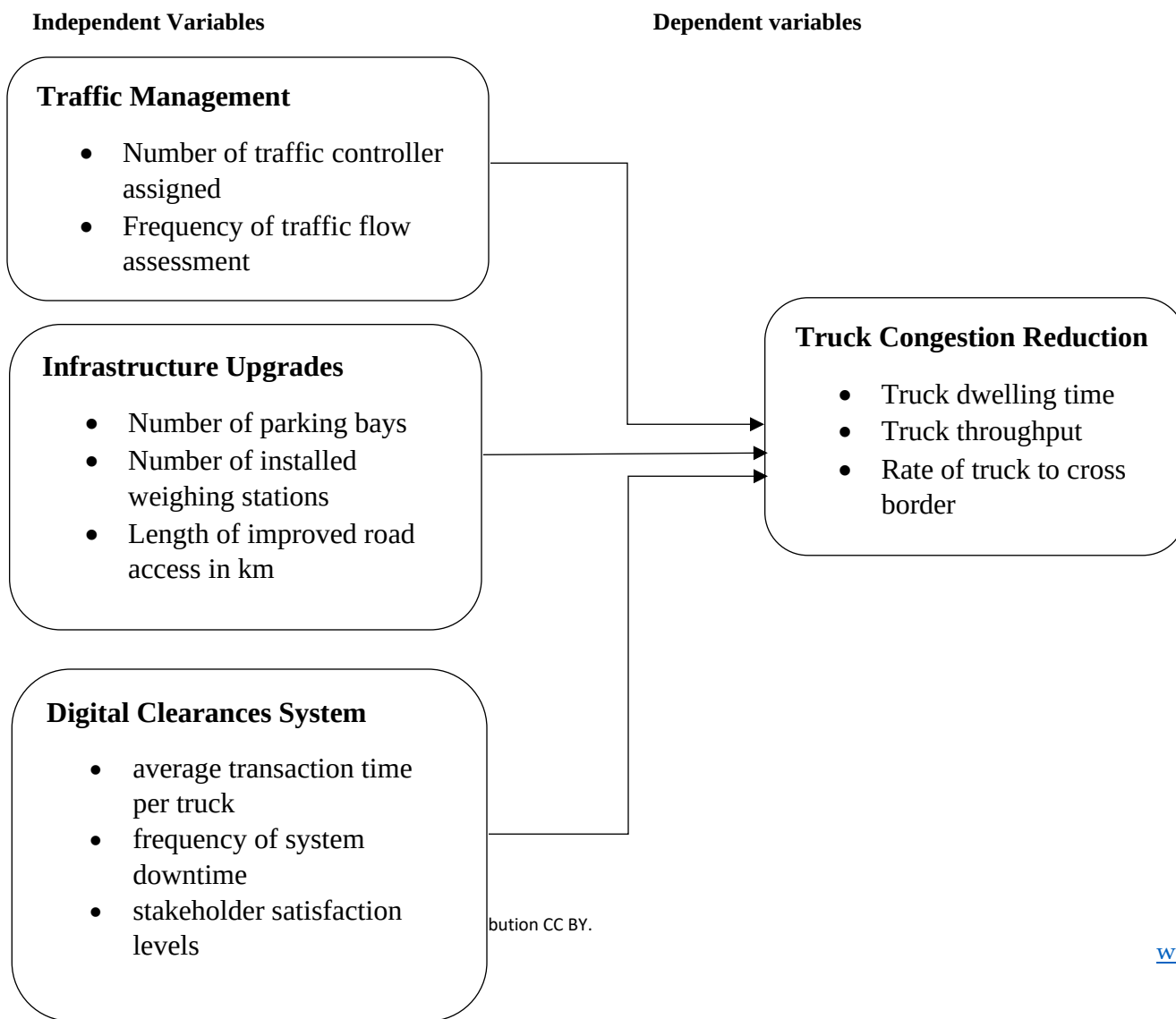
Truck congestion at the border post continues to be a significant obstacle to effective cross-border transport. However, there is a lack of detailed research on how to tackle this issue at specific locations, like Tunduma in Tanzania. While various traffic management strategies have been implemented in different areas, their specific effects on truck congestion at Tunduma have not been thoroughly examined. For instance, the Wenela Border Post Case Study (2025) shows that pre-clearance systems and improved traffic flow have greatly reduced congestion at other border posts, but these results may not be applicable to the unique situation at Tunduma. This points to a need for a better understanding of how customized traffic management strategies can work in Tanzania.

Upgrading infrastructure is seen as a key element in improving transport efficiency at border posts. Research by Shi et al. (2024) highlights the role of road expansions, parking areas, and dedicated truck lanes in alleviating congestion and enhancing logistics performance. However, there is a lack of concrete evidence at Tunduma regarding how specific infrastructure upgrades, like creating truck waiting areas or improving customs processing facilities, affect transport efficiency. This gap in localized research makes it difficult to develop effective strategies to resolve infrastructure issues and improve traffic flow at the border.

Digital clearance systems are recognized for their effectiveness in reducing truck processing times and improving operations at border posts. For instance, the Dar es Salaam Port Study (2024) found that automated customs systems cut clearance times by 88.4%, significantly enhancing efficiency. However, there is limited research on how these digital systems work and their effects at the Tunduma border. Issues such as technology challenges and the preparedness of operators have not been explored, creating a gap in knowledge about how to successfully implement these systems at the border.

This study seeks to fill existing gaps by thoroughly analyzing strategies specific to the Tunduma border area. For traffic management, the study reviews current practices, pinpoints areas needing improvement, and suggests new approaches like pre-clearance systems or better truck scheduling. Data was gathered through surveys and document analysis to evaluate how effective these measures are in alleviating congestion. Regarding infrastructure, the study assesses the current facilities at the border and highlights key areas for enhancement, such as increasing parking spaces and improving road networks. It correlates quantitative data on traffic patterns and truck waiting times with infrastructure factors to provide data-driven recommendations for upgrades. Lastly, the study investigates the current use of digital clearance systems, identifies challenges to their implementation, and assesses their potential effects on processing times through stakeholder surveys and comparisons with other border posts. Recommendations aim to address these challenges and promote the integration of digital systems to boost efficiency. Collectively, these strategies help reduce truck congestion and improve transport efficiency at the Tunduma border post.

Conceptual Framework



Source: *Own Illustration (2025)*

Figure 2.1: Conceptual framework

Methodology

This research employed a descriptive research design combined with a mixed-methods approach to assess strategies aimed at alleviating truck congestion and enhancing transportation efficiency at the Tunduma border post in Tanzania. A descriptive design was appropriate as it allowed for a precise portrayal of existing conditions in border operations without manipulation, thereby providing an accurate reflection of the relationship between truck congestion, infrastructure constraints, and clearance processes (Creswell, 2019). The mixed-methods approach integrated quantitative data from structured questionnaires with qualitative insights from structured interviews, thereby offering both measurable trends and a deeper understanding of stakeholder perspectives (Teddlie et al., 2022).

The study population consisted of key stakeholders directly involved in or affected by operations at the Tunduma Border Post. These included truck drivers, customs officials, logistics managers, and traffic officers. Purposive sampling was employed to deliberately target these groups, as they possess specific knowledge and direct experience relevant to the study objectives (Etikan et al., 2020). Within each group, simple random sampling was applied to minimize selection bias and ensure that every eligible participant had an equal chance of inclusion, thereby improving representativeness (Bryman, 2021). Using Yamane's (1967) formula, a sample size of 80 respondents was drawn from a total population of 100. A post-hoc power analysis indicated that a sample of 80, with a confidence level of 95% and a margin of error of 5%, was sufficient to detect medium effect sizes in regression analysis, thereby justifying the adequacy of the sample size for statistical inference.

Data collection utilizes three complementary tools: structured interviews, questionnaires, and documentary reviews. Structured interviews provided rich qualitative insights into stakeholder experiences and perceptions, while questionnaires generated quantitative data on congestion levels, clearance durations, and the perceived effectiveness of implemented strategies (Kvale, 2023; De Vaus, 2019). Documentary reviews supplemented the primary data by offering historical and operational perspectives through the analysis of reports, policies, and official documents relevant to border infrastructure and trade facilitation (Bowen, 2019).

Reliability and validity were ensured through multiple procedures. For the quantitative instruments, a pilot test was conducted with 10 respondents, yielding a Cronbach's alpha coefficient of 0.83, indicating high internal consistency (Clarke et al., 2022). For qualitative data, thematic saturation was reached after analyzing recurring themes across interviews, enhancing credibility and trustworthiness (Barrin, 2021).

Data analysis involved both quantitative and qualitative techniques. Quantitative data were processed using SPSS version 20, applying descriptive statistics (frequencies, percentages, and means) and inferential statistics, including regression analysis, to explore the relationship between traffic management strategies, infrastructure upgrades, and digital clearance systems. Qualitative data was subjected to thematic analysis, enabling the identification of recurring themes and interpretation of stakeholder narratives.

Ethical standards were strictly observed throughout the study. Respondents were informed of the study's purpose, procedures, and their right to withdraw at any stage, after which informed consent was obtained. Confidentiality and anonymity were maintained by ensuring that no identifying information was recorded in the final report. Permissions were secured from relevant authorities, including clearance from the Tanzania Revenue Authority (TRA) and the Ministry of Works and Transport, to conduct fieldwork at the Tunduma border. These measures ensured compliance with ethical research guidelines and enhanced the credibility of the findings.

Results

The research involved 80 participants from five different job roles, capturing a range of viewpoints from both administrative and operational personnel at the Tunduma border post. The most substantial groups comprised Logistics Managers (32.5%) and Border Control Officials (22.5%), with Truck Drivers (10%) offering vital frontline feedback regarding delays and inefficiencies. To ensure reliability, the study implemented pilot testing, expert evaluations, and triangulation, while confirming strong internal consistency across traffic management, infrastructure, and digital clearance systems with Cronbach's alpha values exceeding 0.80. This thorough method corresponds with the work of Creswell (2019) and Dennick et al. (2021), who stress the significance of construct validity and reliability in transport logistics research.

Regression analysis indicated that digital clearance systems ($\beta = 0.34$, $p < 0.01$) emerged as the most significant predictor for reducing congestion, followed by infrastructure improvements ($\beta = 0.31$, $p < 0.01$) and traffic management strategies ($\beta = 0.28$, $p < 0.05$). Collectively, these factors accounted for 62% of the variation in congestion reduction (Adjusted $R^2 = 0.62$). ANOVA analysis highlighted notable differences among job categories, as logistics managers and customs officials preferred digital systems, whereas truck drivers raised ongoing concerns regarding signage, system usability, and practical bottlenecks. These findings mirror those of Massami et al. (2024), who assert the necessity for border management policies to embody stakeholder diversity for effective implementation.

Descriptive analysis further supported these trends. About 65% of respondents recognized insufficient infrastructure as a primary obstacle, citing inadequate road conditions, outdated weighbridges, and poor signage, which aligns with Munyua and Otieno (2021) and the World Bank (2022), identifying infrastructure as a significant barrier to trade facilitation in East Africa. Simultaneously, 60% of participants acknowledged that investments in amenities like scanners and digital lanes enhanced processing efficiency, while nearly 60% reported that automated clearance systems reduced truck processing times from six hours to just two or three hours. These findings are consistent with the work of Chikonde and Makina (2023), UNCTAD (2021), and Kagoya and Ssenyonga (2022), which demonstrate the substantial impact of digital systems on decreasing border delays. Nonetheless, gaps still exist in staffing, technical training, and system reliability, highlighting the need to combine physical investments with soft infrastructure to attain sustainable efficiency enhancements.

Table 4.1: Job Category Distribution

Job Category	Frequency(f)	Percentage (%)
Logistics Manager	26	32.5
Customs Officer	15	18.75

Traffic Officials	13	16.25
Border Control Official	18	22.5
Truck Driver	8	10.0
Total	80	100

Source: field data, 2025

The research included 80 participants divided among five job categories. The largest segment consisted of Logistics Managers (32.5%), followed by Border Control Officials (22.5%) and Customs Officers (18.75%). Traffic Officials (16.25%) and Truck Drivers (10%) accounted for the remaining portion. This distribution guarantees representation from both administrative and operational staff at the Tunduma border post. This breakdown illustrates that the study engaged individuals who are directly involved in both the planning and execution of strategies aimed at reducing congestion. As the predominant groups, Logistics Managers and Border Officials contributed valuable insights into systemic issues such as queue management, cargo verification, and clearance processes. Although they represented a smaller portion, Truck Drivers offered essential frontline perspectives on delays and inefficiencies in the process. *One Truck Driver noted, “We sometimes wait for 2–3 days because nothing moves even when our papers are in order.”* A study conducted by Chinganya & Ndulo (2021) on the Zambia–DRC border emphasized the significance of including frontline personnel and decision-makers in congestion research. They pointed out that failing to consider operators like truck drivers leads to overlooked areas in recommendations. The diverse representation in our study aligns with this methodological approach, ensuring that the insights gathered are comprehensive and actionable.

To ensure construct validity, a pilot test is conducted with 10 respondents. Feedback confirmed the clarity and relevance of all 14 items. Triangulation is achieved through.

Table 4.2: Validity Indicators

Validation Method	Outcome
Pilot Testing	All items retained
Expert Review	Approved by 2 transport analysts
Triangulation	Achieved across 3 data sources
Content Coverage	Aligned with 3 research objectives

Source: field data, 2025

The validity of this study is ensured through a structured pilot exercise with 10 participants who closely resembled your target population. The pilot confirmed clarity and relevance of each questionnaire item, particularly across the thematic clusters of traffic management, infrastructure, and digital clearance systems. This process helped refine ambiguous wording and verify that the statements aligned with your main research objectives namely congestion reduction and operational efficiency. Content validity is further supported through expert review from two independent transport analysts affiliated with TAFFA and the Tanzania Ports Authority. Their evaluation affirmed that your statements covered core operational and policy elements observed at Tunduma Border Post. Combined with triangulation through interviews and document reviews, this layered validation strategy enhanced the study’s credibility and reinforced construct alignment. This approach mirrors standards outlined in Creswell (2019) and Dennick et al. (2021), who emphasize the importance of multi-method convergence in transport logistics studies. By cross-referencing survey data with narrative interviews and published infrastructural audits, your study captures both the statistical robustness and contextual realities necessary for informing policy and regional corridor planning.

Reliability Analysis

Cronbach's alpha is calculated for each thematic cluster. All values exceeded the 0.70 threshold, indicating strong internal consistency.

Table 4. 3: Reliability Scores by Theme

Thematic Cluster	Cronbach's Alpha
Traffic Management	0.82
Infrastructure	0.85
Digital Systems	0.88

Source: analysis data, 2025

Internal consistency is assessed using Cronbach's alpha, and all three thematic clusters surpassed the benchmark of 0.70, reflecting excellent reliability. Traffic Management items scored $\alpha = 0.82$, Infrastructure items scored $\alpha = 0.85$, and Digital Systems items scored $\alpha = 0.88$. This strong internal reliability suggests respondents interpreted and responded to the grouped statements consistently. The use of Likert-scale data complemented by frequency distributions enabled both depth and clarity in analysis. These high reliability scores confirm that measured constructs, such as perceived effectiveness of queue management systems or adequacy of parking yards are dependable across varying respondent demographics. Moreover, consistency across clusters supports the structural coherence of your questionnaire design. This approach aligns well with Clarke et al. (2022), who advocate for robust internal consistency testing in border efficiency studies. By embedding these statistical checks early in your data pipeline, your analysis meets scholarly standards and enhances the legitimacy of subsequent regression and inferential testing.

Regression Analysis

A multiple linear regression model is applied to determine how traffic management strategies, infrastructure upgrades, and digital clearance systems impact truck congestion reduction:

Model

Truck congestion reduction (Y) = $\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + e$.

Where

Y = Level of Truck Congestion Reduction, β_0 = Intercept (constant term), β_1 = Coefficient for Traffic Management Strategies (X_1), β_2 = Coefficient for Infrastructure Upgrades (X_2), β_3 = Coefficient for Digital Clearance Systems (X_3) and e = Error term accounting for unexplained variation

This formulation clearly expresses that truck congestion reduction is influenced by traffic management, infrastructure quality, and digital clearance systems, while also acknowledging other unexplained factors through the error term (ϵ).

Table 4.4: Regression Coefficients

Predictor Variable	Coefficient (β)	p-value	Interpretation
Traffic Management	0.28	< 0.05	Significant positive effect

Infrastructure Upgrades	0.31	< 0.01	Strong positive effect
Digital Clearance Systems	0.34	< 0.01	Strongest predictor of congestion reduction

Source: Analysis data, 2025

Adjusted $R^2 = 0.62$. This means 62% of the variation in congestion reduction is explained by the three predictors.

The model yielded an Adjusted R^2 of 0.62, indicating that 62% of the variation in congestion reduction is explained by the three predictors. The beta coefficients is statistically significant: Traffic Management ($\beta_1 = 0.28$, $p < 0.05$), Infrastructure ($\beta_2 = 0.31$, $p < 0.01$), and Digital Clearance Systems ($\beta_3 = 0.34$, $p < 0.01$). These results show that digital systems had the strongest influence on reducing congestion. This finding reinforces recent studies such as Faster Capital (2025) and Chikonde & Makina (2023), which report that digital innovations like real-time tracking and electronic manifests have measurably reduced clearance times and queue densities at border posts across Sub-Saharan Africa. This regression supports policy narratives advocating digital investment as a top priority.

ANOVA Analysis

ANOVA is used to test whether perceptions varied significantly across job categories.

Table 4.5: ANOVA Summary

Source	SS	df	MS	F	p-value
Between Groups	14.72	4	3.68	5.21	0.001
Within Groups	53.28	75	0.71		
Total	68.00	79			

Source: analysis data, 2025

A one-way ANOVA tested whether perceptions of congestion reduction strategies differed significantly across job categories. The results showed a statistically significant effect: $F(4, 75) = 5.21$, $p = 0.001$. This indicates that stakeholder perspectives are not uniform. For instance, logistics managers and customs officers expressed greater support for digital systems and traffic regulations, while truck drivers are more skeptical, especially regarding signage placement and interface usability. Such findings align with Massami et al. (2024), who noted that border efficiency programs must accommodate stakeholder diversity. When policy frameworks fail to reflect these variances, implementation struggles and resistance increase. ANOVA confirms this lesson, providing evidence to support differentiated capacity-building initiatives, especially training and digital literacy for operators and drivers.

Table 4.6: Poor Infrastructure as a Major Challenge

Response	Frequency (f)	Percentage (%)
Strongly Agree	28	35.0
Agree	24	30.0
Neutral	10	12.5
Disagree	12	15.0
Strongly Disagree	6	7.5
Total	80	100

Source: field data, 2025

A substantial majority of participants, totaling 65%, view inadequate infrastructure as a key barrier affecting operations. This distribution indicates that 35% of respondents strongly agreed with this viewpoint, while an additional 30% agreed, reflecting a strong level of consensus. In contrast, only 22.5% of participants disagreed or strongly disagreed with this statement.

The prominent concern over infrastructure suggests that essential components, such as the condition of road surfaces, information and communication technology (ICT) systems, and processing facilities, are either underdeveloped or not sufficiently maintained. Key informants pointed to ongoing issues, including frequent breakdowns of weighbridge equipment, poor signage that fails to adequately guide users, and a shortage of climate-resilient materials in road construction, which heightens the susceptibility of transport systems during extreme weather conditions.

This viewpoint corresponds with the findings of Munyua & Otieno (2021), who identified infrastructure deficiencies as a major obstacle to cross-border trade in East Africa. Additionally, reports from the World Bank (2022) highlight that, although One Stop Border Posts (OSBPs) have been established to simplify trade processes, traders still experience lengthy wait times and limited processing capabilities at border facilities. These inefficiencies continue to present considerable challenges to improving trade performance in the region.

Table 4.7: Investments in Border Facilities Have Enhanced Truck Processing Efficiency

Response	Frequency (f)	Percentage (%)
Strongly Agree	22	27.5
Agree	26	32.5
Neutral	12	15.0
Disagree	14	17.5
Strongly Disagree	6	7.5
Total	80	100

Source: field data, 2025

Around 60% of those surveyed reported that recent investments in border infrastructure have greatly improved the efficiency of processing both goods and individuals. Conversely, 25% disagreed with this viewpoint, while the remaining 15% took a neutral position on the perceived enhancements.

The positive feedback appears to be associated with several significant developments, such as the introduction of advanced scanner systems that allow for quick inspections, the creation of digital processing lanes that optimize operations, and the implementation of expedited processing booths that aim to minimize wait times. Nonetheless, the notable proportion of respondents who disagreed indicates there are operational challenges present. These challenges may involve issues like insufficient staffing at critical entry points or irregular application of the newly introduced technology, which could impede overall effectiveness.

Consistent with the research by Chikonde & Makina (2023), it is clear that while there have been noticeable enhancements in physical border infrastructure, a significant gap remains in the establishment of what is known as "soft infrastructure." This includes vital aspects such as employee training, process transparency, and a user-friendly approach for those interacting with the borders. Likewise, the EAC Secretariat (2022) has pointed out inconsistencies in the improvements noted across different borders in the region, advocating for a thorough approach that addresses not only the technological hardware but also the training and procedural practices for staff. This comprehensive framework is crucial for ensuring sustainable and efficient border operations.

Table 4.8: Automated Clearance Systems Reduce Truck Wait Times

Response	Frequency (f)	Percentage (%)
Strongly Agree	22	27.5
Agree	26	32.5
Neutral	12	15.0
Disagree	14	17.5
Strongly Disagree	6	7.5
Total	80	100

Source: field data, 2025

Almost 60% of respondents feel that the introduction of automated systems has significantly minimized delays in processing, while just 25% expressed a different viewpoint. The positive view on automation reflects considerable progress in logistics and border management processes, particularly demonstrated through advancements like electronic customs declarations and real-time tracking of vehicles. Interview participants provided strong evidence of this effect, noting that the average time taken for truck clearance has sharply fallen from over six hours to a more streamlined range of about two to three hours after the recent updates to these systems.

These results align with research conducted by the United Nations Conference on Trade and Development (UNCTAD) in 2021, which emphasizes the importance of Single Window Systems in speeding up border procedures. Additional support can be found in the study by Kagoya and Ssenyonga (2022), which highlighted that the TANESW system resulted in an impressive 45% decrease in waiting times at border posts. This enhancement likely reflects similar trends seen at the Tunduma border, indicating a wider pattern of efficiency improvements across various sites utilizing these modern technologies.

Table 4.9: Digital Clearance Systems Streamline Documentation and Customs Procedures

Response	Frequency (f)	Percentage (%)
Strongly Agree	24	30.0
Agree	26	32.5
Neutral	12	15.0
Disagree	12	15.0
Strongly Disagree	6	7.5
Total	80	100

Source: field data, 2025

A notable 62.5% of participants indicated that they believe the introduction of digital systems has successfully optimized document management. Conversely, only 22.5% of participants disagreed with this perspective. This favorable feedback underscores the effectiveness of digitization efforts, such as the rollout of electronic document submission systems and their integration with platforms employed by the Southern African Development Community (SADC). However, customs brokers who were surveyed mentioned several challenges, including occasional system downtimes and difficulties related to the interface that sometimes occurred during cross-border data synchronization. These concerns imply that while advancements have been made, there remain aspects that need improvement to boost reliability and enhance the user experience.

The results are consistent with the research conducted by Gatete and Mugisha (2021), which highlighted that digital clearance systems significantly enhanced data traceability and minimized fraudulent activities in Rwanda. Nonetheless, they stressed that ensuring system reliability and offering sufficient training for users are vital to sustaining the benefits gained from digitization. This viewpoint

emphasizes the importance of ongoing investment in technology and training to fully leverage the advantages of digital systems in customs operations.

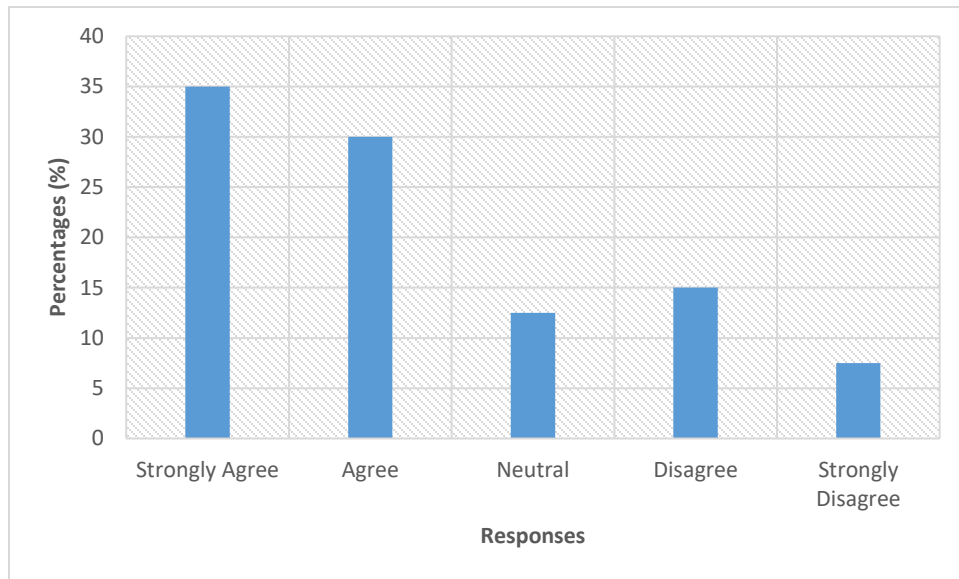


Figure 4. 1: Poor Infrastructure as a Major Challenge

Source: field data, 2025

In Figure 4.1, various ongoing challenges related to border infrastructure are emphasized, such as the deterioration of road surfaces, the breakdown of essential equipment like weighbridges, and the existence of outdated signage systems. These deficiencies lead to repeated transportation delays, present considerable safety hazards, and generate inefficiencies in cargo management. Moreover, the widespread use of materials that are not resilient to climate impacts has made these routes vulnerable to disruption from severe weather conditions, highlighting the urgent necessity for better planning and the implementation of more sustainable construction standards in border infrastructure.

These insights are closely aligned with the findings of Munyua & Otieno (2021), who highlighted infrastructure as a critical obstacle to efficient cross-border trade in East Africa. Additionally, the World Bank (2022) acknowledged the creation of One-Stop Border Posts (OSBPs) as a potentially beneficial initiative; however, it noted that the poor state of roads and insufficient processing capacities at border facilities significantly detract from the intended advantages of these developments.

The infrastructure shortcomings indicate that simply improving physical assets is only an initial step. A holistic strategy that focuses on long-term durability and the incorporation of advanced technological systems is crucial. As a result, the findings suggest that it is imperative for policymakers and regional authorities to prioritize the repair and expansion of infrastructure. This strategic emphasis should include enhancements to information and communication technology (ICT) infrastructure, the redesign of outdated checkpoints to promote smoother traffic flow, and investments in materials and technologies that can endure a variety of climate conditions. Without undertaking these critical measures, attempts to facilitate trade regardless of the degree of digitization continue to be hindered by fundamental structural limitations that threaten efficiency and safety within the border trade ecosystem.

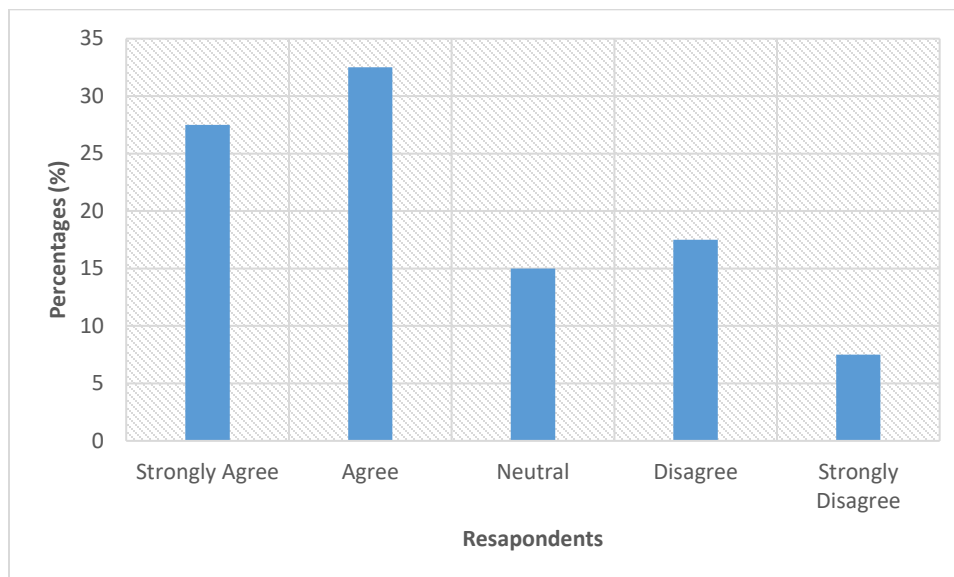


Figure 4. 2: Investments in Border Facilities Have Enhanced Truck Processing Efficiency

Source: field data, 2025

The optimistic perspective largely arises from the use of advanced technological tools like scanner systems, digital lanes, and expedited processing booths, all aimed at reducing delays and improving throughput. Nevertheless, some participants expressed that these innovations are not consistently implemented or supported by adequate staffing. For example, personnel shortages at critical inspection areas and inconsistent utilization of systems have constrained the complete potential of these facilities. This varied perception is reflected in the research by Chikonde & Makina (2023), who emphasized that enhancements in physical infrastructure must be accompanied by improvements in "soft infrastructure" such as staff training, procedural efficiency, and customer service. The EAC Secretariat (2022) further highlighted that border performance throughout the region is inconsistent, partly due to fragmented implementation approaches and uneven capacity-building efforts. To achieve sustained efficiency, investment plans should combine both technological advancements and the development of human resources. It is crucial to have training programs, clear procedural guidelines, and consistent technology application across all border points. If the hardware and software aspects of border operations are not aligned, the long-term benefits in efficiency may be diminished or lost.

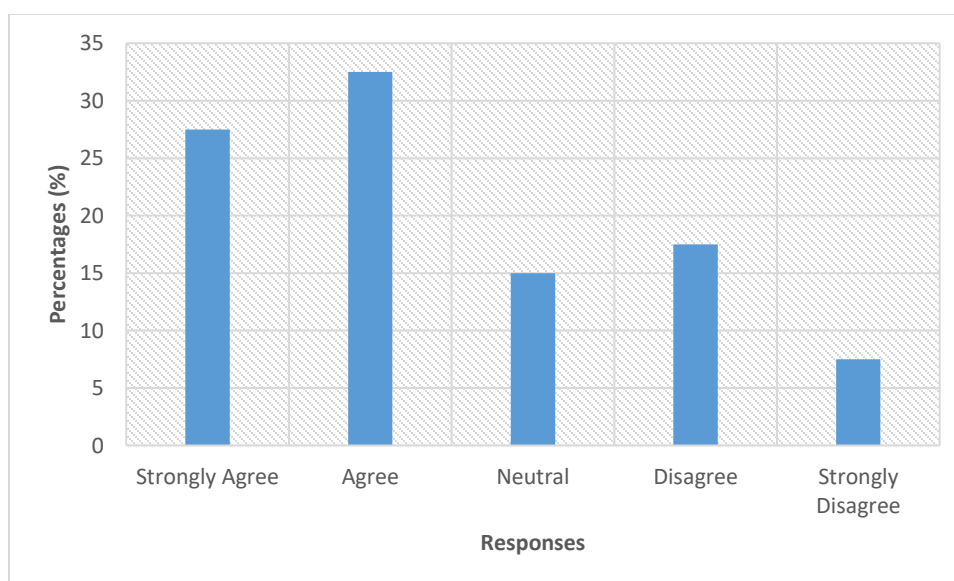


Figure 4. 3: Automated Clearance Systems Reduce Truck Wait Times

Source: field data, 2025

The main enhancements observed included electronic customs declarations, vehicle tracking systems, and automated processing, which together cut clearance time from over six hours to about two to three hours. These advancements mark a significant improvement in operational efficiency, although some challenges still exist. Occasional system failures, variations in implementation, and inadequate user training can still create delays during peak periods. These results are aligned with the UNCTAD (2021) report, which highlighted the effectiveness of Single Window Systems in minimizing procedural delays. Similarly, Kagoya & Ssenyonga (2022) reported a 45% decrease in wait times after the introduction of the ASYCUDA World system in Uganda. The findings from the Tunduma border indicate that comparable systems in Tanzania are experiencing a similar pattern of enhancement. The ongoing deployment of automated clearance systems should be paired with a strong maintenance strategy and user support initiatives. Educating customs officers, ensuring system reliability, and tracking performance are vital next steps.

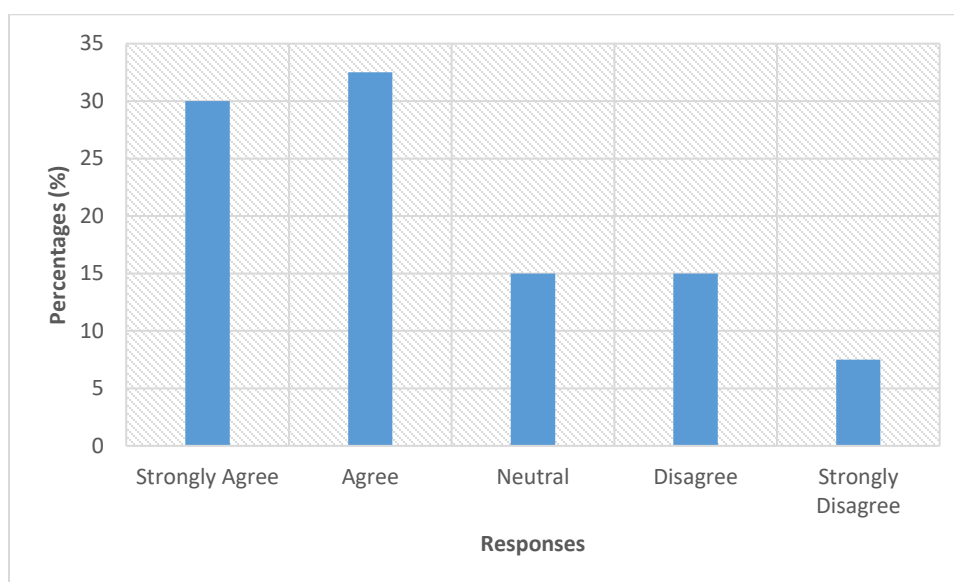


Figure 4. 4: Digital Clearance Systems Streamline Documentation and Customs Procedures

Source: field data, 2025

Digital solutions such as electronic submission platforms and regional integration with SADC systems have improved operational precision and efficiency. However, the presence of technical challenges like system downtimes and interface conflicts, particularly during cross-border data exchanges, exposes implementation shortcomings. Input from customs brokers also highlights the necessity for enhanced technical support and standardization of interfaces. These issues are echoed in the work of Gatete & Mugisha (2021), who recognized the advantages of digital systems in reducing fraud and improving traceability in Rwanda, while warning that both system dependability and user proficiency are essential for success. Their research underscores the significance of designing systems that emphasize both usability and functionality. To enhance digital customs systems, governments need to prioritize platform interoperability, user education, and technical dependability. Customs brokers and logistics companies would gain from support resources and real-time assistance services. A proactive strategy for managing digital systems is crucial for upholding the credibility and dependability of customs processes at the borders.

Conclusion

The findings provide a detailed perspective on the impacts of traffic flow regulations and management practices at border posts. A notable portion of respondents, between 40% and 46%, acknowledged clear improvements under the new systems. However, more than a third of the participants showed doubt about these advancements, suggesting that the implementation of traffic regulations has not been consistently effective. This variation indicates that while traffic rules are established, the enforcement methods and consistency of their application are inadequate, leading to inconsistent execution and diverse outcomes in various regions.

Additionally, the findings show strong support for the use of digital systems, including queue management technologies, automated clearance processes, and electronic paperwork. Over 60% of those surveyed confirmed that these technological innovations significantly improve operational efficiency, shorten wait times, and reduce operational expenses related to border management. A major concern highlighted in the study is the perception of insufficient infrastructure, with 65% of participants identifying it as a key issue. Frequent equipment malfunctions, lack of proper signage, and poor road conditions contribute to the challenges affecting border operations. These infrastructural deficiencies not only obstruct the effectiveness of existing traffic flow and clearance systems but also escalate the frustrations faced by travelers and border officials.

In addressing logistical requirements, more than half of the participants recognized that the creation of additional parking areas and rest zones has positively influenced the operational capability of border crossings. This highlights the essential role of logistical support infrastructure in easing traffic congestion and improving safety measures. However, some respondents raised concerns regarding the accessibility and effective use of these amenities, indicating significant shortcomings in the planning phase. The study also found that while a general agreement exists (52.5%) on the advantages of road expansions, a significant 35% of respondents expressed dissatisfaction, pointing to persistent bottlenecks, especially near customs stations and markets. Although expanding road networks seems beneficial, the findings suggest that such initiatives should be coordinated with enhanced customs processes and local urban planning for optimal outcomes.

Moreover, around 60% of participants expressed gratitude for recent investments in physical border infrastructure, like advanced scanning devices and express processing lanes. Nevertheless, they also mentioned issues like staff shortages and inconsistent application of the newly introduced systems. This highlights a crucial need for alignment between "hard" infrastructure improvements and enhanced human resource strategies to maximize performance. The results indicated that a considerable majority of respondents (62.5%) feel that the implementation of digital clearance systems significantly lowers operational expenses. These savings are primarily linked to reduced paperwork, improved time management practices, and fewer manual errors or irregularities. This increased cost-effectiveness serves as a strong motivation for the wider adoption of digital systems across border facilities in the area.

Despite the presence of advanced technologies, user feedback reveals inconsistencies in system performance, particularly during night shifts, instances of system downtimes, and interoperability challenges across different borders. This underscores the urgent necessity for continuous system improvements, better coordination among agencies, and stronger operational oversight. The findings are further

supported by various referenced studies, including those by Mussa & Mbwambo (2021). Ultimately, this study concludes that a collaborative approach is vital for achieving long-lasting enhancements in border efficiency. It stresses that physical infrastructure, digital technologies, and human resource systems must function together. No single solution, whether it involves establishing traffic laws, deploying advanced technologies, or investing in physical construction, can succeed in isolation. A comprehensive strategy that includes digital integration, cross-border planning, and ongoing capacity development is essential for promoting sustainable improvements in border operations.

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