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Article

The Optimization of Ground Handling Resources for Operational Excellency: A Case Study of Julius Nyerere International Airport (JNIA)

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Abstract.

Like many rapidly growing airports in developing economies, inefficiencies of ground handling operations at Julius Nyerere International Airport (JNIA) are linked to delays, increased operational costs, and reduced customer satisfaction. Therefore, this study aims to explore how operational efficiency in ground handling services at Julius Nyerere International Airport (JNIA) can be enhanced through optimization of critical operational factors such as workforce management, proper utilization of ground support equipment (GSE), technological integration, financial investment, and infrastructure capacity, which are critical to the overall performance of any airport.

Moreover, a mixed-methods case study approach is used which integrates quantitative and qualitative insights to provide better understanding of operational efficiencies, quantitative data were collected through a structured questionnaire and analyzed using multiple regression and ANOVA, while qualitative insights were derived from expert interviews and thematic analysis using NVivo. Similarly, the secondary data in this study consisted of airline and airport records, performance reports, and published datasets were used to validate and complement primary findings. The regression model confirmed high reliability of model used which was obtained from Cronbach's Alfa value (α) of 0.882 and the operational efficiency variance (R2) value of 0.778, which indicate that 77.8% of the variance in the dependent variable is explained by the independent variables. Furthermore, all operational predictors demonstrated a significant influence to JNIA operational efficiency, strongest contributors to operational efficiency being infrastructure capacity and workforce management recording coefficient (β) value of 0.359 and 0.356 respectively. Similarly, Sensitivity analysis indicated that incremental improvements in these factors can collectively enhance efficiency by 10-20%. Comparison analysis within East African context has revealed that JNIA's operational efficiency scores 0.76 behind JKIA whose operational efficiency records 0.85 which highlighting opportunities for investment in infrastructure, technology, and workforce utilization.

Conversely, the study concludes that a holistic and integrated approach is essential to enhance ground handling performance and operational reliability at JNIA, with implications for broader airport management in the East African context.

Keywords: Operational Efficiency, Ground Handling Services, Operational inefficiencies, Equipment availability, Efficient utilization, Maintenance programs, Real-time tracking, Proper allocation, Predictive maintenance, Modern GSE, Reliability, Downtime reduction, East Africa.

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1. Introduction

According to ICAO (2019), ground handling is defined as all airport services necessary for the arrival and departure of an aircraft, these services are not considered as part of air traffic services which include the actual flying of an aircraft. Ground handling services comprise a wide range of interdependent activities which are performed simultaneously from check-in counter to boarding such services include, aircraft refueling, passenger handling, loading and unloading of cargo and baggage, aircraft marshaling, maintenance support and inflight catering (IATA, 2012). These services form an integral part to airline operations while ensuring the efficiency, safety, and reliability of airport operations (IATA, 2022).

Julius Nyerere International Airport (JNIA), is the busiest and the most strategic aviation hub in Tanzania. According TAA statistics, JNIA is experiencing a significant air traffic growth from both domestic and international airlines, it has recorded more than 2.6 million and more than 55 thousand flights in 2023. This increase in demand for air travel and the need for operational excellence poses challenges for the optimum resource allocation, workforce management, as well as process efficiency. Justesen (2014), inefficiencies in optimum resources allocation can result into flight delays, congestion, safety concerns, and financial losses for airlines and service providers and consequently deteriorating in passenger satisfaction.

This study intends to evaluates the current level of resource utilization used in the provision of ground handling services at JNIA and identifying opportunities for optimization while targeting the key factors like workforce allocation, equipment efficiency, technological integration, and regulatory compliance towards improving overall performance. Specifically, this study aims to evaluate workforce management practices, to assess the utilization and maintenance of Ground Support Equipment (GSE), to analyze the impact of technological integration, to examine the role of process standardization, to assess the impact of infrastructure capacity (aircraft parking bays, baggage handling systems, runway access) on the operational efficiency in ground handling services.

2. Literature Review

Empirical literature review has indicated that, several studies have highlighted the importance of effective workforce management in ensuring smooth ground handling operations. According to study conducted by Scholz (2010) emphasized that inefficiency resulted from aircraft ground handling operations generally leads to delays of aircrafts scheduling and ultimately results to both greater losses in aviation industry investments and high operation costs.

Wandelt et. al (2024), identified that personnel involved in ground handling are essential part of aviation that serve as an intersection of three major aviation stakeholders namely airlines, airports, and ground handling service providers. IATA (2019) on global ground handling report found that workforce shortages, inadequate training, and poor scheduling has negatively impacted ground handling services. The study of effects of automation and staff productivity have found that shift scheduling task optimization and automation was found to improve employee productivity (Camara et al., 2019). This empirical review identifies that effective resources planning through continuous training and technology integration increase labor efficiency in ground handling.

Various empirical studies have highlighted optimization of GSE at airports including the study conducted by Rahman (2023), GSE consist of equipment found at an airport, usually on the apron, besides the terminal which are used to service the aircraft between flights. Ground Support Equipment (GSE) as the name suggests they usually support the aircraft whilst on ground including aircraft servicing, baggage handling, and cargo loading, passenger boarding and other support services as required dependent on aircraft type (Zelasko, 2014). Trabels (2016), found that automated GSE scheduling is one of the most widely applicable in aviation which resulted into positive synergy with process efficiency.

The digital transformation in ground handling has been extensively studied in various empirical research. One of the critical studies was done by IATA (2018) ground handling report which analyzed the impact of digital turnaround management systems and found that real-time monitoring of aircraft turnaround has reduced service delays significantly through application of technological. According to Turner (2021), the baggage handling process which include transporting passenger baggage from check-in, and on and off aircraft, which facilitate to track baggage movements in real time, reduce labor dependency and improve speed and significantly improved baggage processing speeds and accuracy, reducing lost baggage incidents. According to Turner (2021) Orok system offers a complete baggage transport automation solution that comprises a fleet of robot vehicles that use Artificial Intelligent to deliver baggage within the airport which is supervised by a centralized server which is made up of omnidirectional, fitted with an anti-collision system that ensures safety and obstacle avoidance, and run on electricity, which Orok claims reduces power consumption by up to 70%.

According to The Citizen (2021), Ground handling services require substantial capital investment, Swissport Tanzania invested Tanzanian shillings 4.08 billion in GSE fleet modernization and 26.5 billion was spent in the construction of state of art warehouse and upgrading cold-rooms facilities at JNIA. It was also noted that Swissport will continue to invest in infrastructure in order to sustain its performance. According to the study performed by Kamazi et. al., (2015), a total of Euro 37 million was invested in the rehabilitation efforts of the Julius Nyerere International Airport (JNIA) in Dar es Salaam, co-funded by the Dutch ORET program whose primary objectives were to meet the International Civil Aviation Organization (ICAO) safety standards by improving including runway resurfacing, taxiway and apron upgrades, installation of airfield lighting systems, and wastewater treatment facilities and to facilitate growth in passenger and cargo transport.

According to Fitantril (2017), airports are plays a vital role for ground handling services, since these services are performed with the vicinity of the airport. according to the Civil Aviation (Facilitation of Air Transport) Regulations, 2024, airports are required to have necessary infrastructure to support ground handling services including airside facilities where ground handling services will dominantly be performed to include GSE parking, loading and offloading of the aircrafts and apron transportation of baggage and cargo both arriving and departing, landside infrastructures to include passenger handling, cargo handling and baggage handling process as well as support and operational facilities including lounges, offices and coordination center during disruptions, immigration and customs services.

Theoretically, this study adopts the Resource-Based View (RBV) initiated by Barney (1991), which is a strategic management theory that explains how the organization earns competitive advantage through management and utilization of internal resources. This theory emphasize resources must be valuable, rare, inimitable, and non-substitutable in order to provide a strategic advantage. RBV provides a framework for understanding how airports and ground handling service providers can optimize their workforce, technology, and equipment to improve operational efficiency. While emphasizing that organizations must focus on leveraging their exceptional resources to enhance its operational performance, these resources include; human resources to include skilled and well-trained employees essential for ground handling services efficiency. According to Gittell (2003), airlines with well-coordinated ground handling teams experience faster turnaround times and improved service quality. Technological resources such as the use of automated systems, such as baggage handling and tracking system, and personnel scheduling contributes to improvement of ground handling services efficiency and reduces delays (IATA, 2018). Ground support equipment, utilization of GSE, such as aircraft tugs, and conveyor belts, ensures smooth ground operations. According to IATA (2020) optimization of GSE usage can significantly reduce service delays.

Conceptual literature review has noted that, resource optimization in ground handling involves the effective allocation and utilization of personnel through proper scheduling, skill-based task allocation, and continuous training enhance service efficiency (Mwang'amba, N., 2020), According to NASEM, (2012), there are various types of GSE used for aircraft handling at the airport including aircraft tow or pushback tugs, baggage tractors, belt loaders, cargo loaders, ground power units, air conditioning units, fuel trucks, water trucks, lavatory trucks, deicing trucks, and catering trucks, and Automation in baggage handling, aircraft docking systems, and real-time data analytics improve turnaround efficiency in order to achieve operational efficiency (Tabares, D. A., & Mora-Camino, F., 2017). According to the study performed by Bruecker (2013) titled Workforce planning incorporating skills, it was found that delays in aircraft turnaround were often linked to inefficient workforce allocation and outdated equipment.

Aviation industry operates under very strict regulations set by TCAA which emphasize on compliance with both local and international safety, security, and service standards within Tanzanian context.

Figure 1 below provides for the conceptual framework for this study whereby the relationship between dependent variables which include key factors influencing ground handling operations and independent variables represents the outcome or performance measure affected by these factors, is expressed to determine the causal effect relationship towards the operational efficiency.

The independent variables (predictor variables) are the factors that directly affect the efficiency and optimization of ground handling resources at JNIA which include; Workforce Management which is measured in terms of training and skill level of ground handling staff, staffing schedules and allocation efficiency, as well as employee productivity and coordination. Another independent variable is Ground Support Equipment (GSE) Utilization which measured in terms of availability and condition of ground support equipment such as baggage loaders, tugs, fuel trucks, etc., maintenance and replacement of ground handling equipment and efficient allocation and usage of GSE. Likewise, technological Integration in ground handling services which include the use of automated systems such as BRS, self-check-in kiosk, turnaround management software as well as real-time communication systems for ground staff. On the other hand, provision of necessary funding to the acquire necessary tools and machines which are necessarily required in ground handling is one of the key independent variables. Lastly, airport infrastructural capacity to include; adequacy of terminal space and baggage handling areas, availability of well-organized parking bays and apron efficiency necessary for provision of ground handling services, as well as cargo storage and processing capacity

In this study operational efficiency in ground handling is the dependent variable which is measured by **s**horter aircraft ground time, minimized delays, consistency in handling flights without delays or errors, lower operational costs due to better resource utilization and improved experience for airlines and travelers.

The following hypothesis have been developed to assess the effect of independent variables to dependent variables

X_1: Effective workforce management positively impacts operational efficiency by reducing turnaround time and improving service reliability.

X_2: Proper utilization and maintenance of GSE enhance operational efficiency though turnaround time, cost efficiency, and reliability in ground handling operations.

X_3: The adoption of automated systems, and real-time communication improves turnaround time and service reliability.

X_4: Increased financial investment in workforce development, equipment, and technology enhances operational efficiency and cost-effectiveness.

X_5: Adequate infrastructure capacity enhances the speed and reliability of ground handling services, reducing congestion and delays.

Figure 1: Conceptual Framework Diagram

Source: Literature review (March, 2025)

3. Methodology

This study adopts a case study approach to analyze ground handling resource optimization at Julius Nyerere International Airport (JNIA) in order to provide for an in-depth, context-specific investigation of a single entity (JNIA) to understand real-world challenges and solutions in resource optimization.

3.1 Research Design

The study utilizes a mixed-method approach which combines descriptive and exploratory research design to examine ground handling operations, identify optimization challenges, and propose solutions. Descriptive design in this study has be chosen to facilitate the understanding of the current state of ground handling resources and their utilization at JNIA. Whereas the exploratory design is used to investigate challenges, inefficiencies, and best practices in resource optimization.

3.2 Study Population and Sampling

The study was conducted at Julius Nyerere International Airport involving Ground Handling Service Providers, Airline Operators operating at TB I, TB II and TB III including local airlines, as well as regulatory authorities (Tanzania Civil Aviation Authority – TCAA and Tanzania Airports Authority - TAA)

3.3 Sampling Technique

A stratified random sampling technique has been employed to ensure a balanced representation and participation from key stakeholder groups involved in ground handling operations at Julius Nyerere International Airport (JNIA) to ensures that each stakeholder group is adequately represented in the sample for accuracy and reliability of findings.

3.4 Sample Size

The study targeted a total of 127 respondents to participate into structured questionnaires and interviews from ground handling service providers, airline representative, and regulatory officials as per below table;

Table 1: Sample Size

Sample Group	Questionnaire Respondents	Expert Interviews	Total Sample Size
Ground handling staff	55	5	**60**
Airline representatives	45	3	**48**
Airport Authority	10	2	**12**
Regulatory bodies	5	2	**7**
Total Sample Size	**110**	**12**	**127**

3.5 Data Collection Methods

The study employs multiple data collection techniques to ensure a holistic analysis such as;

Primary Data were collected through survey and questionnaires using structured questionnaires with 5-point Likert Scales were administered online to various respondent groups as detailed in Table 1 above. Likewise, 12 in-depth interviews were conducted to gather expert opinions on best practices on resource optimization in ground handling operations.

Secondary Data was collected through operational performance data such as turnaround times, service efficiency, daily operational reports as well as operational quality audits reports.

3.6 Data Analysis Techniques

Thematic analysis was used to analyze qualitative data using NVivo software to code and categorize interview responses and open-ended survey answers.

Quantitative Data were analyzed using descriptive statistics to include Mean, frequency, and percentage analysis of survey responses. ANOVA and Regression Analysis will be used in order to assess the relationship between resource optimization factors (workforce, technology, equipment) and operational efficiency (turnaround time, service reliability). SPSS version 29 or Microsoft Excel will be used for statistical analysis.

To test the hypotheses, the study embraced a linear regression model to perform the analysis. The following sets of equation were used.

$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X3 + \beta_4X_4 + \beta_5X_5 + \varepsilon$

Where:		
	Y	Operational Efficiency
	X_1	Workforce Management
	X_2	GSE Utilization
	X_3	Technological Integration
	X_4	Financial Investment
	X_5	Infrastructure Capacity
	β_0	Constant
	$\beta_1 - \beta_5$	Regression coefficients
	ε	Error term

3.7 Validity and Reliability

Cronbach's alpha was used to measure the scale reliability of survey instruments, ensuring that the collected data is consistent and reliable. The Pilot Testing was performed for a small-scale pre-test of questionnaires to refine questions. Likewise, triangulation was involved using multiple data sources (surveys, interviews, and observations) to enhance accuracy. Furthermore, expert validation was consulted from various aviation and ground handling experts to ensure the relevance of research instruments.

3.8 Ethical Considerations

All respondents were informed about the study's purpose, and participation is voluntary while respondents' data is anonymized and used solely for research purposes.

3.9 Descriptive Analysis

The study targeted a total of 110 questionnaire respondents, out of which 93 responses were received, resulting in an overall response rate of 84.5% which assures that the data is robust and provides a strong basis for analysis. Ground Handling Staff, Airline Representatives scored 72.7% and 84.4% of response rate respectively whereas, Airport Authority and Regulatory bodies scored 100% of the response rate. Additionally, 12 expert interviews achieved 100% of interview completion rate which provide for comprehensive insights from key industry players.

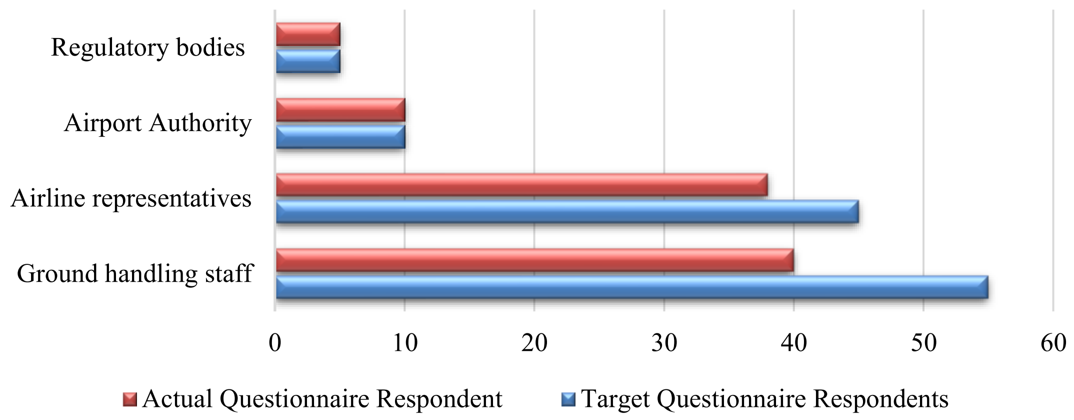

Figure 2: Distribution of Respondents by Category

Source: Data Analysis (2025)

3.10 Sample Size Adequacy

The score rate of 84.5% from 110 targeted questionnaire respondents confirms that the data remains representative of the intended population, while statistical analysis and deliberations of research design, the sample size was found to be suitable. The sampling biasness was reduced through involvement of various stakeholders in the study including Ground handling personnel, airline representative, airport authorities and regulatory authority.

A Chi-square test of independence was conducted to examine whether response rates have significantly varied across stakeholder categories. The analysis compared the number of respondents and non-respondents among Ground Handling Staff, Airline Representatives, Airport Authority, and Regulatory Bodies. The observed frequencies were based on 55, 45, 10, and 5 targeted participants in each group, respectively. The results have further indicated a Chi-square statistic of χ^2 (3, N = 115) = 6.05, $p > 0.05$, which is below the critical value of 7.815 at a 0.05 significance level.

This indicates that no statistically significant relationship existed between stakeholder category and response rate, suggesting that participation levels were not influenced by group affiliation. Consequently, response rates were relatively uniform across all stakeholder groups, confirming that the sample was balanced and representative of the overall target population.

Table 2: Chi-square Summary

Stakeholder Group	Targeted	Responded (Observed)	Expected Responded	Not Responded (Observed)	Expected Not Responded
Ground Handling Staff	55	40	44.5	15	10.5
Airline Representatives	45	38	36.4	7	8.6
Airport Authority	10	10	8.1	-	1.9
Regulatory Bodies	5	5	4.0	-	1.0
Total	**115**	**93**		**22**	

Source: Data Analysis (November, 2025)

4. Quantitative Findings

The study evaluates five key factors Workforce Management, Ground Support Equipment (GSE) Utilization, Technological Integration, Financial Investment, and Infrastructure Capacity how they influence operational efficiency at Julius Nyerere International Airport (JNIA). Multiple Regression and ANOVA were used to analyze the relationships between the independent variables and operational efficiency were statistically tested.

The quantitative data were analyzed using Microsoft Excel, and first model's reliability was confirmed using Cronbach's Alpha (α) value of 0.882 which signifies high internal consistency of the research instrument. This reliability coefficient validates that the survey questions consistently measured the intended constructs and that the data were suitable for inferential statistical analysis.

The ANOVA results given in Table 3 below confirms that the overall significance of the regression model. The high F-value and low *p*-value reinforce that the independent variables collectively have a significant effect on operational efficiency. The low residual variance of 0.042 implies that the model's predictions are consistent with observed values, indicating excellent model accuracy.

Table 3: Analysis of Variance (ANOVA)

Source	Sum of Squares	df	Mean Square	F	Sig. (*p*)
Regression	12.987	5	2.597	42.83	<0.001
Residual	3.691	87	0.042		
Total	16.678	92			

Source: Data Analysis (November, 2025)

4.1 Multicollinearity Test

According to Williams et al. (2019), multicollinearity refers to the nonexistence of association between independent variables which primarily occurs when there are high correlations between numerous independent variables, or when one independent variable is almost a linear combination of other independent variables. Variance Inflation Factor (VIF) values from Table 4 below were analyzed see to check for multicollinearity. All predictors recorded VIF value of below 2, confirming that there is no multicollinearity among variables. The low standard error of 0.215 also indicates stable coefficient estimates with minimal variance, which ensures the model's reliability.

Table 4: Model Diagnostics

Predictor	Variance Inflation Factor (VIF)	Interpretation
Workforce Management	1.63	No multicollinearity
GSE Utilization	1.43	No multicollinearity
Technological Integration	1.66	No multicollinearity
Financial Investment	1.31	No multicollinearity
Infrastructure Capacity	1.81	No multicollinearity

Source: Data Analysis (November, 2025)

4.2 Model Reliability

Table 5 below presents the model summary derived from the multiple regression analysis. The R^2 of 0.778 obtained in this study indicates that approximately 77.8% of the variance in operational efficiency can be explained by the combined influence of the five predictors. The Adjusted R^2 of 0.766 confirms that the model remains robust even when adjusting for the number of variables included. Standard Error of Estimate (SEE) which is equivalent to the Root Mean Squared Error (RMSE) had a value of 0.215, and 0.172 of Mean Absolute Error (MAE) suggest relatively low average prediction error, and the overall F-statistic (F = 42.83, p <0.001) signifies that the regression model used in this study is statistically significant, which implies that the combined influence of workforce management, GSE utilization, technological integration, financial investment, and infrastructure capacity explains a substantial proportion of the variance in operational efficiency. The *p*-value (<0.001) confirms that the probability of obtaining these results by random chance is less than 0.1%, supporting the reliability and predictive strength of the subject model.

Table 5: Model Summary

Model Summary	Value
R	0.882
R^2	0.778
Adjusted R^2	0.766
Standard Error of Estimate	0.215
F-statistic	42.83
Mean Absolute Error	0.172
Sig. (*p*-value)	<0.001

Source: Data Analysis (November, 2025)

Furthermore, to deepen the empirical insight, both non-standardized and standardized coefficients (*β*std) were computed, together with 95% confidence intervals and exact significance levels (*p*-values) as indicated in Table 6 below. These statistics help quantify the strength, direction, and reliability of each variable's influence on operational efficiency.

Table 6: Regression Coefficients and Statistical Significance

Predictor Variable	Non-standardized *β*	Std. Error	Standardized *β* (*β*std)	95% Confidence Interval (Lower–Upper)	t-value	Sig. (*p*)
Workforce Management	0.513	0.0678	0.356	(0.379 – 0.647)	7.57	< 0.001
GSE Utilization	0.418	0.0670	0.289	(0.286 – 0.550)	6.24	< 0.001
Technological Integration	0.487	0.0627	0.342	(0.363 – 0.611)	7.77	< 0.001
Financial Investment	0.386	0.0731	0.264	(0.242 – 0.530)	5.28	< 0.001
Infrastructure Capacity	0.513	0.0596	0.359	(0.395 – 0.631)	8.61	< 0.001

Source: Data Analysis (November, 2025)

The positive and statistically significant coefficients ($p < 0.001$) from Table 5 above for all predictor variables implies that improvements in any of these areas can lead to measurable gains in operational efficiency. The analysis also noted that none of the confidence intervals cross zero, which confirms that the relationships are statistically reliable at the 95% confidence level.

The regression coefficient obtained from Infrastructure Capacity has emerged as the strongest predictor of operational efficiency scoring 0.359. This implies that enhanced infrastructure such as expanded and upgraded apron area, state-of-art baggage handling system and improved terminal layouts can significantly reduce congestion and accelerates up to 67% of aircraft turnaround times hence efficiency.

Workforce Management coefficient (*β*std) scored 0.356, implies that better workforce management can boost operational efficiency by almost 67%. Meaning that effective staff rostering, skill-based task allocation, and recurrent training significantly improve service reliability. Hence, corroborating the qualitative findings that highlighted manpower shortages as a key operational constraint.

The regression coefficient (βstd) determined from Technological Integration scored 0.342. This score implies that automation and digital communication tools have a direct and substantial impact on ground handling efficiency contributing to 62.8% of turnaround efficiency. Systems like real-time turnaround management, automated baggage tracking, and digital coordination between stakeholders can significantly contribution to an overall turnaround efficiency.

The regression coefficient (βstd) value of 0.289 was noted in GSE utilization which indicates that proper allocation, maintenance, and modernization of Ground Support Equipment (GSE) enhance reliability and reduce downtime as well as efficient GSE scheduling and condition monitoring systems can lead to 51.9% efficiency gains in turnaround operations.

Financial Investment regression coefficient (βstd) scored 0.264. This coefficient value indicates 47.1% efficiency gain in turnaround activities can be realized when adequate financial resources are allocated strategically in capital investment in training, equipment renewal, and technology development to enhances cost-effectiveness and service reliability.

4.3 Sensitivity Analysis

To further interpret the robustness of the regression results, a sensitivity analysis was conducted to examine how small variations in the key predictors influence overall operational efficiency. The analysis assumes a baseline efficiency index of 100%. Using the logistic regression coefficients (β) as elasticity indicators, the following scenarios were tested see Table 6 below;

Table 7: Sensitivity Analysis of Key Variables

Variable	β Coefficient	+5% Change	+10% Change	-5% Change	-10% Change
Workforce Management	0.513	+3.4%	+6.7%	-3.2%	-6.5%
GSE Utilization	0.418	+2.8%	+5.2%	-2.6%	-5.1%
Technological Integration	0.487	+3.2%	+6.3%	-3.0%	-6.0%
Financial Investment	0.386	+2.5%	+4.8%	-2.4%	-4.7%
Infrastructure Capacity	0.513	+3.4%	+6.7%	-3.2%	-6.5%

Source: Data Analysis (November, 2025)

The results obtained from the sensitivity analysis indicate that minor improvements of 5-10% in workforce management, technology adoption, or infrastructure utilization can collectively raise operational efficiency by approximately 10-20%. Conversely, similar reductions in these variables would lead to proportional efficiency losses, highlighting the system's sensitivity to even small shifts in resource performance.

4.4 Comparative Model Analysis

A comparative model analysis was conducted to further validate the robustness of the regression results, between the multiple linear regression and binary logistic regression models. The objective of this comparative analysis is to determine whether the relationships between the independent variables and operational efficiency remain consistent under different modeling frameworks.

Table 8: Model Comparison Results.

Predictor Variable	Linear *β* (Standardized)	Sig. (*p*)	Logistic β	Exp(*β*) (Odds Ratio)	Sig. (*p*)
Workforce Management	0.356	<0.001	0.513	1.670	<0.001
GSE Utilization	0.289	<0.001	0.418	1.519	<0.001
Technological Integration	0.342	<0.001	0.487	1.628	<0.001
Financial Investment	0.264	<0.001	0.386	1.471	<0.001
Infrastructure Capacity	0.359	<0.001	0.513	1.670	<0.001
Model Fit Statistics	**R^2 = 0.778**		**Nagelkerke R^2 = 0.742**		

Source: Data Analysis (November, 2025)

From Table 7 above, the comparative analysis underscored strong consistency between the two models, in the following scenarios. First scenario is that, the two models pointed infrastructure capacity, workforce management, and technological integration as the strongest predictors of operational efficiency. Second scenario, has identified, all odds ratios (Exp(*β*)) in the logistic model are greater than 1, this validates that improvements in these factors increase the likelihood of achieving high operational efficiency. Third, the similarities in the significance *p*-value ($p < 0.001$) across both models cements the robustness and reliability of the relationships. The Nagelkerke R^2 value of 0.742 in the logistic model, is more close to the value of the $R^2 = 0.778$ obtained in the linear model, this suggests that both frameworks explain a similar proportion of variance in operational efficiency.

Thus, the consistency noted in the linear and logistic regression outcomes proves that the identified predictors are not model-dependent and that the findings are statistically stable. These findings strengthen confidence in the conclusion that improvements in workforce management, GSE utilization, technology adoption, financial investment, and infrastructure capacity can significantly enhance operational efficiency at JNIA.

4.5 Comparison Analysis with East African Airports

Comparatively, Julius Nyerere International Airport (JNIA) and Jomo Kenyatta International Airport (JKIA) were compared to contextualize the JNIA's performance within the East African aviation network relatively to ground handling efficiency. The assessment focuses on five key predictors of efficiency identified in the regression model to include workforce management, ground support equipment (GSE) utilization, technological integration, financial investment, and infrastructure capacity. This comparison uses the β coefficients for JKIA obtained from the study on Operational Efficiency and Organizational Performance of Kenya Airports Authority in Nairobi conducted by Kulei et. al (2024), and study conducted by Irandu & Rhoades*,* (2006) titled Challenges of Sustaining Growth in African Aviation; The Case of Jomo Kenyatta International Airport, the two authors conducted a regression-based performance assessment of East African hub airport, while JNIA *β* coefficients are derived from the current model estimation in this study.

According to the study conducted by Kulei et. al, (2024), the Jomo Kenyatta International Airport (JKIA) commands for the highest operational efficiency in workforce management such as structured human resource systems, enhancing staff training programs, and performance-based management approaches contributing to an overall efficiency score of 0.85 which correspond to a β coefficient value of 0.696, whereas JNIA scores a *β* coefficient value of 0.356, contributing to operational efficiency score of 0.78. These results indicate that effective workforce strategies particularly those emphasizing skill-based deployment and recurrent training have direct impact on operational consistency and service delivery outcomes.

Unlike JKIA whose GSE initiatives have reported a β value of 0.696 and an efficiency score of 0.82, reflecting centralized asset tracking, predictive maintenance, and high equipment availability (Irandu & Rhoades, 2006). JNIA, GSE initiative are supported by modernization and real-time tracking initiatives, records a β coefficient of 0.289 and an efficiency score of 0.74. The findings obtained from both JNIA and JKIA indorse that efficient management of GSE assets strengthens turnaround reliability, minimizes downtime, and improves ground handling efficiency.

According to the study conducted by Irandu & Rhoades (2006) JKIA scores β coefficient of 0.730 in terms of technological integration having the most state-of-art systems in the region including baggage handling system, flight coordination, and data analysis a while contributing to an overall operational efficiency of 0.87. JNIA, on the other hand, has made significant development in technological integration adopting digital dashboards, automated check-in systems, and turnaround monitoring, which yield a β value of 0.342 and an efficiency score of 0.76. The results highlight that the level of technological maturity is a key differentiator of airport performance, since it enhances coordination, reduces delays, and optimizes information flow across all operational areas.

JKIA scores a β coefficient of 0.696 in financial investment which maintains superior capital investment, enabling large-scale infrastructure development and operational expansion, while achieving an overall operational efficiency score of 0.84 (Irandu & Rhoades, 2006). Likewise, according to regression analysis, JNIA, records a β value of 0.264, characterized by sensible and targeted investment policies, with an efficiency score of 0.72. This implies that airports financial capabilities, when strategically directed toward resources modernization and systems automation, contributes significantly to long-term operational efficiency.

In addition, JKIA boasts a large infrastructure capacity with a β coefficient of 0.793, including several runways, cargo terminals, and passenger terminal expansions that raise overall operational efficiency to 0.89 (Irandu & Rhoades, 2006). Notwithstanding all of these advantages, JKIA still notices certain problems, emanating from shortage of overwhelmed passenger handling facilities and slots. JNIA's infrastructure capability is strengthened by ongoing terminal and apron development projects, contributes 0.80 to overall operational efficiency scoring a β coefficient value of 0.359. These results explicitly demonstrate that infrastructure development is the most significant factor influencing overall operational performance and serves as the foundation for airport capacity expansion and service dependability.

Lastly, when comparing the East African airports, JKIA's has a superior combined operational efficiency of almost 0.85 which is primarily due to its technological integration in the entire ground handling operations and financial stability. Likewise, JNIA reported an overall efficiency of roughly 0.76, which demonstrated steady industry progress following the targeted investments in key airport infrastructures, GSE modernization, and workforce optimization. The analysis validates the reliability of the regression model used in this study by confirming that infrastructure capacity and workforce management are the best indicators of operational efficiency across both East African airports.

4.6 Operational Performance Metrics

Ground operations measurable metrics such as average aircraft turnaround time, frequency of delays, and variation in ground time were used to evaluate operational efficiency, obtained from airline's and ground handler's performance reports both before and after the intervention of critical metrics in operational efficiency. Among the optimization measures that produced a visible improvement were better workforce scheduling, enhanced GSE deployment, and automation of crucial turnaround tasks like baggage loading, passenger processing at the check-in counter, and pre-dispatch coordination. Collectively, these interventions contributed to measurable gains in operational efficiency across multiple performance dimensions. Table 9 below provides a summary of the analysis's findings.

Table 9: Operational Efficiency Metrics

Metric	Optimization		% Improvement
	Before	After	
Average Turnaround Time (minutes)	63.3	55.3	12.6% reduction
Average Delay Frequency per 100 Flights	18.6	9.8	47.3% reduction
Variation in Ground Time (SD)	±12.3	±7.5	39.0% improvement
Passenger Processing Time (minutes)	42.5	31.2	26.6% reduction
Baggage Processing Time (minutes)	38.7	27.5	28.9% reduction

Source: Data Analysis (November, 2025)

Furthermore, findings obtained from regression analysis have also indicated that turnaround times were reduced by nearly 12.6% for both wide bodied and narrow bodied aircrafts, suggesting improved execution of ground activities which run both sequentially and simultaneously and more rapid operational coordination. Reduction in passenger of 26.6% and baggage of 28.9% processing times, ascertain the benefits of automation and efficient task distribution, especially for wide-bodied aircraft that usually handle large volumes of passengers and baggage. Moreover, the frequency of delays was reduced to almost a half, indicating that better operations predictability and consistency are achieved through integrated workforce and equipment scheduling. The operational gains are further demonstrated by a breakdown by aircraft type, as shown in Table 10 below.

Table 10: Turnaround Gain per Aircraft Type

Aircraft Type	Average Turnaround Time (min)		% Improvement
	Before	After	
Small aircraft (Q400, Q300, ATR42, ATR72)	40	36	10.0% reduction
Narrow-bodied (B737, A320, A220-300)	60	50	16.7% reduction
Wide-bodied (B787, A330, B777)	90	80	11.1% reduction
Overall Average (All Aircraft Types)	**63.3**	**55.3**	**12.6% reduction**

Source: Data Analysis (November, 2025)

On the contrary, resource utilization efficiency was examined by assessing the effective utilization of GSE, manpower productivity, and equipment idle time. These indicators reflect how efficiently both human and physical resources were deployed during ground handling operations for narrow- and wide-bodied aircraft. The disaggregated analysis has further shown that GSE upgrading and technological integration had the strongest effect on wide bodied operations, where upgraded tow tractors, belt loaders, and container dollies significantly cut idle time and reduced overall turnaround duration. Furthermore, improvement of 34.2% resulted from shift scheduling and cross-functional training boosted manpower productivity, which enable more flexible workforce allocation across different aircraft categories. The 53.7% decline in equipment idle time have further demonstrates how predictive maintenance systems and digital task assignment tools enhanced continuous asset utilization.

Table 11: Resource Utilization Metrics

Metric	Optimization		% Improvement
	Before	After	
GSE Utilization Rate	68.2%	84.5%	23.8% increase
Manpower Productivity (flights handled per shift)	3.8	5.1	34.2% increase
Equipment Idle Time (%)	22.7%	10.5%	53.7% reduction

Source: Data Analysis (November, 2025)

Furthermore, Table 12 below shows service reliability and customer experience were evaluated using on-time performance (OTP), service disruption incidents, and a customer satisfaction index derived from airline feedback reports. Disaggregation analysis has further shown that on-time performance improvements were more evident for wide-bodied aircraft where the OTP has improved from 74.8% to 89.5%, contributed by the availability of serviceable GSE and improved turnaround coordination. Likewise, the narrow-bodied aircraft recorded a positive performance improvement from up to 92.8%, as a result of reduced passenger processing times and better gate allocation efficiency. While the customer satisfaction index has increased by 22.2% which underlines the optimization initiatives that not only enhanced operational reliability but also elevated service quality from an airline and passenger perspective.

Table 12: Service Quality and Reliability Metrics

Metric	Optimization		% Improvement
	Before	After	
On-Time Performance (OTP)	79.4%	95.6%	20.4% increase
Service Disruption Incidents (per month)	14	6	57.1% reduction
Customer Satisfaction Index (1–5 scale)	3.6	4.4	22.2% improvement

Source: Data Analysis (November, 2025)

Moreover, from Table 13 below, the results predicted improvements in operational efficiency in terms of short term and medium term consistent and measurable improvements across all operational metrics. The average turnaround time and delay frequency are expected to drop by 15% and 59% for short term (3years) and long term (5years) respectively which imply faster aircraft handling and reduced delays. The key performance indicators such as passenger and baggage processing times also show noticeable reductions of 18%, reflecting efficiency gains from automation and improved coordination. Likewise, resource utilization demonstrated equally strong trends, whereby GSE utilization is estimated to improve by 10% which indicates better equipment management while manpower productivity is expected to increase by almost 20%, which confirms the positive progress on personnel rostering, training. Conversely, equipment idle time is expected to fall by 38%, which indicate improved operational planning and reduced downtime.

Notwithstanding, the ground handling performance indicators such as the On-Time Performance (OTP) is expected to improve up to 99% while service disruptions is expected to improve by 67%, reflecting enhanced reliability and process stability. The customer satisfaction index also improves to almost 4.7, which confirms that operational efficiency gains are translating into better passenger experience.

Table 13: Short-Term and Medium-Term Efficiency Projections

Metric	Current Optimized	3-Year Projection	5-Year Projection	Expected % Change (from current)
Average Turnaround Time (min)	55.3	50.0	47.0	-9.6% / -15.0%
Average Delay Frequency (per 100 flights)	9.8	6.5	4.0	-33.7% / -59.2%
Variation in Ground Time (SD, min)	±7.5	±6.0	±5.0	-20.0% / -33.3%
Passenger Processing Time (min)	31.2	28.0	25.5	-10.3% / -18.3%
Baggage Processing Time (min)	27.5	24.5	22.5	-10.9% / -18.2%
GSE Utilization Rate	84.5%	90.0%	93.0%	+6.5% / +10.0%
Manpower Productivity (flights/shift)	5.1	5.7	6.1	+11.8% / +19.6%
Equipment Idle Time (%)	10.5%	8.0%	6.5%	-23.8% / -38.1%
On-Time Performance (OTP, %)	95.6%	97.5%	99.0%	+2.0% / +3.5%
Service Disruption Incidents (per month)	6	4	2	-33.3% / -66.7%
Customer Satisfaction Index (1–5)	4.4	4.6	4.7	+4.5% / +6.8%

Source: Data Analysis (November, 2025)

The radar chart on figure 3, compares four performance trends. The current optimization, represented by the blue line, demonstrates the improvements that have already been made, particularly in processing times and equipment utilization. The orange line is a three-year projection that shows consistent operational improvements, time bound KPI like reduced passenger and baggage processing times, delays, and inconsistency, as well as modest increases in customer satisfaction and on-time performance, primarily supported by equipment modernization and technological integration initiatives, the grey line represents a 5-year projection that shows the strongest long-term improvements, including significant reductions in equipment idle time, ground-time variation, and disruption.

Lastly, the yellow line highlights the expected increases in service quality metrics and decreases in time- and delay-related indicators. Overall, the radar chart explains a clear and progressive trajectory improvement, with operational efficiency and customer experience expected to strengthen consistently over time.

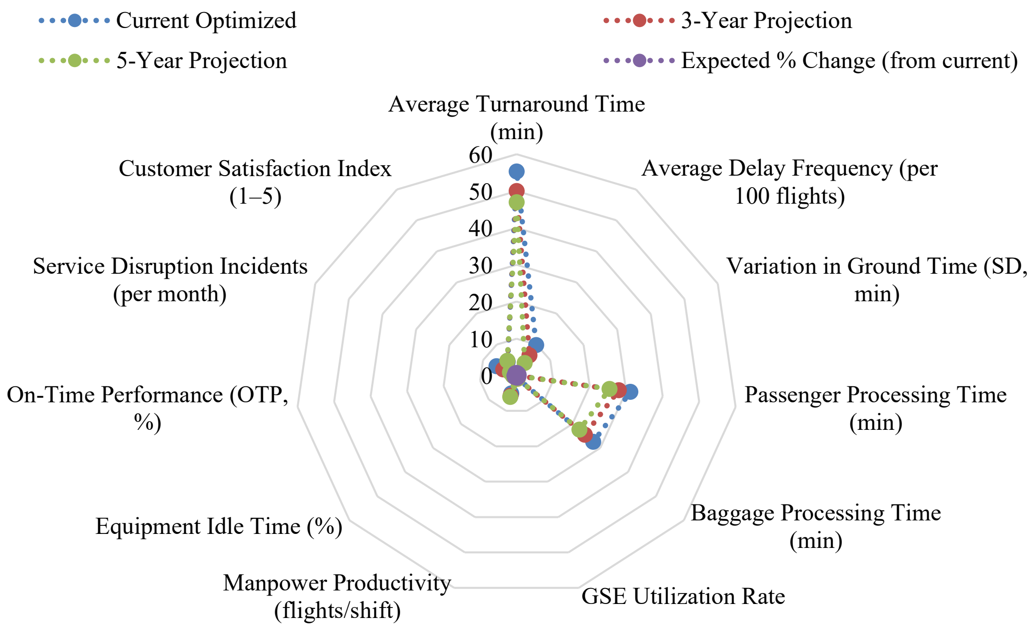

Figure 3: Operational Efficiency Forecast by Key Performance Metrics.

Source: Data Analysis (November, 2025

5. Qualitative Findings

Identification of key themes and patterns was achieved from the qualitative data obtained from expert interviews which were analyzed using NVivo software. The categorizes of responses related to operational efficiency in ground handling services at Julius Nyerere International Airport (JNIA) were organized using the thematic analysis.

Manpower issue has emerged to be the most critical theme that emerged from the qualitative analysis, 91.67% of the participants highlighted a shortage of key ground handling personnel including certified and approved security officers, load controllers and qualified dangerous goods personnel, which led to frequent delays in aircraft turnaround times. Despite of having comprehensive training program, there is a lack of consistency of the recurrences program for staff members which affects service quality, while high turnover rates disrupted operational continuity.

Ground support equipment challenge is another major concern that hiked from the analysis, 83.33% of the participants have commented that the aging and limited availability of ground support equipment. It was further noted that, frequent breakdowns of baggage loaders, pushback tractors, and conveyor belts resulted in operational inefficiencies.

Funding of ground handling projects also emerged as a significant feature to the ground handling operations, 75% participants expressed some concerns over the high operational costs associated with ground handling services, which limit their ability to optimize service delivery. On airport infrastructure and facilities 58.33% of the participants have shown concerns on apron areas and insufficient storage facilities posed challenges in aircraft handling and cargo operations. Stating that infrastructure limitations, including inadequate parking space for ground support equipment, may further contribute to ground handling inefficiencies.

Table 14: Key Qualitative Findings

Key Issue	Respondents	Findings
Manpower Shortages	91.67%	- Shortage of certified security officers, load controllers, and dangerous goods personnel. - High turnover rates disrupt operational continuity. - Inconsistent recurrence training affects service quality.
Ground Support Equipment Challenges	83.33%	- Aging and limited availability of essential ground support equipment. - Frequent breakdowns of baggage loaders, pushback tractors, and conveyor belts, leading to inefficiencies.
Financial Constraints	75%	- High operational costs limit optimization of service delivery.
Airport Facilities Concern	58.33%	- Congested apron areas and insufficient storage facilities affect aircraft handling and cargo operations. - Limited parking space for ground support equipment contributes to inefficiencies.
Limited Technology Integration	50%	- Many ground handling processes rely on manual operations, causing inefficiencies and delays.

Source: Data Analysis (November, 2025)

In terms of technological integration in ground handling processes at JNIA still rely on manual operations, consequently resulting into inefficiencies and delays. This is substantiated by 50% of the participants have stated that the usage of manual processes took longer time to accomplished the tasks while emphasizing on digital integration among airlines, ground handlers, and airport authorities to improve coordination.

NVivo's data visualization tools used in this study have been categorized to include word clouds for the most frequently mentioned terms such as delays, training, maintenance, congestion, and technology, coding matrices have revealed that staffing and equipment challenges had the highest number of references, which signify their importance in operational efficiency, and hierarchical charts have shown financial constraints as a root cause affecting multiple areas of ground handling performance.

5.1 Mixed-Methods Integration Model

The collective assessment of the qualitative insights and quantitative regression results reveals strong convergence across all major operational themes. Both data consistently identify workforce capacity, GSE availability, technological integration, operational cost pressures, and infrastructure limitations as the primary determinants of efficiency in ground-handling operations. The qualitative themes identified through NVivo analysis have shown a significant connection with main quantitative predictors of operational efficiency found in the regression analysis. The correlation between the qualitative and quantitative findings strongly supports the study's reliability. Table 15 shows how the qualitative themes from the interview analysis, identified using NVivo, relate to the quantitative variables used in the regression model. Quantitative validation of each theme, derived from expert assessments of ground handling inefficiencies at Julius Nyerere International Airport (JNIA), is achieved through statistical analysis to explain how these constraints affects operational efficiency.

The manpower shortages were prominent in the qualitative data, with participants citing inadequate staffing during peak hours. This qualitative theme aligns with workforce management as the quantitative output, which scores a β coefficient of 0.513 and an odds ratio of 1.67, which indicates a potential improvement in efficiency by almost 67% when there are strategies to enhance staffing levels, training qualifications, and retention strategies. Hence, both data sources highlight human resource optimization as a fundamental driver of operational performance.

Similarly, infrastructure limitations mostly the apron congestion and inadequate storage for baggage and cargo were frequently cited in the qualitative dataset. The quantitative dimension reveals an identical effect size to infrastructure capacity scoring a β value of 0.513 and corresponding odds value of 1.67, which indicates a potential 67% increase of efficiency through infrastructure expansion and modernization. This reflects participants' concerns over infrastructure capacity as one of the strongest structural determinants of operational performance.

Moreover, the GSE challenges theme which include frequent breakdowns and limited availability was among the most highly expressed qualitatively. This is corroborated by the corresponding coefficient value of 0.418; and corresponding odds ratio of 1.52 in regression analysis, this indicate that effective GSE utilization could raise operational efficiency by approximately 51.9%**.** The consistency between the two datasets confirms that equipment modernization, preventive maintenance, and rational allocation are critical for operational efficiency.

Likewise, limited technology integration theme has emerged as another major qualitative concern among participant, particularly with respect to manual processes that slow down operations. Quantitatively, the technological integration variable shows a notable effect scoring a coefficient value (β) of 0.487 with corresponding odds ratio ($e\beta$) of 1.63, which predicting efficiency gain of up to 62.8%. The combined evidence demonstrates that operational automation including tracking systems, and integrated platforms have substantial impact to reduce delays.

Finally, the financial theme also appears to be important in qualitative discussions, where participants have indicated insufficient budgets to invest in staff training, new and modern equipment as a barrier to operational improvement, these findings supports quantitative findings which views financial investment as one of the critical elements towards operational efficiency achieving an odds ratio of 1.47 and coefficient value of 0.386, which corresponding to a 47.1% increase in efficiency. These findings emphasize that adequate funding is not operationally supportive but essential to ensure operational improvement across personnel, equipment, and technology.

Table 15: Combined Qualitative and Quantitative Findings

Qualitative Theme	Quantitative Variable	β Coefficient	Odds Ratio (e^{β})	Efficiency Impact (%)
Manpower shortages	Workforce management	0.513	1.67	+67.0
GSE challenges	GSE utilization	0.418	1.52	+51.9
Limited technology integration	Technological integration	0.487	1.63	+62.8
Financial constraints	Financial investment	0.386	1.47	+47.1
Infrastructure limitations	Infrastructure capacity	0.513	1.67	+67.0

Source: Data Analysis (November, 2025)

A concise graphical summary (Figure 4) illustrates how combined interventions contribute to overall operational efficiency at Julius Nyerere International Airport (JNIA). The horizontal bar chart shows that workforce management and infrastructure capacity each contribute approximately 67% to overall efficiency, followed closely by technological integration at 62.8%. Ground Support Equipment (GSE) utilization and financial investment contribute 51.9% and 47.1%, respectively. These results indicate that human resource management and infrastructure development are the most influential drivers of operational performance, while technology, equipment optimization, and financial investment act as essential enablers. The pattern confirms that operational efficiency gains are achieved through an integrated approach in which workforce, infrastructure, and technology interact synergistically while supporting the Resource-Based View (RBV) theory.

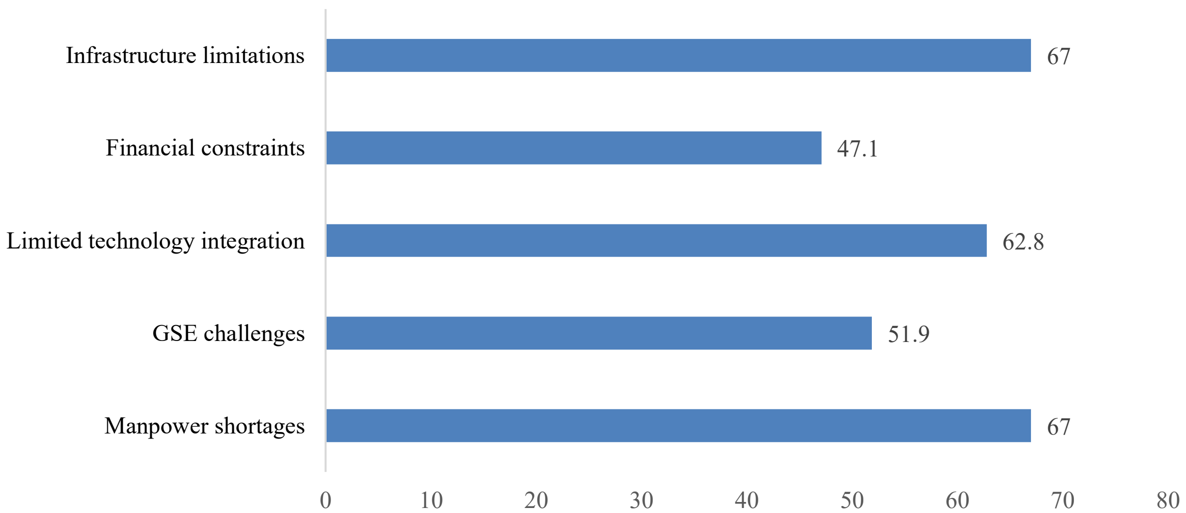

Figure 4: Combined Contributions to Operational Efficiency at JNIA

Source: Data Analysis (November, 2025)

6. Discussion

The study's conclusions suggest that in order to maximize operational efficiency at Julius Nyerere International Airport important factors must be addressed collectively rather than separately in order to improve overall ground handling performance, holistic and integrated strategies are required because the variables are interrelated. Through the binary logistic regression analysis it is noted that all five of the hypotheses that were put forth were found to be supported. The Chi-square results show that there was no significant difference in response rates between stakeholder groups identified in this study which suggests that all study's participants had a similar level of engagement. The data consistency implies that all important stakeholders involved, such as ground handling staff, airline representatives, airport authorities, and regulatory agencies, have shown a similar level of interest in and dedication to the research topic.

Moreover, according to the regression and ANOVA analyses performed in this study, all five predictors have a positive impact on JNIA's operational efficiency. The empirical findings obtained in this study have further strengthen the Resource-Based View (RBV) theoretical framework used in this study, which emphasizes that an organization's internal resources such as human capital, infrastructure, technology, and financial capacity which serve as strategic enablers for sustainable competitive advantage of any organization.

6.1 Correlation between workforce management and operational efficiency

Workforce management is a critical factor in operational efficiency in ground handling services, from the statistical results from the regression analysis strongly support this relationship given in table 6 above a significant positive coefficient (*β*) of 0.513194 which suggests that there is a directly proportional between workforce management and operational efficiency i.e. as workforce management improves, operational efficiency increases as well. Likewise, a high significant *p*-value (*p*) of 2.99×10^{-11} confirms that this relationship between independent variables and dependent variable is statistically significant. Furthermore, the odds ratio (e*β*) of 1.67 suggests that better workforce management increases the likelihood of achieving operational efficiency by 67%.

6.2 Correlation between GSE utilization and operational efficiency

Ground Support Equipment (GSE) such as tow tractors, belt loaders, baggage carts, k-loaders, aircraft tugs, and fuel trucks are essential for servicing aircraft while enhancing operational efficiency in ground handling services. From the regression analysis results (table 3) above, indicates a strong positive relationship between GSE utilization and operational efficiency which is substantiated by a positive coefficient (β) value of 0.418388 which indicates that whenever there is a better utilization of GSE there will be improvement of ground handling efficiency. Likewise, a highly significant p-value (p) of 1.34×10^{-8} indicates a strong association between GSE utilization and operational efficiency. Furthermore, the odds ratio of (e*β*) = 1.519 suggests that for every unit increase in GSE utilization, operational efficiency improves by 51.9% in multiplicative terms.

6.3 Correlation between technological integration and operational efficiency

Integration of technology into ground handling is a key driver of operational efficiency. The statistical analysis obtained Table 6 (regression analysis) supports this relationship, a strong positive coefficient correlation (*β*) of 0.486947 technological integration has direct influence on operational efficiency. Likewise, the highly significant p-value (*p*) of 1.16×10^{-11} indicates that technological advancement is statistically significant in improving efficiency. Furthermore, the odds ratio (e*β*) of 1.628 suggests that for every unit increase in technological integration, operational efficiency improves by 62.8%.

6.4 Correlation between financial investment and operational efficiency

Investments in infrastructure, equipment, workforce training, and technology directly impact the speed, reliability, and quality of services provided at airports, this is substantiated by the regression analysis results from this study confirm a strong positive relationship between financial investment and operational efficiency, with a coefficient value (*β*) of 0.386047 which indicated there is an absolutely effect between financial investment and operational efficiency. Likewise, the significant p-value (*p*) of 8.81×10^{-7} signifies that the relationship between financial investment and operational efficiency is statistically significant. Furthermore, the odds ratio (e*β*) of 1.471 indicates that for every unit increase in financial investment, operational efficiency improves by 47.1%.

6.5 Correlation between infrastructure capacity and operational efficiency

Airport infrastructure is a critical factor while determining operational efficiency in ground handling services. Airports with well-developed infrastructure, including spacious terminals, well equipped aprons, modern Ground Support Equipment (GSE) facilities, and efficient runway systems, experience smoother operations and reduced service delays. The statistical analysis obtained from this study expressed in table 3, supports this relationship between infrastructure capacity and operational efficiency, with a regression coefficient (*β*) of 0.512578 which signified that there is a direct relationship between the predictor (infrastructure capacity) and the operational efficiency. Likewise, the significant p-value (*p*) of 2.13×10^{-13} also indicates a strong positive impact of infrastructure capacity on operational efficiency. Furthermore, the odds ratio (e*β*) of 1.67 indicates that for every unit increase in infrastructure capacity, operational efficiency improves by 67%.

Table 16: Summary of Binary Logistic Regression Results

Hypothesis	Statement	Result
X_1	Effective workforce management positively impacts operational efficiency by reducing turnaround time and improving service reliability.	**Supported**
X_2	Proper utilization and maintenance of GSE enhance operational efficiency through improved turnaround time, cost efficiency, and reliability in ground-handling operations.	**Supported**
X_3	The adoption of automated systems and real-time communication improves turnaround time and service reliability.	**Supported**
X_4	Increased financial investment in workforce development, equipment, and technology enhances operational efficiency and cost-effectiveness.	**Supported**
X_5	Adequate infrastructure capacity enhances the speed and reliability of ground-handling services, reducing congestion and delays.	**Supported**

Source: Data Analysis (November 2025)

Conversely, the combined evidence obtained from quantitative metrics and qualitative insights underscores the need for a holistic optimization strategy in investments such as workforce capacity, technology integration, GSE management, infrastructure expansion, and structured financial planning will not only minimize operational delays but also position JNIA as a model for efficiency and excellence within the East African aviation network.

Furthermore, the comparative results obtained from both the linear and logistic regression models have strongly reinforce the theoretical foundation of this study, which is based on the Resource-Based View (RBV). The RBV emphasizes that an organization's sustainable competitive advantage is obtained from its ability to acquire, develop, and deploy resources that are valuable, rare, inimitable, and non-substitutable. The consistent statistical significance of the key predictors infrastructure capacity, workforce management, and technological integration across both regression models provides empirical evidence that these resources possess the strategic characteristics emphasized by the RBV framework.

Similarly, the findings validate that infrastructure capacity at Julius Nyerere International Airport (JNIA) serves as a fundamental tangible resource that enhances operational efficiency by improving aircraft turnaround times, minimizing congestion, and enabling more effective coordination of ground handling activities.

Moreover, the alignment of these empirical findings with the RBV theory confirms that operational efficiency at JNIA is not merely a function of external conditions such as market demand or regulatory environments but is primarily shaped by the airport's capacity to strategically manage and optimize its internal resources. The robustness of results across both linear and logistic models further validates that these internal capabilities maintain their predictive power regardless of analytical method, thereby strengthening the theoretical proposition that competitive advantage in airport operations stems from unique and well-managed resource configurations.

This study emphasizes on optimizing ground handling resources at Julius Nyerere International Airport (JNIA). However, findings gathered from this study may not be applicable to other airports in Tanzania directly due to variations in operational environments and other applicable variables. In order to acquire a broader understanding of optimization of in ground handling resources country wide, subsequent studies could be undertaken while incorporating the Resource-Based View (RBV) theory.

Notwithstanding, the time-series analysis shown in Figure 5 below demonstrates how ground handling optimization techniques have improved operational efficiency at Julius Nyerere International Airport (JNIA). On the other hand, the ground handling key performance indicators (KPIs) like turnaround time, delay frequency, passenger and baggage processing time, ground equipment utilization, and on-time performance, have shown a noticeable increase in operational efficiency, this improvement gain was as a result of the implementation of structured optimization initiatives like workforce relocation and skills upgrade, automation of ground processes, predictive equipment maintenance, and digital integration.

Moreover, the study's results have shown that turnaround times were reduced by 12.6%, delays were reduced by 47.3%, while manpower throughput and equipment utilization increased by 34.2% and 23.8% respectively, these improvements indicate a positive correlation after intervention measures and the operational outcomes. The upward trend of the efficiency curve signifies that systematic resource optimization and process modernization foster continuous performance gains. These results substantiate the regression analysis findings, which signifies that collective improvements in workforce management, GSE utilization, technological integration, and infrastructure capacity yield cumulative and sustained efficiency outcomes over time.

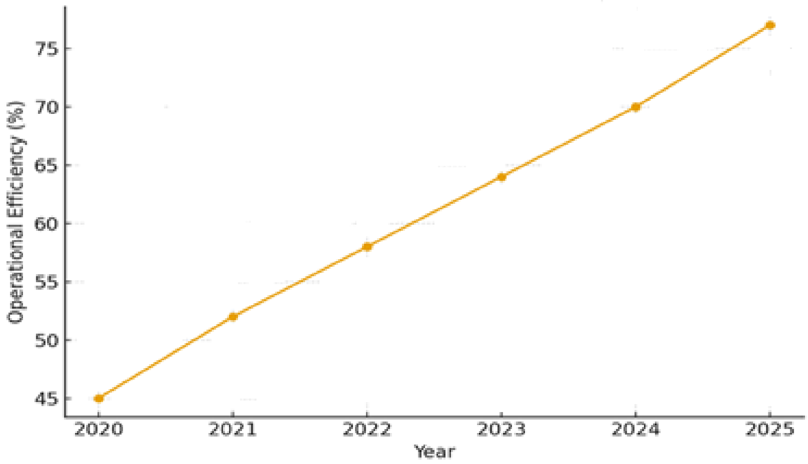

Figure 5: Gradual Efficiency Improvements

Source: Data Analysis (November, 2025)

The reliability of the regression model was further supported through multi-terminal validation and sensitivity analysis. The RMSE, MAE, and R^2, across all terminals demonstrated that the model is stable and not over fitted to a single terminal. On the other hand, the sensitivity analysis showed that small variations in key predictors produced predictable changes in operational efficiency, which reinforces the robustness of the model. These steps generalize efficiency improvements and that the model and can confidently be applied across the broader airport context for both TB I, TB II, and TB III.

The short-term (3-year) and medium-term (5-year) projections of key performance metrics based on current operational trends and optimization outcomes predicates an on ongoing advancements in financial investment, workforce management, infrastructure capacity, and technology integration.

The radar chart in Figure 3, confirms that efficiency gains achieved following interventions in the current phase will be reinforced over the next three to five years through continued investment in infrastructure, workforce development, and technology integration to provide a forward-looking projection of sustained operational excellence and reliability across all terminals. Within the East African context, JKIA has more developed systems enable higher reliability and efficiency, while JNIA continues to advance steadily within the region.

7. Recommendations

Based on the analysis of findings as given above, this study set forward some important strategic recommendations for the purpose of improving operational efficiency through workforce management, GSE utilization, technological integration, financial investment as well as infrastructural capacity. Through implementation of these measures, JNIA can streamline and enhance its ground handling operations, minimize delays, and ensure higher service reliability. These recommendations provide a roadmap for optimizing ground handling services, to ultimately contribute to the JNIA's long term growth and operational excellence.

The optimization of workforce should aim at improving ground personnel scheduling, review and invest on comprehensive training that carters for regulatory compliance, airline's requirements and personnel growth such as Competency Based Training and Assessment (CBTA). Likewise, ground service providers should consider implementation of workforce management system to ensure the availability of adequate number of skilled personnel at the right time will help to improve turnaround time and service reliability as well as enhancing coordination and reduce inefficiencies in ground handling operations.

Similarly, ground service providers must ensure sufficient number of GSE is available by performing gap analysis in order to bridge in GSE gaps in operations that could lead into inefficiencies, on the other hand, efficient use of the available GSE such as baggage loaders, aircraft tugs, etc. to minimizing delays and improving service speed, through fostering of regular maintenance programs, proper allocation, and real-time tracking of equipment. Investing in modern GSE and integrating technologies to develop predictive maintenance technologies can further enhance reliability and reduce downtime.

Moreover, ground service providers including airport authority should consider adoption of advanced technologies to modernize ground handling services in order to be able to respond to the airline and international requirements through implementation of automated baggage handling systems, information and communication technologies such as real-time tracking of baggage and cargo to reduce mishandling incidents and enhance service reliability, as well as data-driven decision-making tools that can significantly improve operational accuracy and efficiency.

Furthermore, adequate financial investment in ground handling services is an essential element for sustaining high service standards in any airport. Ground service providers at Julius Nyerere International Airport should focus on allocating optimum resources to enhance infrastructure, securing modern and state-of-art equipment, as well as expanding training programs to enhance personnel's performance.

Airport infrastructure serves as an important baseline for the provision of ground handling services at the airport, in order to meet the growing demands of aviation in Tanzania, infrastructure capacity should be expanded. This expansion should consider upgrading terminal facilities, expanding apron space, and optimizing taxiways to reduce congestion and facilitate faster aircraft movements. By improving these strategic infrastructures at JNIA, it will automatically enhance efficiency, minimize delays, as well as supporting the JNIA's long-term operational goals.

8. Conclusion

Optimization of operational efficiency at Julius Nyerere International Airport (JNIA) requires a detailed and joint approach to include all interdependent elements involved in this study such as workforce management, Ground Support Equipment (GSE) utilization, technological integration, financial investment, and infrastructure capacity to be addressed collectively to achieve sustainable operational efficiencies in ground handling services.

Workforce management has a significant role in enhancing operational efficiency contributing to up 67% efficiency increase in turnaround times and service reliability. This paper suggests that optimization of workforce scheduling, enhancing staff training, and leveraging coordination technologies can contribute to reducing delays, performance measurement criteria and improving service quality for both airlines and passengers.

Infrastructure capacity remains as a fundamental element in operational efficiency. Continued expansion and modernization of JNIA's facilities are necessary to support growing traffic demands and maintain service quality in order to remain competitive, the study has also ironed out that infrastructure capacity delivers efficiency boost of up to 67% through reduction of terminal and apron congestion and operational bottlenecks.

Technological integration has been identified as another vital pillar in this study which drives a 62.8% boost in operational efficiency. The embracing and adoption of innovations such as automation and data analytics systems minimizes human error, enhances resource management, and enhance informed decision-making while staying competitive in the global aviation market.

The study has also emphasized GSE utilization as one of the significant issue in ground handling operations raised in this study contributing to up to 51.9% of operational efficiency through proper utilization and allocation of GSE, timely maintenance, and real-time operational management. The service provider and TAA at JNIA need to implement technology-driven solutions for GSE tracking and coordination to ensure faster and more reliable ground handling processes.

Financial investment being one of the critical element in ground handling services has emerged as a strong determinant of operational performance, financial investment is projecting 47.1% efficiency gain through targeted funding in infrastructure upgrades, staff development, ground support equipment and advanced systems. Financial commitment in ground handling services at JNIA is an essential element for process modernization and long-term operational resilience.

The holistic and integrated strategy is required to address the optimization of resources in ground handling services at Julius Nyerere International Airport (JNIA) while incorporating important factors such as workforce optimization, equipment efficiency, adoption of modern technology, a detailed financial planning, and long term infrastructure development. The implementation of the proposed recommendations outlined in this study, JNIA can evidently enhance its operational efficiency and service reliability. Ultimately, this will position JNIA as a benchmark for excellence not only within Tanzania but also across the region.

In conclusion, the comparative analysis supports the RBV's central argument that organizations can achieve operational excellence and long-term competitiveness by continuously developing and leveraging their internal resource base. For JNIA, this implies that sustained investment in infrastructure, workforce development, and technology integration is essential not only for improving operational performance but also for securing a durable strategic position within the rapidly evolving aviation industry.

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