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Performance Comparison of the Railway Stations: A Case of North-South of the Addis Ababa Light Rail Transit, Addis Ababa, Ethiopia

Habeeb Solihu[1,2*], Jackson Sekasi[1], Pradip Kumar Ray[3]

[1]Railway Engineering Civil Infrastructure Department, Addis Ababa Institute of Technology, Addis Ababa University, Ethiopia

[2]Department of Civil Engineering, Faculty of Engineering and Technology, Kwara State University, Malete, P.M.B. 1530, Malete, Kwara State, Nigeria

[3]Department of Industrial Engineering and Management, Indian Institute of Technology, Kharagpur, India

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Aside from providing services and infrastructure for the mobility of people and goods, sustainable transport is a cross-cutting accelerator that can fast-track progress towards other crucial goals such as SDGs 1, 4, 5, and 13; as such, it is imperative in achieving the 2030 Agenda for Sustainable Development. This, therefore, serves as the impetus for this study. This study administered about two hundred and forty (240) questionnaires to railway transportation passengers and was analyzed to compare the performance of the Railway Stations along the North-South Axis of the Addis Ababa Light Rail Transit (AA-LRT). Six (6) out of seventeen (17) stations along this axis were considered for this study, not only because they comprise terminal stations but also, because they are situated in highly populated areas with high demand potential. The stations were categorized and the comparison was based on the passengers' perspectives on the selected performance indicators. Also, because the data are dichotomous, Binary Logistic Regression Model was used to model a relationship equation between the dependent variable (level of performance) and the performance indicators (predictors). The selected stations were ranked according to their performances while conclusions and recommendations were suggested to further enhance their performance for customers' satisfaction. Finally, adopting the methodology in this study for investigating the performance of railway stations elsewhere in the world is recommended.

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1. Introduction

Transport's role in sustainable development was first recognized at the 1992 United Nations' Earth Summit and reinforced in its outcome document – Agenda 21. The necessity for increased use of more efficient transport infrastructure is of interest to researchers in the areas of road transport informatics to ameliorate traffic congestion [1]. And in the Agenda 2030 Agenda for Sustainable Development, sustainable transport is mainstreamed across several SDGs and targets, particularly those related to SDGs 2, 3, 7, 8, 9, and 11. Thus, in developed nations, more attention is being directed toward the sustainability of current and

*Corresponding author
Email address: solihu.habeeb@aait.edu.et

emerging transportation patterns and land use [2].

Generally, the world's population increases with its resources unchanged [3], thus, cities around the world are in the race to achieve better and more equitable access to important destinations and services, by reducing energy consumption and mobility's environmental impacts [4]. This creates a necessity to address the sustainability of transportation systems [3]. Again, sustainable transportation is a popular concept with great influence on political decisions [5]. A sustainable transportation system is, therefore, defined as one in which fuel and its environmental impacts, congestion, safety, and socioeconomic access are of levels that can be sustained into the indefinite future without significant harm to future generations of people worldwide [3].

Again, sustainable transport and mobility are fundamental to progress in realizing the promise of the 2030 Agenda for Sustainable Development and in achieving the 17 Sustainable Development Goals (SDGs) [6]. However, according to Yoram et at., [7], identifying policies that will result in a sustainable transportation system is a major challenge for policymakers since it involves a high level of uncertainty in terms of the future effect of a given policy package on the urban environment and transportation system [7]. Aside from providing services and infrastructure for the mobility of people and goods, sustainable transport is a cross-cutting accelerator that can fast-track progress towards other crucial goals such as SDGs 1, 4, 5, and 13; as such, it is imperative in achieving the 2030 Agenda for Sustainable Development [8].

The AALRT system was constructed to resolve the existing transport challenge while at the same time integrating with other transport modes in Addis Ababa [9]. Given the fact that urban public transport plays a key role in making cities sustainable [10] & [11], several attempts at measuring performance have been particularly initiated in Europe [12], for the last thirty years to better the service delivery and public transport modes in cities aesthetically [13] & [14]. The light rail transit systems are urban transport systems composed of electrically powered coaches (rolling stock), and tracks used to transport passengers between fixed stations [15].

Again, [15] broadly defined urban LRMT systems which can be classified based on system right-of-way, whether they are segregated or not, and rolling stock capacity. The establishment of light rail systems requires heavy initial capital for the necessary infrastructure to be constructed [16]. This results in the need to recoup the invested money through service operations. Oftentimes, situations of conflict always emerge when operators strive to grab market operations. Meanwhile, the projected performance and efficient use of such capital-intensive infrastructure is anticipated to be proportionate to the investments made in terms of ameliorating the existing transportation challenges [17].

A railway station is a public transport facility of high quality, usually located at points of high travel demand, and acts as a central departure and destination point to accommodate high passenger volumes where passengers travel from and to different modes of transport services [9]. Railway traffic has increased over the last few years and it is forecasted to increase further in the next decade [18], with the transition from road to rail transportation modes, due to the increasing energy costs and the demand to reduce emissions [19]. However, there is no easier way to explain the capacity of railway infrastructure because it depends largely on the high degree of its usage [20].

Stations are meeting points between railways and passengers, providing means for passengers to acquire tickets and board the trains [21]. This implies that train stations are a source of bottlenecks in railway infrastructure operations, but limited work has been done on assessing and ranking their performance [22]. It is very crucial to analyze the performance of stations for better infrastructure utilization and planning for effective service delivery. The European Commission (EC) pioneered the performance measurement of Public Passenger Transport. Of course, public transport is a driver for improved standards of living. The fact remains that urban public transport is a ladder to sustainability and inclusive metropolitan development.

The station carrying capacity problem which is also referred to as the railway infrastructure saturation problem in Europe [23] has been explored in several studies. The capacity analysis is one alternative to addressing the problem and there are various tools, methodologies, and approaches for this case

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[24]. This capacity can be defined as the maximum train numbers that may be transmitted simultaneously using a specific part of the infrastructure during a given period and with a fixed level of service [25]. It is a balance between the average speed, train numbers, stability, and heterogeneity [26].

In addition, capacity is the chord length that connects the four axes. This indicates that railway capacity is a trade-off between quantity and quality, i.e., between the train numbers and the level of delays they will experience. However, train capacity varies for each station due to reasons such as the distribution of waiting passengers on the platform and customer willingness to board crowded trains [27]. This is why effective capacity differs from physical train fixed capacity. It is therefore unquestionable that accurate capacity estimation is the fulcrum for efficient and effective performance and deployment of rail infrastructure [28].

Higher traffic demands increase the awareness of delays, with some of these delays coming from train-to-train journeys and operation arrangements [17]. This presents a timetabling problem (TTP) especially in setting up feasible train arrival and departure routes [29]. The challenge is more existent in tracks with a heterogeneous traffic mixed flow. Although timetables are important in ensuring the punctuality of trains, their construction becomes more difficult with an unstable waiting time [30]. The problem is more advanced when crossings and over-takings become more frequent.

The operational conflict that arises in trying to harmonize the existing train schedule with new demands in the form of train traffic always leads to train operations safety threats [31]. The need to solve this conflict accurately grows when the market for railway operation is deregulated and service operators have to be denied train slots due to capacity constraints [17]. Since train timetabling focuses on minimizing such conflicts [32], the location of trains is an important parameter of concern in trying to tame such conflicts. Stations are normally located at points of high travel demand and can be sited from outer suburban areas to inner-city areas [9].

In some situations, depending on the location of stations, the capacity of railway infrastructure is low compared to the population and growing passenger demand. Such situations result in the deterioration of the quality of services received by the customers [33]. It all means that the order of performance of railway infrastructure assets such as stations needs to be determined so that all concerned stakeholders can fathom ways to improve customer satisfaction while ensuring maximum usage of facilities. Many performance indicators have been developed by different organizations and each country has a different set of frameworks for its transport system [34]. For example, in 2019-20, the office of rail and road in the UK released a new set of indicators for train punctuality, train reliability, and train operating company (TOC) analysis [35]. However, for this study, we have singled out reliability, level of comfort, and service delivery as the performance measures to be considered.

Therefore, investigating the performance of railway stations is a good way of determining whether their capacity is fully utilized or otherwise, and this serves as an impetus and rationale for this study. The study, therefore, aimed at comparing the performance of railway stations along the North-South Axis of the AALRT using some selected performance indicators. This study will assist the following stakeholders; Addis Ababa Road and Transport Bureau (AARTB), Addis Ababa City Roads Authority (AACRA), Federal Transport Authority (FTA), and Ethiopian Railways Corporation (ERC) in their plans to ameliorate the transportation challenges specifically in Addis Ababa and the entire country at large. Also, this will assist in assessing the 8th, 9th, and 11th Goals amongst the 17 sustainable development goals which are “Decent Work and Economic Growth”, “Industry, Innovation and Infrastructure”, and “Sustainable Cities and Communities” respectively by the year 2030 [36].

1.1. Definitions of Performance Indicators Used for Comparison

1.1.1. Reliability

In the railway network, reliability is one of the biggest problems in the daily operations of a railway system. It refers to the consistency of the service delivered to passengers. In a study presented by Van Doorn et. al., [37], the reliability of transport is influenced by rail quality and efficiency. Reliability is a very important factor when choosing any mode of transport used. The reliability of a system is

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directly proportional to the number of sales, which can be applied to service delivery in light rail transit systems. Passengers believe that in public transportation there is a high degree of unreliability to reach customer destinations according to what they scheduled [38].

1.1.2. Level of Comfort

Comfort refers to the extent to which the passengers will be saved from dissatisfaction during their trip. Other researchers also argued that comfort is the overall cleanliness of the train. When a passenger gets on the train, looking for a seat, litter, and junk left behind by other customers raise dissatisfaction. Nobody wants to be in a dirty atmosphere. The stations and train's cleanliness are the aspects that are considered imperative for the passengers. It can be achieved by scheduling a periodic cleaning of the area particularly open to the public [38].

1.1.3. Service Delivery

The positive correlation between quality service and customer satisfaction is longstanding [39], and the collective influence of quality service and customer loyalty (resulting from customer satisfaction), organizational competitiveness, and optimum performance is widely acknowledged in the marketing literature [40]. Consistently, numerous studies have shown quality service delivery and customer satisfaction to be associated with loyal customers, repeat purchases, and the organization's propensity to retain its customers over a longer period [41].

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The AALRT is located in the capital city of Ethiopia where the head offices of many international organizations such as the African Union and the United Nations are located. Addis Ababa has a plateau altitude of about 2400 m with an urban population of over 3.4 million, which takes about 25% of the country's total population with an urban area and density of 530.14 km2 and 5607.96 per km2 respectively [42]. The city metro constructed a phase one light rail transit line aiming to solve the current transport problem. This Light Rail Transit is assumed to transport 80,000 passengers per hour per direction.

For the system to hit the targeted objective on the proposed line, stations have to be positioned at a place where they can attract maximum users, which enables the system to solve the problem and integrate the light rail system with other transport modes in Addis Ababa [9]. Figure 1 shows the AALRT while Figure 2 shows the North-South section of the AALRT considered for this study.

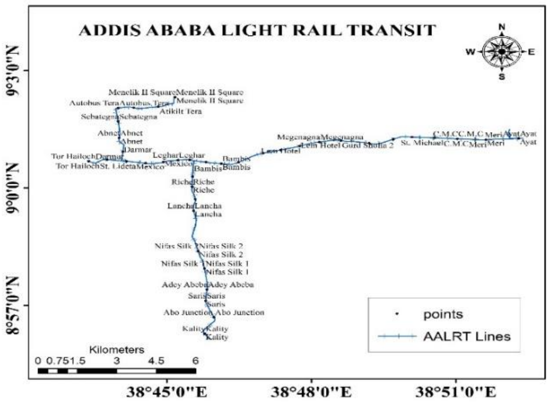

Figure 1. Addis Ababa Light Rail Transit (AALRT)

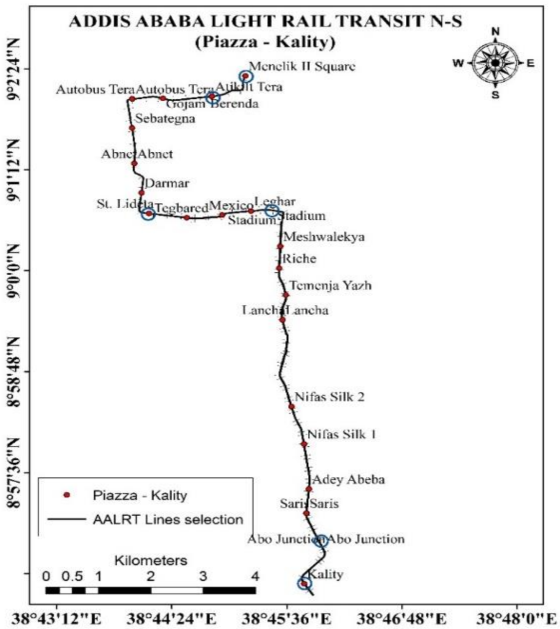

Figure 2. North-South (Piazza – Kality Section) Addis Ababa Light Rail Transit (AALRT)

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2.2. Data Collection

This involved the use of primary data obtained through the administration of structured questionnaires to some selected railway passengers at each of the selected stations. Only six (6) major stations out of seventeen (25) stations along the N-S line, which include Meneliki Squared II, Stadium, Abo Junction, Kality, Lideta, and Altikilt Tera were considered for this study as circled in Figure 2. These stations were selected because Meneliki Squared II and Kality stations are the terminal stations for the N-S axis, while the other four stations were selected because of the high passenger demand in those areas.

The instrument used in this study for the data collection was a structured questionnaire titled "Performance Comparison of Railway Stations along Addis Ababa Light Rail Track North-South Line". It consists of two sections, with section A covering issues on the Bio-data of the respondents and section B covering the issues on performance indicators used for stations' comparison. The data was collected by researchers using this instrument. The questionnaires were administered exclusively to the railway passengers after seeking accord from the respondents. One research assistant who is fluent in the national language helped in the administering of the questionnaires after being trained. About 240 questionnaires in total were administered at each of the selected stations on-site by the researchers and the data collection was carried out for two weeks per station.

2.3. Data Analysis

The collected data, were analyzed using both the descriptive statistics and the inferential statistics (logistic regression model) on both the Microsoft Excel 2016 and IBM SPSS 25.0 versions, while the outputs were presented in tables and charts such as bar charts, histograms, and pie charts appropriately.

2.3.1. Logistic Regression Model

Binary logistic regression (BLR) is a type of regression analysis where the dependent variable is a dummy variable (coded 0, 1) [43]. This involves the use of available data to establish a relationship between the selected performance indicators and the level of performance of railway stations. This model is suitable because both the dependent and independent variables are dichotomous, that is, good or poor performance. That is, the method of choice if the dependent variable is binary (dichotomous) and it is expected to explore the relative influence of continuous and/or categorical independent variables on the dependent variable, and to assess interaction effects between the independent variables.

The analysis was carried out using the BLR Method of Analysis on IBM SPSS version 25.0 using the explanatory variables shown in Table 1 to predict the Dependent Variable (Level of Performance). Thus, it was expressed by following the logistic regression model [44] as in Equation 1:

$$\mathrm{PLi} = \ \mathrm{In}\left[\frac{\mathrm{p}}{1-\mathrm{p}}\right] = a + b1X1 + b2X2 + \cdots . bnXn \qquad (1)$$

Where b1, b2, and bn are logistic regression coefficients.

2.3.2. Data Requirements and Related Methods

For data where the dependent variable is categorical (usually dichotomous), and all independent variables are categorical, or if they are a mix of continuous and categorical variables, or where the independent variables are all continuous but not normally distributed, logistic regression (LR) is recommended [45]. In cases where the independent variables are all continuous and nicely distributed, discriminant analysis is often employed [45]. If the dependent variable had been quantitative continuous (instead of binary as in our data), a One-Way Analysis of Variance (One-Way ANOVA) would have been appropriate to use [46]. Thus, LR was used to establish the relation between the dependent variable (level of performance) and the independent variables (performance indicators).

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Table 1. Explanatory (Categorical) Variables Codings

Performance Indicator	Level of Agreement	Parameter coding
Reliability to the Passenger-Customer Satisfaction	Agree	1
	Disagree	0
Availability of Some Basic Needs at the Stations	Agree	1
	Disagree	0
Safety and Security at the Station	Agree	1
	Disagree	0
Passenger Travel and Waiting Time	Agree	1
	Disagree	0
Accessibility of the Station to the Passengers	Agree	1
	Disagree	0

2.3.3. Steps Involved in Reporting the Results

According to [46] The following data are recommended to be reported on the results of the LR analysis:

- An overall evaluation of the model: This is examined using likelihood ratio tests and score tests [46], where p-values smaller than 0.05 indicate that the independent variables most likely influence the dependent variables. This often provides an answer to the question; does the knowledge of the independent variables improves our ability to predict the value of the dependent variable?
- Statistical tests of individual independent variables: This is usually examined using the Wald Chi-Square statistic. Those predictors whose sig. values that are less than 0.05 are statistically significant and are considered in the relationship.
- Goodness-of-fit test statistics: It assesses the fit of a logistic model against actual outcomes [46]. Also, Peng et al., [43] stressed that this indicates the appropriateness of the model by showing how much the model fits with the actual outcomes which can be estimated using the Hosmer-Lemeshow test, where the insignificance of the Chi^2-value is an indicator of goodness-of-fit. Also, $p>0.05$ indicates that the model fits the data well.
- An Assessment of the predicted probabilities: The predictive accuracy of the model can be presented in a classification table, where the predicted outcome (1/0) is compared to the actual outcome (1/0). The classification table is usually recommended in a report if especially if classification is a stated goal of the analysis [43] [44]. However, Khan & Brouwer [44] stressed that the Hosmer-Lemeshow chi^2-test of goodness-of-fit is often preferred over classification tables.

2.3.4. Limitations of LR Model

According to Dale [47], LR does require random independent sampling but not multivariate distributions, and it does require the linearity between X and the logit. Also, models can be distorted if important variables are left out. And the addition of irrelevant variables may dilute the effects of more interesting variables. Therefore, more data is better since the models can be unstable when samples are small [47].

3. RESULTS AND DISCUSSION

Primary data were collected on-site as described above. These raw data were processed and analyzed on both IBM SPSS 25.0 and Microsoft Excel 2016. The results and discussions are presented in this section using both tables and figures as shown in the subsequent sections.

3.1. Performance Indicators

3.1.1. Accessibility of the Stations to the Passengers

Under this performance indicator, Table 2 and Figures 3 to 7 show the passengers' responses to each of the sub-performance indicators and a graphical representation of their responses respectively.

- **Comfortable Elevator or Ramp Access to the Platform**

As shown in Table 2, the responses of the passengers at each of the selected stations were presented as the percentages of the total response. And these values have also been presented in Figure 3.

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Table 2. Passengers' Responses on the presence of comfortable elevator or ramp access to the platform at each of the selected station

	A. Comfortable elevator or ramp access to the platform					
	MS	AJ	ST	KL	LD	AL
DA	0.0	25.0	12.5	0.0	0.0	50.0
N	15.0	50.0	0.0	27.5	25.0	0.0
A	40.0	0.0	37.5	72.5	0.0	25.0
S/ A	45.0	25.0	50.0	0.0	75.0	25.0
Total%	100	100	100	100	100	100

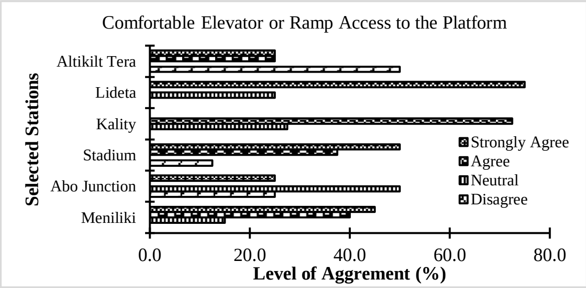

Figure 3. Shows the responses of the respondents on the availability of comfortable elevator or ramp

From Table 2 and Figure 3, about 75% of the respondents strongly agreed that there is a comfortable elevator or ramp access to the platform at Lideta, 50% at Stadium, 45% at Meneliki Squared II while about 73% agreed that this facility is present at Kality railway station.

- **Accessible Toilets and Pay Phone**

As seen in Figure 4, on average, there is no availability of toilets and payphones in the selected railway stations. Also, more than 70% of the respondents strongly disagreed that there is accessibility to toilets and payphones at the selected six stations while about 20% were not sure of the presence of such facilities.

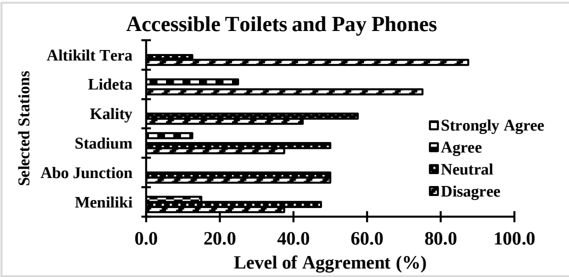

Figure 4. Shows the responses of the respondents on the availability of accessible toilets and pay phones

- **The Height of the Platforms Match with Train Floors**

From Figure 5, on average, about 75% of the respondents strongly agreed that the height of platforms matches the train floors in all the six selected stations while less than 5% disagreed. This implies that the heights of the platforms in the selected stations match with train floors for easy in and out movement of the passengers at these stations.

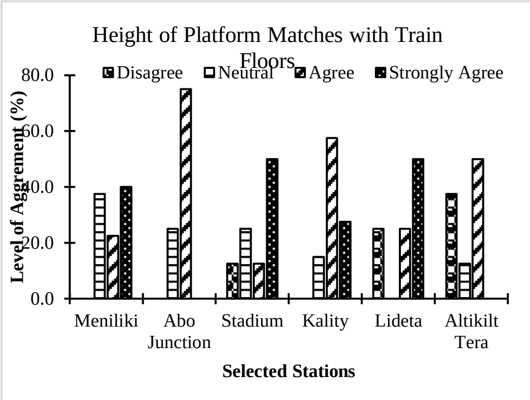

Figure 5. Shows the responses of the respondents on the Height of platforms at each station matches with train floors

- **Audible Station Announcement**

Audible station announcement is an integral part of the facilities at the railway stations which notifies the passengers of the arrival and departure times of the trains. So, from Figure 6 there is total agreement that there is a presence or availability of Audible station announcements at Lideta Station while more than 25% disagreed in all other stations except at Altikilt Tera Station where about 55% agreed to the presence of audible station announcements.

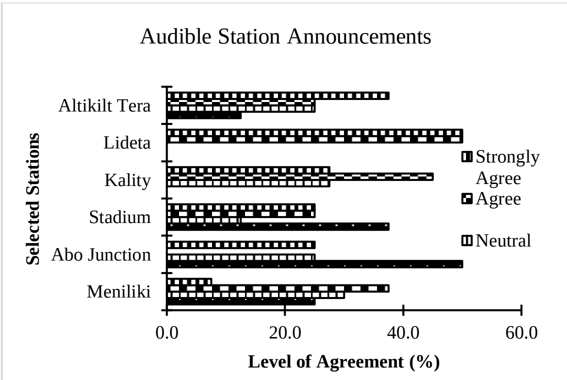

Figure 6. Shows the responses of the respondents on the presence of Audible Stations Announcement at each of the selected station

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▪ **Interconnectivity with Road Transport**

One of the major attributes of a standard railway station is its ability to connect with other means of transportation systems such as roads. This study also accessed the performances of the selected stations by investigating their connectivity with the road transportation system. The result is shown in Figure 7.

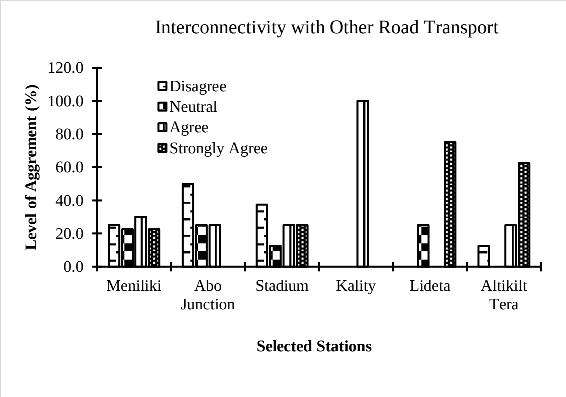

Figure 7. Shows the responses of the respondents on the interconnectivity of the stations to the road transport

3.1.2. Availability of Some Basic Needs at the Stations

Under this performance indicator, Table 3 and Figures 8 to 11 show the passengers' responses to each of the sub-performance indicators and their graphical representations respectively.

▪ **Availability of Automated Ticket Machines at the Stations**

As presented in Table 3, virtually there is no such facility in all the selected responses. However, this facility is installed in all the stations but none of them is working at the time of this study.

Table 3. Passengers' Responses on the availability of Automated Ticket Machines at each of the selected Stations

A. Automated ticket machines are available						
LA	MS	AJ	ST	KL	LD	AL
DA	55.0	75.0	37.5	42.5	25.0	50.0
N	22.5	0.0	0.0	15.0	25.0	25.0
A	7.5	0.0	37.5	0.0	50.0	12.5
S/ A	15.0	25.0	25.0	42.5	0.0	12.5
Total (%)	100	100	100	100	100	100

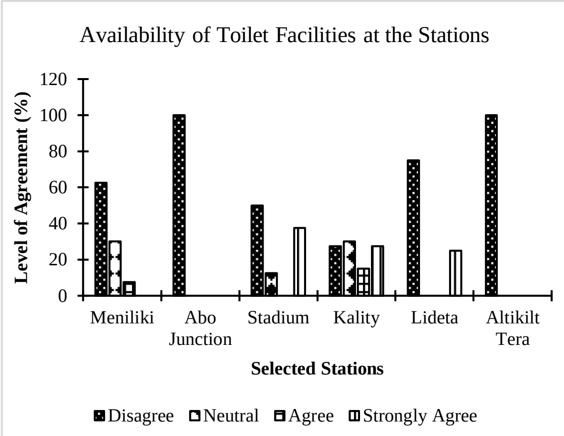

Figure 8. Shows the responses of the respondents on the availability of toilet facilities at the stations

▪ **Availability of Toilet Facilities at the Stations**

As in Figure 8, it has been noted that more than 85% of the respondents strongly disagreed with the availability of toilet facilities in all six selected stations.

▪ **Availability of Left Luggage, and Lost-and-Found at the Station**

As is seen in Figure 9, any left luggage can easily be retrieved by the owners at the six selected stations as most respondents agreed to the availability of monitoring agents who are in charge of keeping and retrieving any left or lost-and-found luggage. However, at Abo Junction Station, about 75% of the respondents disagreed that this facility is available and this makes any left or lost-and-found luggage at this station to be retrievable.

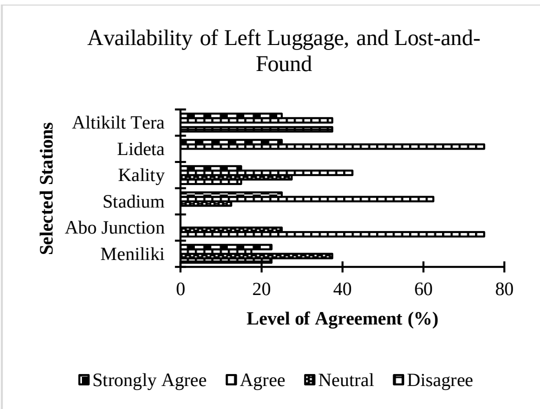

Figure 9. Shows the responses of the respondents on the availability of Left Luggage and Lost-and-Found at the stations

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- **Availability of Security Office at the Stations**

From Figure 10, it has been noted that more than 75% of the respondents disagreed with the availability of security offices, with most of them from Abo Junction and Altikilt Tera Stations while less than 20% with the highest percentages from Lideta, Kality, and Stadium Stations.

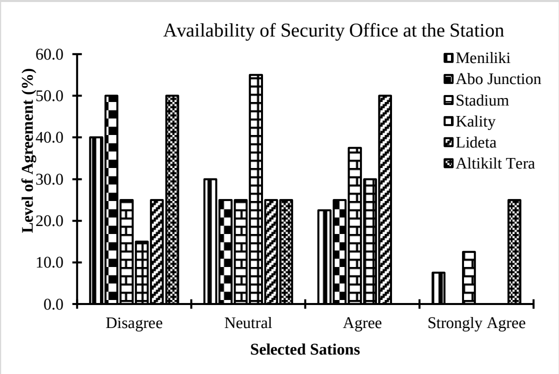

Figure 10. Shows the responses of the respondents on the availability of the Security office at the selection stations

- **Availability of Comfort Waiting Rooms at the Stations**

From Figure 11, more than 85% of the respondents agreed to the availability of comfortable waiting rooms only at Kality and Abo Junction Stations while about 63% strongly agreed to the availability of such facility at Altikilt Tera Station.

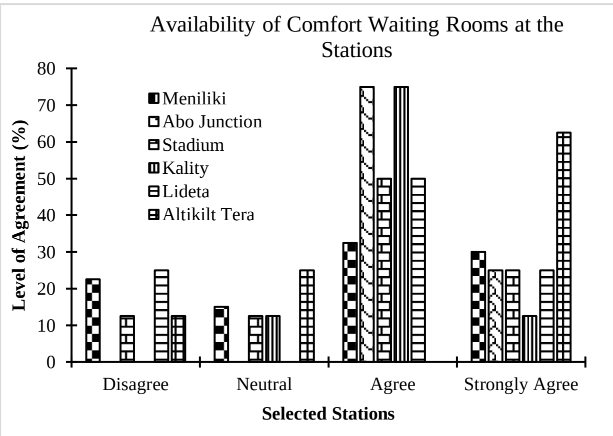

Figure 11. Shows the responses of the respondents on the availability of Comfort Waiting Rooms at the selection stations

3.1.3. Safety and Security at the Stations

Under this performance indicator, Figures 12 to 14 show the passengers' responses to each of the sub-performance indicators and their graphical representations respectively.

- **Availability of Adequate Light at Night-Time**

One of the means of ensuring a sustainable security system is the availability of adequate light during the nighttime. The performance of the selected stations in terms of safety and security was accessed using the availability of adequate light at nighttime as an indicator. The results are presented in Figure 12.

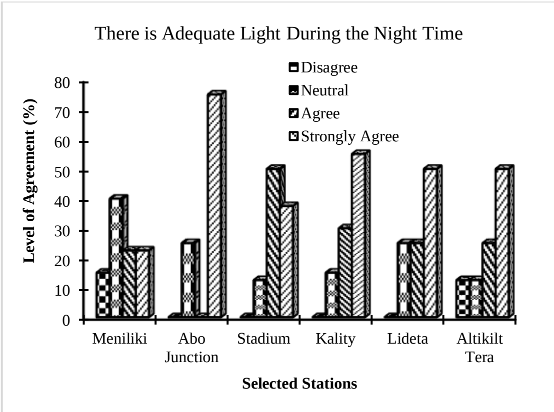

Figure 12. Shows the responses of the respondents on the availability of Adequate Light during Night-Time at the selection stations

- **No Vandalism at the Stations**

The absence of vandalism records in a railway station could indicate the availability of adequate safety and security. The results of each station's performance are presented in Figure 13. The results show an overall no vandalization.

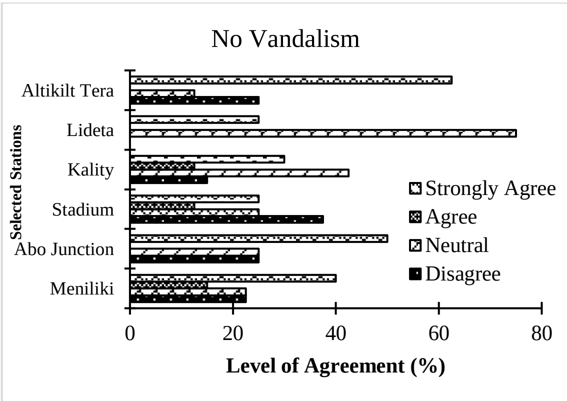

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Figure 13. Shows the responses of the respondents on the absence of vandalism at the selection stations

- **Availability of Well Firefighting Systems at the Stations**

From Figure 14, it can be noted that about 62.5%, 50%, and 37.5% of the respondents strongly agreed with the availability of well firefighting systems at Stadium, Lideta, and Meneliki stations respectively while about 75% are not sure of the availability of such facility at Abo Junction Station.

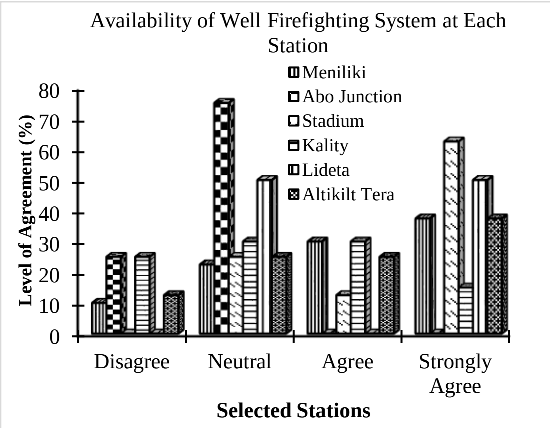

Figure 14. Shows the responses of the respondents on the Well Firefighting system at the selection stations

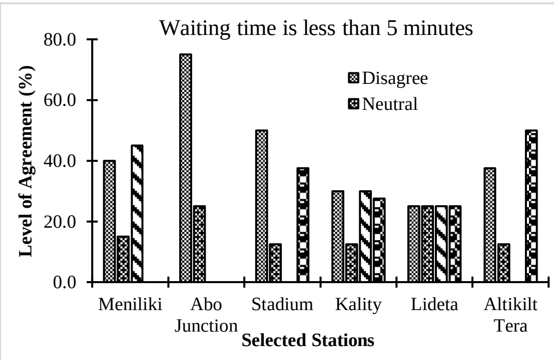

Figure 15. Shows the responses of the respondents on the waiting time is less than 5 minutes at each of the selected stations

3.1.4. Passengers' Travel and Waiting Time

Under this performance indicator, Figures 15 to 17 show the passengers' responses to each of the sub-performance indicators and their graphical representations respectively. From Figure 15, it is seen that more than 70% of the respondents disagreed that the waiting time is less than 5 minutes in all the six selected stations. This was equally observed during the data collection exercise as there were more passengers than the capacities of the available trains. Other factors that contribute to passengers' travel and waiting time are ticketing time and loading and offloading time. The results are shown in Figure 16 and Figure 17 respectively.

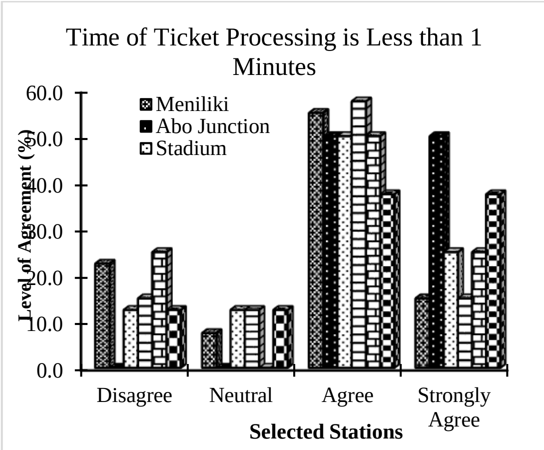

Figure 16. Shows the responses of the respondents on the estimated time of ticket processing is less than 1 minute at each of the selected stations

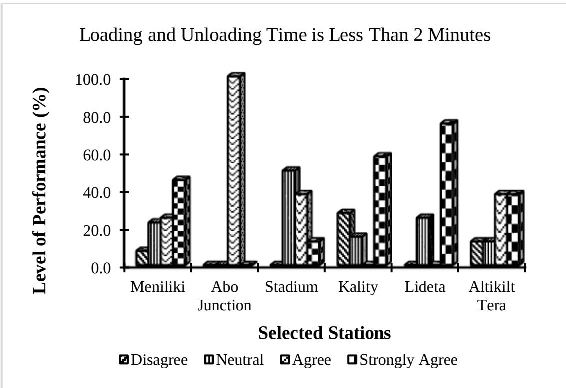

Figure 17. Shows the responses of the respondents on the estimated loading and unloading is less than 2 minutes at each of the selected stations

3.1.5. Reliability to the Passengers-Customer's Satisfaction

Under this performance indicator, Tables 4 to 6 and Figures 18 to 19 show the passengers' responses to each of the sub-performance indicators and their graphical representations respectively.

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Table 4. Passengers' Responses on there is well-received by the customers at each of the selected Stations

	A. Well reception to customers					
LA	MS	AJ	ST	KL	LD	AL
DA	47.5	0.0	50.0	0.0	100.0	50.0
N	37.5	50.0	12.5	27.5	0.0	25.0
A	7.5	25.0	0.0	45.0	0.0	12.5
S/ A	7.5	25.0	37.5	27.5	0.0	12.5
Total (%)	100	100	100	100	100	100

Table 5. Passengers' Responses on whether there is fair transportation cost at each of the selected Stations)

	B. Fair transportation cost					
LA	MS	AJ	ST	KL	LD	AL
DA	30.0	0.0	25.0	15.0	0.0	37.5
N	15.0	25.0	0.0	0.0	25.0	12.5
A	40.0	50.0	37.5	30.0	50.0	25.0
S/ A	15.0	25.0	37.5	55.0	25.0	25.0
Total (%)	100	100	100	100	100	100

Table 6. Passengers' Responses on there is the availability of comfortable seats at each of the selected Stations

	C. Comfort seats					
LA	MS	AJ	ST	KL	LD	AL
DA	0.0	100.0	25.0	15.0	50.0	25.0
N	37.5	0.0	25.0	30.0	0.0	0.0
A	47.5	0.0	25.0	27.5	50.0	37.5
S/ A	15.0	0.0	25.0	27.5	0.0	37.5
Total (%)	100	100	100	100	100	100

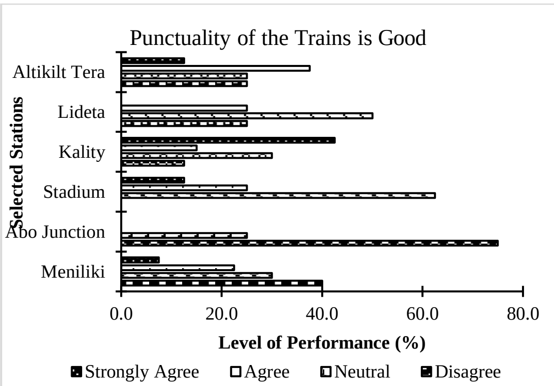

Figure 18. Shows the responses of the respondents on the punctuality of the trains is good at each of the selected stations

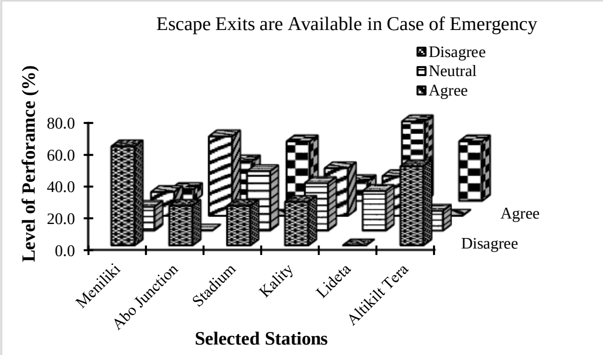

Figure 19. Shows the responses of the respondents on the availability of escape exits in case of emergency at each of the selected stations.

Table 7. Performance comparison of each of the selected Stations under each of the selected sub-performance indicators

PERFORMANCE COMPARISON OF STATIONS UNDER EACH PERFORMANCE INDICATOR						
SI	MS	ST	AJ	LD	KL	AL
A	172	170	150	180	149	130
B	161	160	150	160	165	125
C	111	115	100	100	103	85
D	131	135	120	180	160	155
E	140	135	110	180	160	175
F	160	150	150	160	144	150
G	113	140	110	130	137	115
H	98	130	80	110	137	80
I	136	165	90	170	143	140
J	140	140	150	170	138	150
K	119	135	110	130	126	120
L	134	140	120	170	153	135
M	148	155	170	150	160	175
N	141	170	180	170	176	165
O	149	130	150	140	143	160
P	158	175	110	160	134	155
Q	125	165	190	160	154	140
R	167	135	130	170	177	155
S	122	130	90	140	142	145
T	128	155	130	170	158	160
U	163	145	160	180	155	160
V	145	155	180	150	149	160
W	116	145	150	120	132	130
X	110	130	150	80	160	115
Y	136	155	160	160	170	135
Z	151	140	80	120	147	155
AA	119	140	90	120	155	135
AB	107	140	150	170	131	130

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3.2. Performance Comparison of Stations under Each of the Selected Performance Indicators

Performances of each of the six selected stations are investigated based on each of the chosen performance indicators.

Table 7 shows the summations of the responses received from the respondents while Figure 20 shows the graphical representations of Table 7.

3.2.1. Performance Comparison of Stations under each Indicator

The overall performances of each of the six selected stations are investigated based on the total sum of performances under each of the chosen indicators. Figure 20 shows the graphical representations of the overall performances. So, from Figure 20, under Accessibility of Stations to the passengers as a comparison Indicator (indicator 1), Lideta is the best, followed by Kality, Meneliki, Stadium, Altikilt Tera, and least is Abo Junction Stations respectively.

Under Availability of Some Basic Needs at the Station as a comparison indicator (Indicator 2), Lideta is the best, followed by Stadium, Kality, Altikilt Tera, Meneliki and the least is Abo Junction. Under Safety and Security at the Station as a comparison Indicator (Indicator 3), Lideta is the best, followed by Kality, Altikilt Tera & Stadium, Abo Junction, and the least is Meneliki Stations. Under Passengers’ Travel and Waiting Time at the Station as a comparison Indicator (Indicator 4), Lideta is the best, followed by Altikilt Tera, Kality, Stadium, Abo Junction, and the least is Meneliki Stations. Under Reliability to the Passengers-Customers’ Satisfaction as a comparison Indicator (Indicator 5), Kality is the best, followed by Stadium, Altikilt Tera, Lideta, Abo Junction, and the least is Meneliki Stations.

3.2.2. Overall Performance Comparison of Stations

The overall performances of each of the six selected stations are investigated based on the total sum of performances under each of the chosen indicators. Thus, Figure 21 shows the graphical representations of the overall performances of the stations.

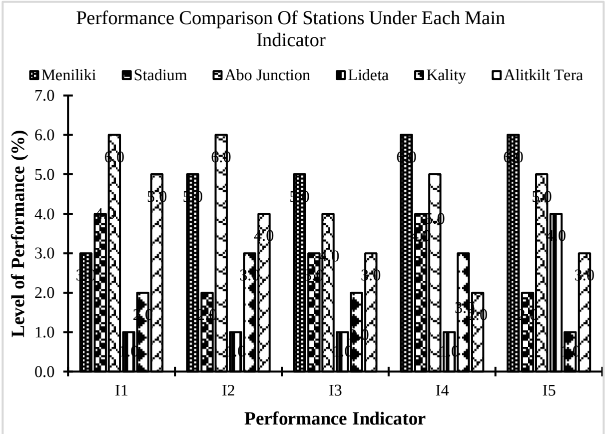

Figure 20. Shows the performance comparison of each of the selected stations under the Five (5) performance indicators

Table 8. Summary Table for the Overall Performance Comparison of Stations

Stations	Meneliki Squared II	Stadium	Abo Junction	Lideta	Kality	Atikilt Tera
Performance (%)	15.9	17.1	15.5	17.6	17.4	16.5
Rank	5^{TH}	3^{RD}	6^{TH}	1^{ST}	2^{ND}	4^{TH}

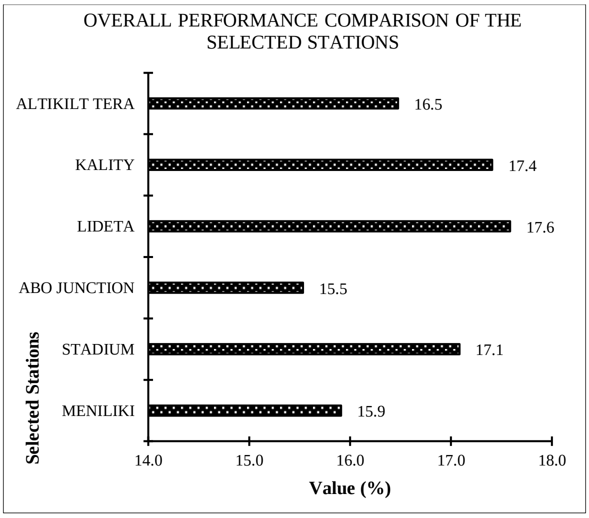

Figure 21. Shows the Overall performance comparison of each of the selected stations along Addis Ababa Light Rail Track N-S Line

3.3. LOGISTIC REGRESSION MODEL

The output of the BLR on SPSS is shown in the tables. Table 9 shows that 99.2% of the sample size is included in the analysis while only about 0.8% are missing cases.

Table 9. Descriptive Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	240	99.2
	Missing Cases	2	.8
	Total	242	100.0
Unselected Cases		0	.0
Total		242	100.0

a. If weight is in effect, see the classification table for the total number of cases.

Table 10. Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	125.289	5	.000
	Block	125.289	5	.000
	Model	125.289	5	.000

Table 11. Shows Model Summary

Step	Chi-square	df	Sig.
1	344.385	8	0.000

Also, Table 11 indicated that only about 50% of this model is correctly explained or predicted

Table 12. Shows Hosmer and Lemeshow Test

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	174.079[a]	0.484	0.645

a. At iteration number 6, estimation was terminated because parameter estimates changed by < .001.

by the predictors. In model fit, if the X^2 test is significant, it means the expanded model (with the independent variables), improves prediction. Thus, Table 11 shows that the X^2 test is significant, and the model is fit for the data. Again, in a perfect model, the -2 log-likelihood would be equal to 0. However, from Table 11, this value is lower than zero, thus, the model is a better fit. Also, considering Negelkerke R Square in Table 11, explains that about 64.5% of the predictors are contributing to the dependent variable.

Therefore, the binary regression equation is derived from Table 13, as shown in Equation 3.

$$Y = 0.397 + 0.182x1 - 0.223x2 - 0.182x3 - 0.174x4 - 0.377x5 \qquad (2)$$

Where;

Y is the measure of the Level of Performance of stations (Dependent Variable)

x1 is the measure of the Accessibility of stations to the passenger (Indicator 1)

x2 is the measure of the Availability of some basic needs at the stations (Indicator 2)

Table 13. Variables in Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Accessibility of the Station to the Passengers	0.182	0.085	39.054	1	0.000	2.200
	Availability of Some Basic Needs at the Stations	-0.223	0.137	32.171	1	0.000	1.800
	Safety and Security at the Station	-0.182	0.040	47.281	1	0.000	0.833
	Passenger Travel and Waiting Time	-0.174	0.192	52.873	1	0.000	0.840
	Reliability to the Passenger-Customer Satisfaction	-0.377	0.172	43.187	1	0.000	0.986
	Constant	0.397	1.046	0.145	1	0.704	1.488

a. Variable(s) entered in step 1: Accessibility of the Station to the Passengers, Availability of Some Basic Needs at the Stations, Safety, and Security at the Station, Passenger Travel and Waiting Time, Reliability to the Passenger-Customer Satisfaction.

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x3 is the measure of Safety and Security at the stations (Indicator 3)

x4 is the measure of Passengers' travel and waiting time (Indicator 4)

x5 is the measure of Reliability to the passenger-customer satisfaction (Indicator 5).

4. CONCLUSIONS

Following the site observation, results, and discussions as highlighted in the previous sections, the following conclusions were made:

Addis Ababa North-South Light Rail Track is made up of different types of stations which include Terminal Stations, stopping stations, crossing stations, etc. Based on the results and discussions, it can be concluded that out of the six selected railway stations considered for this study, their performances as a measure of the indicators are in the following order; Lideta, Kality, Stadium, Atikilt Tera, Meneliki Squared II, and Abo Junction respectively.

Also, a relationship has been established between the Level of Performance and the Performance Indicators using the Logistic Regression Model. It follows that it is possible to predict the Level of Performance in the AA-LRT stations along the N-S line provided that information on the performance indicators is known. Therefore, to further improve the performances of those other five under-performance stations as identified in this study, this study recommends that more attention be paid to improving those criteria listed under each of the performance indicators identified.

Finally, this study recommends the use of the methodological procedure adopted in this study to be used for any similar study elsewhere in the world.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest concerning this article's research, authorship, and/or publication.

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Data Availability Statement

All data, models, and codes generated or used during the study appear in the submitted article.

Data Availability Statement

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