Tanzania Journal of Engineering and Technology 2024, 43(2):23 - 45
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Websites: https://ajol.org/tjet; https://tjet.udsm.ac.tz

ISSN 1821-536X (**print**); ISSN 2619-8789 (**electronic**)
https://doi.org/10.52339/tjet.v43i2.1027

Regular Research Manuscript

Assessment of the Factors Affecting the National ICT Broadband Backbone (NICTBB) Systems Restoration Time

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ABSTRACT

This study investigates the factors affecting the prolonged system restoration time when national ICT broadband backbone (NICTBB) services are affected by breakdown incidents. NICTBB is the government-owned backbone infrastructure constructed nationally by the Republic of Tanzania to increase the usage of ICT for equitable and sustainable socio-economic development and accelerate poverty reduction. This study utilised a mixture of exploratory and descriptive study approaches. The sample size determination was executed using purposing and simple random sampling, thus involving 289 respondents. The data reliability test was undertaken. It was followed by factor analysis, analysis of variances (ANOVA), linear regression analysis, and confirmed with confirmatory factor analysis (CFA) using IBM SPSS Amos 28 to test the model fitness. The study revealed that the maintenance centres are few and sparsely located, and the distance from maintenance centres increases travelling time, resulting in increased time to restore services. Some factors affecting the restoration time include initial infrastructure design not trenching to locate points of cut, absence of dedicated vehicles standby for NICTBB restoration, retirements of experienced and well-trained staff leaving behind untrained personnel for maintenance activities, and insufficient funds for maintenance. Lastly, power equipment is not looked upon as sometimes the services are down due to commercial power cuts, tripped circuit breakers, and batteries not being charged. Some recommendations include having proper maintenance processes, having enough restoration resources at all maintenance centres, and maintaining proper communication.

ARTICLE INFO
Submitted: **Aug. 15, 2023**
Revised: **May 27, 2024**
Accepted: **June 15, 2024**
Published: **Aug. 2024**

Keywords: *NICTBB factors, National ICT Broadband Backbone, NICTBB system, system restoration time, Tanzania*

INTRODUCTION

Information and Communication Technologies (ICTs) have proved to be increasingly fundamental to the socio-economic development of any nation. Realizing the potential of ICT towards national socio-economic development, the government of Tanzania has constructed the National ICT Broadband Backbone (NICTBB) to facilitate ICT usage for Tanzania's equitable and sustainable social – economic and cultural development. ICT services require stable, reliable and available infrastructures throughout their life span. Failures and outages of the infrastructure are intolerable. In Tanzania, NICTBB is a catalyst for implementing the National Development Vision 2025, and national ICT policies (MWTC, 2016a; MoFP, 2020).

NICTBB infrastructure was built in phases. Construction works of Phase I began in February 2009 and ended in July 2010. The second phase began in August 2010 and ended in June 2012, covering 7560 km of fibre length (2112 km over TANESCO power pylons while 5448 km underground fibre cable). The government built the national Internet Data Centre (IDC) and Internet Protocol Multi-Protocol label Switching (IP-MPLS) Service Layer during phase III from February 2015 to 2017. Likewise, the consortium of Telco operators built metro networks and missing links through Public Private Partnerships arrangement in phase IV. After completion of the initial phase of NICTBB construction on July 2010, the Ministry of Communication, Science and Technology (MCST), in collaboration with TTCL, established a special NICTBB Unit to manage the national backbone. The unit started operating in August 2010 (Kowero, 2012a; Mbarawa, 2012; Pazi and Chatwin, 2013; Pima and Sedoyeka, 2016).

The NICTBB operates under set guidelines expressed under the Business and Operating Model, accompanied by several tools. The principles for the management and operation of the NICTBB plan are one of the tools used to facilitate the day-to-day NICTBB technical infrastructure management. Due to the importance and sensitivity of the NICTBB and the related services, the ministry responsible for NICTBB issued this plan as a tool to ensure minimum outage when damage happens (MCST, 2011).

Statistics from TCRA show the presence of the NICTBB has revolutionized the provision of communications services in Tanzania. TCRA reports on Telecom service subscriptions (fixed and mobile) increased from 39,808,419 in 2015 to 51,292,702 in December 2020, with a penetration of 89%. The number of Internet service users (fixed wireless, mobile wireless and fixed wired) also increased from 17,263,523 in 2015 to 28,470,506 in December 2020, with a penetration of 49% (TCRA, 2020). Moreover, a concept like e-government services comprises e-services, including e-education, e-health, Tele-medicine, e-agriculture, e-tourism, e-commerce, and e-procurement emerged, and it was more popularly used to enhance service delivery to the public (MWTC, 2016b; Sedoyeka and Sicilima, 2016).

Network availability is a key to service reliability. Network availability measures the length of time a network is functioning. High availability occurs when downtime or repair times are minimal. The NICTBB systems are required to perform and sustain the desired goal of availability value of 99.999% (five-nines), while the Mean time taken to restore (MTTR) of the failed system should also be minimal. Exposure of NICTBB infrastructures to repeated damage contributes to poor service quality. Depending on the magnitude of failure, the average time to bring back failed systems should not exceed the minimum time of 4 hours (i.e. MTTR $\leqslant$ 4 hours). As shown in Figures 1 and 2, the recorded NICTBB systems availability for 2020 was below the KPI of 99.999%. Similarly, the calculated MTTR was 16.72 hours, contrary to the required MTTR (4 hours). The longer outages not only affect the availability of NICTBB services but also contribute to the loss of required services, revenue, and reputation from customers. This study investigates and establishes the factors affecting NICTBB systems restoration time to improve the National ICT Broadband Backbone's efficiency and productivity to sustain NICTBB services. The research is expected to complement the gap from other scholars who recommended the assessment of NICTBB operation performance to improve service availability and subsequently increase infrastructure uptake

(Kowero, 2012; Pazi, 2014; Sedoyeka and Sicilima, 2016). This research study was geared toward answering three major queries. The first is what factors affect NICTBB-MTTR, secondly, what is the time taken to restore services when NICTBB breakdowns occur? and lastly, what are the recommended mitigation measures to improve restoration time.

Overview of ICT infrastructure in Tanzania

ICT infrastructure is the physical capital that promotes economic growth by developing capital stock and facilitating new technologies into production. ICT infrastructure encompasses digital telephone networks, computers, mobile phones, internet capability, internet servers, fixed broadband, and other technologies (MWTC, 2016b, 2019). ICT is a dynamic investment component that improves global economies by down economic cycles. At the individual level, ICT Infrastructure improves the quality of life of a person to access information and exchanges of ideas and aspirations that often occur in all levels of economies (Yonah, 2007; Yonazi, 2009; Wangwe, 2010; Mbarawa, 2012; Elder et al., 2013; Masenya et al., 2018).

Tanzania is well-connected in terms of hard ICT infrastructure, submarine cables, and NICTBB (UNCTAD, 2020). Extending ICT infrastructure to cover all deserved areas in the country brought mass opportunities for service provision availability in large cities and towns. Mobile banking extends financial services to areas where traditional banking services were not normally reached. Likewise, internet services in schools make the next generation more computer literate (Wangwe, 2010; Elder et al., 2013; Pazi and Chatwin, 2013). The availability of reliable ICT infrastructure facilitates the provisioning of various e-services to the community, creating an information and knowledge-based economy and forming a knowledge-based society. ICT infrastructure is a fundamental tool for forming a knowledge–based future.

The prospects and achievements of the NICTBB attracted scholars to access the various scenarios on NICTBB. Kowero (2012b) took time to assess the potentials of NICTBB in Tanzania. Kowero (2012b) explored the reasons for under-utilization because NICTB utilization was only 10% of its installed capacity. It was found that NICTBB efficiency and productivity, among others, contributed to the low uptake of NICTBB services. The study recommended the assessments of the operating performance of each NICTBB link.

Pazi and Chatwin (2013) explored NICTBB infrastructure from implementation, operation and bandwidth costing. They also assessed the ICT delivery. These researchers noted some improvements in consumption efficiency, usefulness and ICT service dependability as an impact of NICTBB infrastructure on society. However, it was noted that unreliable internet connection hinders growth in ICT services; hence a need for improving MTTR to sustain the reliability of the NICTBB services arose. Similarly, the NICTBB conducted a study on operational efficiency to assess the factors contributing to the low uptake by examining the challenges and opportunities of NICTBB to mobile operators. The susceptibility of NICTBB infrastructures to recurrent damage was a factor in poor service quality (Sedoyeka and Sicilima, 2016).

Operation and maintenance of NICTBB infrastructure

NICTBB infrastructures comprise government-built OFC, Tanesco OFC, and a Portion of Viettel and Consortium OFC. The government owns six cores of fibre optic cables at consortium and Viettel's networks, and eight at TANESCO (mainly the Northern route and Makambako – Njombe link). Responsible utility owners maintain these government fibre cores. The main tasks of NICTBB Manager are to carry out operation and maintenance works and commercialise NICTBB services. To subscribe and resell NICTBB services within and outside the country, local telecom operators, ISP and broadcasters must contact the NICTBB office for a capacity lease agreement (short or long-term) and fulfill business requirements before official connectivity. To be connected to NICTBB, the licensed operator has to extend their last mile or lease another operator's last mile to the nearest point of presence. The NICTBB manager (TTCL) is responsible for link configuration, activation and maintenance, i.e. service restoration in case of failures or fibre cuts or another breakdown related to NICTBB infrastructure, throughout the contract period. The available OFC cores at Consortium's and Viettel's networks are mainly used for government applications, i.e., non-commercial use.

Overview of the NICTBB network

NICTBB network comprised several systems, including optical fibre networks (OFC systems), transmission equipment (WDM and ADM systems), service provisioning equipment (SDH/OTN) and power systems such as Diesel engine generators (DEG set), rectifiers, solar systems, batteries, air conditioning plants and its management systems) to drive the transmitted signals to the receiving end. The key performance indicator (KPI) in monitoring system or network performance is availability. Availability measures how long a system or network has been up and running daily. NICTBB Network Observation Centre (NOC) keeps track of NICTBB system performances and reports weekly, monthly, quarterly and annually. They report any breakdown issues immediately, track outage minutes, and calculate the mean time to restore (MTTR) and availability for all NICTBB infrastructures. NICTBB systems performance is measured against the set target of five nines (i.e. 99.999% (MCST, 2011). System failures reduce the performance of the affected systems. Failure of one system element affects the availability and performance of entire NICTBB network.

Document review on NICTBB's performance in 2020 shows that from January to December 2020, NICTBB availability was below the set target of 99.99%. The worst case was in March when NICTBB recorded numerous network outages leading to an availability of 95.51%. A better performance was recorded in October 2020, with an availability of 98.94% (TTCL, 2020). Similarly, analysis of the breakdown records from 2017 to 2020 indicates that the highest number of breakdown incidents recorded in 2017 dropped to 132 in 2018 and increased to 172 and 174 in 2019 and 2020, respectively (TTCL, 2020).

Causes of NICTBB outages

According to TTCL internal reports on NICTBB, 682 failures were recorded between 2017 and 2020 (TTCL, 2020). This record includes 199 failures in 2017, 134 in 2018, 172 in 2018 and 177 in year 2020. During this period, the network faced obstacles mostly by construction works (161 failures). The contractors tend to cut fibre infrastructures while executing their works along the road where fibers have been buried. These breakdowns contributed to NICTBB outages which reduced system availability. Sometimes, human activities like farming, brick making and digging pit holes along fiber routes tend to cut the fibre (70 failures) accidentally. Vandalism acts (106 failures) also contribute to NICTBB service outages. NICTBB equipment failures (41), animal chew (rodents, 115), natural disasters (rainfall, soil erosion, 78), power failures (88) and working part interruption (23) also contribute to the unavailability of NICTBB services. When NICTBB service is detected to be unavailable, the restoration team is informed for restoration services to start.

NICTBB MTTR and network availability performance

MTTR is a maintenance metric used to calculate the time (average time) required to repair and restore a system to its working state. MTTR starts counting when repair starts and goes on until operations are restored. This includes the time to troubleshoot and analyze the problem and the time taken to repair, test, and return the service to its normal functionality. MTTR is measured in Minutes, hours or days. MTTR is required to be minimal or zero. The standard MTTR is different for different network elements. However, the lower the MTTR, the higher the system availability is. High availability ensures the agreed level of operational performance (uptime). To calculate MTTR (equation 1), we need a documented labor hour used on maintenance and a recorded number of breakdowns.

MTTR=(Total Maintenance Time)/(Total Breakdown incidences) (1)

For NICTBB, MTTR restores transmission bearers' total outages within 4 hours and is treated as priority level one. The second priority is the restoration of route blockage up to 50% of the utilized capacity, of which the designated service restoration time is 24 hours. Lastly, other technical irregularities and performance-related issues must be cleared within 72 hours and prioritized as level three. Based on TTCL internal reports (2020), MTTR was calculated using equation (1). The report also shows that the MTTR in 2020 was 16.72 hours, contrary to the planned MTTR of 4 hours. Availability is the percentage of time a system or network can be used or operated in a specific time interval. It can fulfil the design and purpose of its construction (2).

Availability (%) = Uptime/(Uptime+MTTR) (2)

Factors affecting operations and maintenance of ICT broadband infrastructures

Operations and maintenance of BBI's infrastructures are affected by a number of factors, including commercial power shading (ESCOM load shading), network vandalism, human activities (farming, rail construction) and force majeure (veld fires, heavy rains, flooding, strong winds and heat wave conditions). Others include stolen batteries, people shooting pigeon with pellet bullets (difficult to identify hence long restoration), injury on duty (work part), contract delays, and continuous power failure at some points of presence and unavailability of spare fibre cable to execute permanent repairs.

Proposed Mitigation Strategy in Similar Contexts

In its Annual integrated report of 2019/20, BBI plans to improve network service availability and customer offering by implementing the following strategies (Infraco, 2020): improvement of network resilience through network capacity upgrading, improvement of network reliability performance and route redundancy, and upgrading of its IP network. To sustain the ICT broadband infrastructure and its usage, NITA-U has developed guidelines and standards for operating, using, and managing IT infrastructure applicable to all Ministerial Departments Authorities (MDAs) and Local Government Authorities (LGAs). These tools provide general guidance in the operation, management, usage and maintenance of IT infrastructure to ensure the availability and integrity of NBI infrastructure (NITA - Uganda, 2017; NITA-Uganda, 2018; Uganda, 2020).

METHODS AND MATERIALS

Research design

This study utilized a mixture of exploratory and descriptive study approaches to assess factors affecting NICTBB systems restoration time to improve the national wide ICT broadband backbone availability and reliability performance. Data were gathered at Tanzania TTCL on the mainland of Tanzania, where NICTBB infrastructures are available and maintained. Other data were gathered from the Ministry of Information, Communication and Information Technology representatives and licensed telecom operators connected to NICTBB.

Population and Sampling Design

TTCL staff covered the study's main population. Others included representatives from telecommunications service providers and staff from responsible ministries. This study utilized equation (3) to calculate sample size based on the organization of the proposed study.

$$n = \frac{p \times q \times Z^2}{e^2} \quad (3)$$

where; n = sample size, e = Margin of error (5%), p = estimated proportion of the population (i.e., $q = 1 - p$). It was assumed that a proportion of at least 25% of the study population would participate in a survey, i.e., $p = 0.25$. Z = is the number of standard deviations a given proportion is away from the mean. A desired confidence level of 95% gave a Z value of 1.96. Therefore, based on the study assumptions, 289 respondents were required to provide the required confidence level of 95%.

Adopted Sampling Techniques

Two sampling techniques were employed to select respondents for the study. These included purposive sampling and simple random sampling techniques. To select respondents from TTCL, simple random sampling techniques were used. In contrast, respondents from licensed telecom operators subscribed to NICTBB (providers of internet services) and respondents from the ministry were selected using purposive sampling techniques.

Adopted Sample Distribution Criteria

The main criteria used for sampling respondents included working at TTCL, the Ministry of Communication and Information Technology, and the licensed Telecom operator. Knowing the number of recommended samples of 289 respondents, the distribution of respondents is shown in Table 1.

Ash content determination

Ash is the inorganic solid residue left after the fuel is completely burned. The procedure used to determine ash was using ASTM D1102 (ASTM, 1984). The remaining sample from volatile matter calculation was placed in the furnace at 575℃ for an hour for combustion. All carbon was burnt, and the remaining ashes were reweighted.

Table 1: Respondents Sample Size Distribution

Categories of Respondents	Sampling Procedure	Number of Respondents
Representatives of telecommunications service providers	Purposive sampling	15
Representatives from the Ministry of Communication, Information and Technology	Purposive sampling	28
Representatives from Tanzania Telecommunication Corporation (TTCL)	Simple random sampling	246
Total Sample Size		289

Methods of data collection

Research data were collected through primary and secondary data sources. The study utilized closed-ended questionnaires as a tool for data collection. The secondary data were collected through document reviews. Existing records and reports on similar contexts were examined to reveal the sources of challenges, especially on maintenance issues (recorded challenges, causes, restoration time) and suggestions for improvements. In this study, TTCL NICTBB performance reports documented from the year 2017 up to 2020 were used as the main secondary data source.

Reliability and Validity of Data

Data validity refers to the degree to which the clue one wishes to measure is measured by a particular scale or index (Downs and Adrian, 2003). Data collection instruments (Questionnaires) were designed and validated through expert judgement. Furthermore, 29 questionnaires (10% of the samples) were distributed for pre-testing together with sample interviews to establish a number of variables to be included in the data collection instruments.

Data Analysis Method

Collected data were processed using the computer after data cleaning, editing and coding. The raw research data was imported from Excel into SPSS for analysis. Data were analyzed descriptively to get the indices or measures to summarize the collected data in terms of frequencies and inferentially to test the significance of collected data. Kothari and Gaurav (2019) highlighted that inferential statistics is concerned with the process of generalization, i.e., drawing inferences about population parameters and testing statistical hypotheses.

The factor analysis was done using SPSS software to identify clusters of related variables ideal for reducing a large number of variables to be easily understood in the framework and to form small coherent numbers also defined factor analysis as a statistical approach for describing the unobserved connected variables known as factors. These data-reducing techniques are also used to reduce many factors. Important parameters of factor analysis include. The study used factor analysis to establish the factors affecting NICTBB restoration time, the time taken to restore NICTBB services and the strategies for mitigation.

The Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were performed to examine the sampling adequacy and sphericity. The two tests evaluate all variable data together. Various researchers suggest that a KMO value over 0.5 and a significance level for Bartlett's test below 0.05 suggests a substantial correlation in the data. Before Factor Analysis, the reliability and internal consistency of gathered data were measured using Cronbach's alpha (Sarmento and Costa, 2019).

Lastly, Confirmatory Factor Analysis (CFA) using IBM SPSS Amos 28 was undertaken to confirm if the number of factors (or construct) and the loading of observed variables conform to the model fitness. Confirmatory Factor Analysis is a technique that seeks to confirm if the number of factors and the loadings of observed variables conform to what is expected (Sarmento and Costa, 2019). CFA is also a statistical technique for testing hypotheses about commonality among variables (Hoyle, 2000; Prudon, 2015). CFA also confirms or rejects the measurement theory (Belassi and Tukel, 1996).

RESULTS AND DISCUSSION

Response Rate

In this study, 297 questionnaires were distributed. However, in the responsive questionnaires, 275 (92.6%) and 234 (92.1%) TTCL staff responded. Similarly, 26 out of 28 questionnaires were received from the responsible ministry (92.9%). All 15 questionnaires submitted to the licensed telecom operators were responded to by 100%. Saldivar (2012) recommended that the paper-based survey requires a response return rate of 75% or more for a study to continue. Therefore, the return rate of 92.6% was considered enough to allow generalization of findings.

Respondents Demographic Characteristics

The majority of respondents, 186 (67.6%), were males, compared to 89 (32.4%) who were females. 185 (67.3%) were aged below 35, while 90 respondents (32.7%) aged between 45 and 55. Similarly, the respondents were of different education levels, such as 151 (54.9%) graduates, 55 (20%), Diplomas, 37 (13.5%) Postgraduates, and 32 (11.6%) certificate holders (Table 2). These respondents had working experiences of 1-5 years (94, 34.2%), 5-10 years (46, 16.7%), 10 -15 years (52, 18.9%) and above 15 years (83, 30.2%). The entire sample included Technicians (54.9%), Engineers (19.6%), Senior Engineers (8.4%), Managers (11.3%), Supervisors (2.9%), Directors (1.8%) and other support staff (1.1%).

Table 2: Details of Respondents Demographic Characteristics

Demographic Characteristics			Frequency	Percent	Valid Percent	Cumulative Percent
Gender	Valid	Male	186	67.6	67.6	67.6
		Female	89	32.4	32.4	100
		Total	**275**	**100**	**100**	
Age (years)	Valid	Below 35	185	67.3	67.3	67.3
		45 - 55	90	32.7	32.7	100
		Total	**275**	**100**	**100**	
Education qualification	Valid	Certificate	32	11.6	11.6	11.6
		Diploma	55	20	20	31.6
		Graduate	151	54.9	54.9	86.5
		Postgraduate	37	13.5	13.5	100
		Total	**275**	**100**	**100**	
Current Employer	Valid	TTCL	234	85.1	85.1	85.1
		Other telecom operators	15	5.5	5.5	90.5
		Ministry	26	9.5	9.5	100
		Total	**275**	**100**	**100**	

Factors Affecting NICTBB Restoration Time

Reliability Test on gathered data

Cronbach's Alpha test was applied to check the degree of homogeneousness using SPSS software, and the value was 0.847 implying high internal consistency. Thus, it becomes acceptable for factor analysis. This is because the threshold value for the reliability test was at least 0.7 or higher (Nunnally, 1978; Norusis, 1992; Ofori-Kuragu, Baiden and Badu, 2016).

Factor Analysis to Establish Factors Affecting NICTBB Systems Restoration Time

Factors analysis undertaken to identify a small number of factor groupings are used to represent sets of many interrelated variables; (Norusis, 1992; Ofori-Kuragu, Baiden and Badu, 2016; Kumar et al., 2020). The measured sampling adequacy, KMO, is 0.0.694. Since the KMO value is ≥ 0.5 (the threshold value), it implies that the sample was adequate for factor analysis. Similarly, the result of Bartlett's significant value, Sig. is 0.00, indicates a correlation in the gathered data.

Factor analysis was performed to check the number of variables. These factors were extracted using the principal component method with varimax rotation and factor loading greater than 0.8. Through a series of factor analyses, the variables with low factor loading were removed; this reduced the number of variables from 46 to 7. Only the variables with high factor loadings were retained, as shown in Table 3.

Eigenvalue greater than one rule: using the principal component extraction method (Figure 1); four components were extracted using Eigenvalues greater than one rule (Table 4). The results explain the total variance of the test. This means there exist three strong interrelated links between eleven existing variables.

Figure 1 and Table 4 summarize item loadings. Three dimensions were extracted using the principal component analysis method. The three factors explain 83.575% of the dependent variables. The first factor had the highest eigenvalue of 0.754. It explained about 43.673% of the variances. The second factor had eigenvalue of .431 and explained about 24.974% of the variances, while the third factor had an eigenvalue of .258 and explained about 14.927% of total variances. The results of the rotated complex matrix presented in Table 5 show that three variables (indicators) are loaded into component group one and two variables, each loaded into component groups two and three, respectively. These variables are presented in Table 6 as factors 1, 2 and 3 with their corresponding variable code and variable loadings

Table 3: Communalities for high factor loadings

Factors	Raw Initial	Rescaled Initial
Distance from maintenance centres (more travel time)	.248	1.000
Environmental (hard and rocky soil, forest, wild animals, game reserves areas)	.216	1.000
Insufficient transport facilities	.289	1.000
Lack of staff motivation	.239	1.000
No retention of experienced staff	.256	1.000
Insufficient routine maintenance work	.241	1.000
No routes patrol to proactively detect problems before link breakdown	.238	1.000

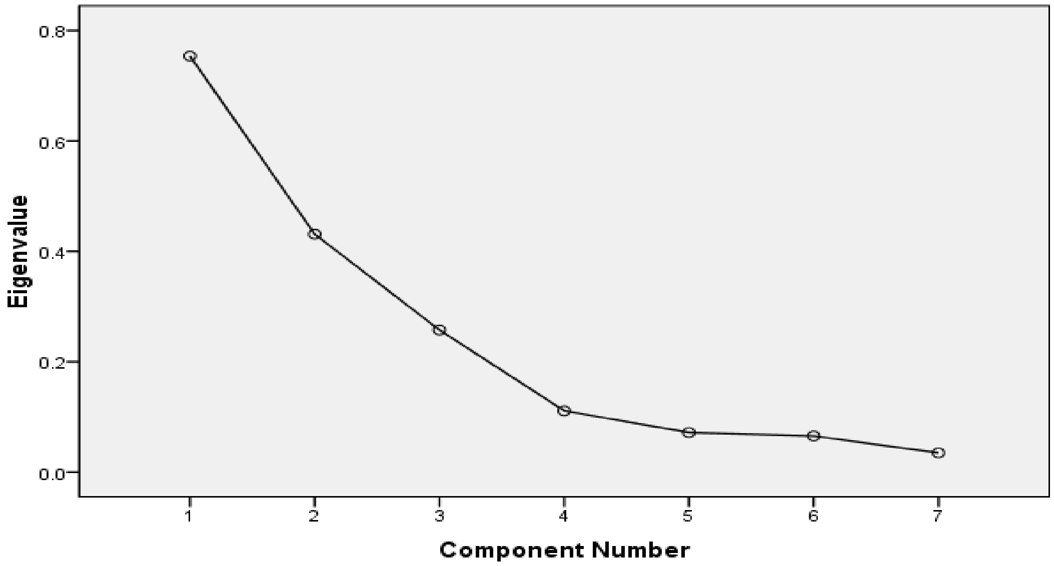

Figure 1: Scree plot to determine the number of components.

Table 4: Total Variance Explained

Items		**Initial Eigenvalues**			**Rotation Sums of Squared Loadings**		
	Component	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
Raw	1	.754	43.673	43.673	.634	36.762	36.762
	2	.431	24.974	68.647	.434	25.150	61.912
	3	.258	14.927	83.575	.374	21.663	83.575
	4	.111	6.442	90.016			
	5	.072	4.163	94.179			
	6	.066	3.796	97.975			
	7	.035	2.025	100.000			
Rescaled	1	.754	43.673	43.673	2.523	36.047	36.047
	2	.431	24.974	68.647	1.743	24.905	60.952
	3	.258	14.927	83.575	1.563	22.329	83.281
	4	.111	6.442	90.016			
	5	.072	4.163	94.179			
	6	.066	3.796	97.975			
	7	.035	2.025	100.000			

Table 5: Rotated Component Matrix

Variables	Raw			Rescaled		
	Component			Component		
	1	2	3	1	2	3
Insufficient transport facilities	.493			.917		
Distance from maintenance centres (more travel time)	.455			.914		
Environmental (hard and rocky soil, forest, wild animals, game reserves areas)	.410			.882		
No retention of experienced staff		.473			.934	
Lack of Staff motivation		.417			.854	
No routes patrol to proactively detect problems before link breakdown			.429			.880
Insufficient routine maintenance work			.417			.851

Table 6: Reliability and Importance of each factor

Factor	Number of Items	Reliability of the Factor	Variables Name	Variable Code	Variable Loading
Factor 1	3	0.906 (excellent*)	Insufficient transport facilities	VAR4	0.917
			Distance from maintenance centres (More travel time)	VAR1	0.914
			Environmental (hard and rocky soil, forest, wild animals, game reserve areas)	VAR2	0.882
Factor 2	2	0.829 (good*)	No retention of experienced staff	VAR12	0.934
			Lack of staff motivation	VAR10	0.854
Factor 3	2	0.691 (acceptable*)	No routes patrol to proactively detect problems before link breakdown	VAR17	0.880
			Insufficient routine maintenance work	VAR16	0.851

Note: * Cronbach's alpha recommendations (Sarmento and Costa, 2019)

CFA to Establish Factors Affecting NICTBB Mean Time to Repair

The number of factors connecting factors, variables and the errors specified in the Measurement model are presented in Figure 2. The model fit summary is in Table 7.

However, the modification indices for covariance suggested a link between Factor 2 and error 2 and Factor 2 and 3, which are connected with Factor 1. This was implemented as shown in Figure 3. The improved model fit is in Table 8.

Table 7: Model fit summary

Reference value	Obtained indices	Threshold value	Remarks
GFI	0.977	≥ 0.9	Very good
Normed Fit Index (NFI)	0.977	≥ 0.95	Very good
Comparative Fit Index (CFI)	0.988	≥ 0.95	Very good

Relative Fit Index (RFI)	0.988	The better, the closer to 1	Very good
Root Mean Square Error of Approximation (RMSEA)	0.061	≤ 0.05	Between Good and adequate

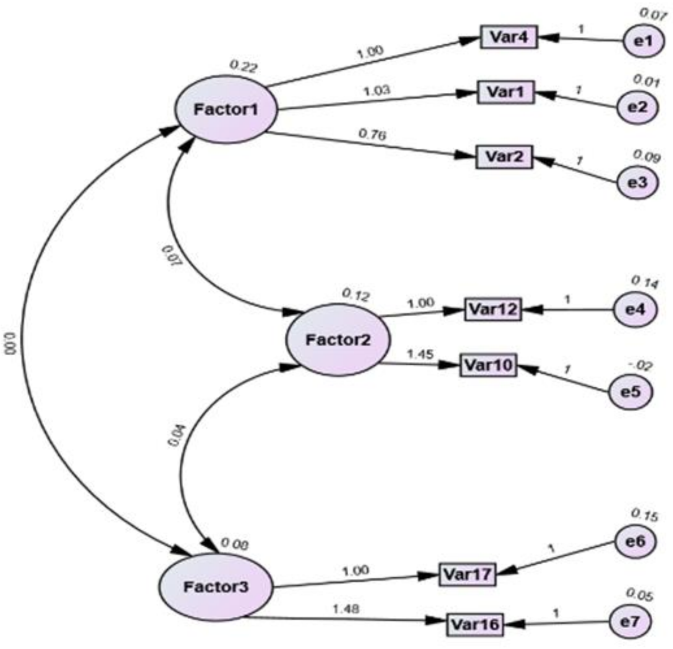

Figure 2: Measurement Model for Three Components

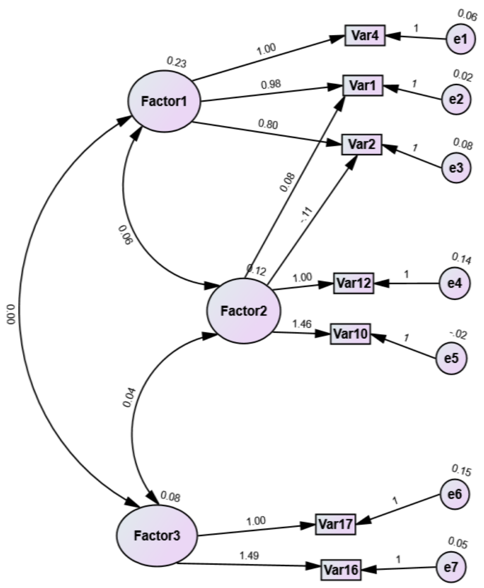

Figure 3: The improved measurement model for three components.

Table 8: The Improved Model Fit Summary

Reference Value	Obtained indices	Threshold Value	Remarks

GFI	0.987	≥ 0.9	Very good
NFI	0.987	≥ 0.95	Very good
CFI	0.996	≥ 0.95	Very good
RFI	0.970	The better the closer to 1	Very good
RMSEA	0.038	≤ 0.05	Very good

The model fit Chi-square has dropped from 22.218 to 12.513, degree of freedom (df), dropped from 11 to nine (9). Similarly, adding the two paths from Factor 2 significantly improved the model's fit. GFI increased from 0.977 to 0.987, CFI from 0.988 to 0.996, and RMSEA dropped from 0.061 to 0.038 (≤ 0.05), indicating a very good fit.

Discussion of Results on Factors Affecting NICTBB - MTTR

The main factors affecting NICTBB restoration time are as follows. First, locality and accessibility to fault location: Insufficient transport facilities prolonged restoration time for the covey restoration team to the site. Similarly, the distance and environmental condition of the affected area contributed to the delayed restoration. Second, availability and readiness of restoration team: Most restoration teams were trained during the establishment of NICTBB infrastructure (2008 -2015). Now, these workforces are retired while others quit TTCL for green pastures. Hence, the missing retention policy and the lack of motivation for the restoration team contribute to delayed restoration time. Third, unsatisfactory preventive maintenance: Insufficient routine maintenance work and absence of route patrols contribute to prolonged restoration time. Threats can be detected or identified during a routine maintenance window or routes patrol and fixed accordingly.

Regression Analysis to Establish Factors Affecting NICTBB Restoration Time

Using a model of Fit test, the linear regression analysis was performed to determine the prediction of independent variables (insufficient transport facilities, distance from maintenance, environment, no retention of experienced staff, lack of staff motivation, no routes patrol to proactively detect problems before link breakdown, insufficient routine maintenance work) over dependent variables age, education, experience and designation (Table 9). Likewise, the model summary for the same variables is in Table 10.

Table 9: ANOVA for the dependent variables

Dependent Variable	Model	Sum of Squares	df	Mean Square	F	Sig.
Age (Years)	Regression	38.973	7	5.568	7.315	.000
	Residual	203.208	267	.761		
	Total	242.182	274			
Education	Regression	64.817	7	9.260	18.911	.000
	Residual	130.732	267	.490		
	Total	195.549	274			
Experience (years)	Regression	34.988	7	4.998	3.448	.002
	Residual	387.099	267	1.450		
	Total	422.087	274			
Designation	Regression	73.774	7	10.539	6.239	.000
	Residual	451.048	267	1.689		
	Total	524.822	274			

Table 10: Model Summary for the dependent variables

Dependent variable	R	R Square	Adjusted R Square	Std. Error of the Estimate
Age	.401	.161	.139	.872
Education	.576	.331	.314	.700
Experience (years)	.288	.083	.059	1.204
Designation	.375	.141	.118	1.300

Time Taken to Restore Services when NICTBB Breakdown Occurs

After performing the reliability check, both inputs were subjected to factor analysis and regression performance on primary and secondary data. Results found that 88% of respondents know the SLA requirements of 4 hrs to restore NICTBB services. Similarly, the results show that 98.9% of the respondents reported that more than 6 hrs were taken to restore NICTBB services. The study further investigated reports on the NICTBB breakdown for 2021 (Table 11). The number of breakdowns recorded in 2021 was 185, with outage minutes of 135,764.0 (equal to 2262.7 hours). The study further found that out of 185 breakdowns, there were no recorded incidents for January and February 2021. However, only 40 breakdowns were restored in less than 4 hours (21.6%), while 7 breakdowns (3.78%) were restored in 4 hours. The remaining 138 breakdowns (74.60%) were restored in more 4 hours. Moreover, out of 138 incidents, 113 were restored in more than 6 hours (61.08%).

Table 11: Recorded NICTBB Restoration Time in 2021

Month	Restored ≤ 4hrs	Restored 4hrs	Restored ≥ 4hrs	Total Restored per Month	Restored ≥ 6hrs
Jan-21	0	0	0	0	0
Feb-21	0	0	0	0	0
Mar-21	6	0	9	15	8
Apr-21	6	0	14	20	9

May-21	7	2	8	17	7
Jun-21	2	0	16	18	14
Jul-21	1	0	10	11	7
Aug-21	3	0	20	23	18
Sep-21	2	0	13	15	10
Oct-21	4	1	16	21	11
Nov-21	3	2	12	17	11
Dec-21	6	2	20	28	18
Total	**40**	**7**	**138**	**185**	**113**
%	**21.62%**	**3.78%**	**74.60%**	**100%**	**61.08%**

Source: TTCL records on NICTBB in 2021.

Proposed Strategies for Improvement of Restoration Time

Cronbach's coefficient alpha was used to check the tool's internal coefficient and the variables' homogeneity in the measurement set. The proposed value for alpha is 0.7 or higher (Nunnally, 1978). The reliability analysis for this study was 0.927; (higher than the proposed value of 0.7), which indicates that the data's high internal consistency and reliability are, hence, acceptable for factor analysis.
The KMO and Bartlett's tests were performed to establish appropriate strategies to improve restoration time. The result shows that the value of KMO = 0.820 and the significant value is 0.000; hence, it is appropriate for the chosen techniques. Generally, to qualify for factor analysis, the recommended values for KMO > 0.5 and Bartlett's Test of Sphericity significant value < 0.05.
Three components were extracted using the principal component analysis method using Eigenvalue greater than one rule, shown in Table 12. The principal component had a total variance of 1.247, with a percentage variance of 63.075%. Other two components had 0.299 and 0.199, responsible for 15.106% and 10.088% of total variances. The extracted components had a cumulative variance of 88.269%.

Table 12: Total variance to establish restoration time strategies

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.247	63.075	63.075	.813	41.138	41.138
2	.299	15.106	78.181	.651	32.960	74.098
3	.199	10.088	88.269	.280	14.170	88.269
4	.092	4.632	92.901			
5	.046	2.327	95.228			
6	.039	1.983	97.211			
7	.030	1.519	98.730			
8	.016	.811	99.540			
9	.007	.332	99.872			
10	.003	.128	100.000			

Varimax with Kaiser Normalization method was used to obtain the interlinked factors in each component. Using varimax simplifies the interpretation of factors, as it is easy to interpret the association of variables with respective factors. The results in Tables 13 and 14 show the association of ten variables in three groupings. Four variables were heavily loaded in factor groups one and two. One variable distributed its loading in the first two groups, while only one variable was associated directly with group three, with a factor loading of 0.954.

Table 13: Rotated component matrix to establish restoration time strategies

Variables	Component		
	1	2	3
Enhance NICTBB maintenance activities	.887		
Enhance availability of funds (Management support)	.885		
Improve the availability of human capacity	.877		
Improve availability of working tools and test gears at all maintenance centres	.870		
Boost Staff motivation		.880	
Enhance proper communication		.797	
Increase availability of spares	.530	.763	
Increase availability of transport facilities		.758	
Revise management decision to prioritize the NICTBB maintenance process.		.668	
Develop relationships with other stakeholders			.954

Table 14: Reliability and importance of each factor

Factor	Number of Items	Reliability of the factor	Variables Name	Variable Code	Variable Loading
Factor 1	4	0.959 (excellent*)	Enhance NICTBB maintenance activities	VAR07	.887
			Enhance the availability of funds	VAR04	.885
			Improve the availability of human capacity	VAR06	.877
			Improve availability of working tools and test gears at all maintenance centres.	VAR05	.870
Factor 2	5	0.920 (Excellent*)	Boost staff motivation	VAR08	.880
			Enhance proper communication	VAR10	.797
			Increase availability of spares	VAR03	.763
			Increase availability of transport facilities	VAR02	.758
			Revise management decisions to prioritize the maintenance process	VAR01	.668
Factor 3	1	0.954 (Excellent*)	Develop relationships with other stakeholders	VAR09	.954

Note: * Cronbach's alpha recommendations (Sarmento and Costa, 2019).

Strategies to improve NICTBB restoration time

The model fitness results imply a very good fit for establishing NICTBB restoration time strategies. The model provides an indicative strategy to improve NICTBB restoration time.

Factor 1 (Figure 3 and Table 16) represents NICTBB operations and maintenance strategy for this case. The strategy will enable the NICTBB manager to align its internal processes with prioritizing NICTBB maintenance works and providing key resources, including funds, proper training, and increased availability of restoration tools and test gears. The strategies were further confirmed via the computation of the model fit indices in Figure 3 and Table 15.

Table 15: Model Fit Summary for Mitigation Strategies

Reference Value	Obtained indices	Threshold Value	Remarks
GFI	0.997	≥ 0.9	Very good
Normed Fit Index (NFI)	0.999	≥ 0.95	Very good
Comparative Fit Index (CFI)	1.000	≥ 0.95	Very good
Relative Fit Index (RFI)	0.998	The better, the closer to 1	Very good
Root Mean Square Error of Approximation (RMSEA)	0.000	≤ 0.05	Very good

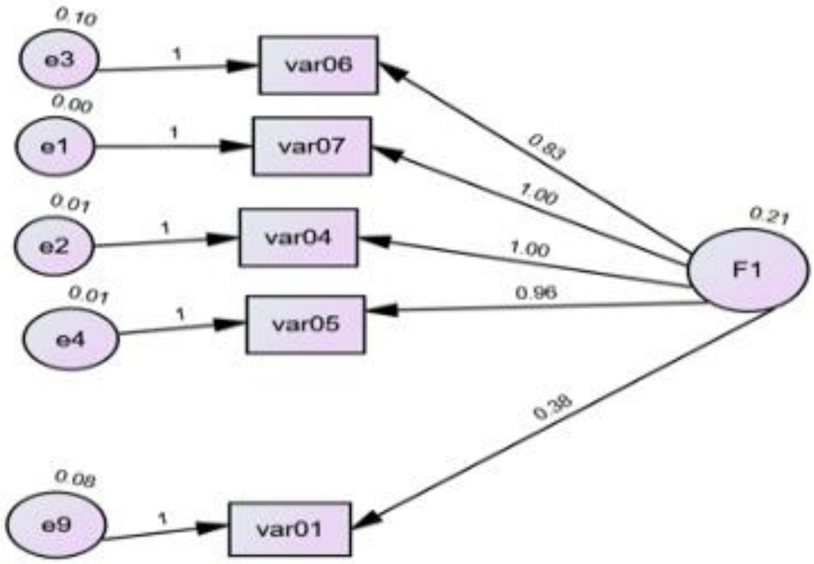

Figure 3: Output of Measurement Model for Mitigation Strategies.

Table 16: Strategies to improve NICTBB restoration time

Factor	Number of Items	Reliability of the factor	Variables Name	Variable Code	Variable Loading
Factor 1	5	0.929 (excellent)*	Enhance NICTBB maintenance activities	VAR07	.887
			Enhance availability of funds	VAR04	.885
			Improve availability of human capacity	VAR06	.877
			Revise Management decision to prioritize NICTBB maintenance process	VAR01	.668
			Improve availability of working tools and test gears at all maintenance centres	VAR05	.870

Note: * Cronbach's alpha recommendations (Sarmento and Costa, 2019)

Regression analysis to establish restoration time strategies

The results of this study paved the way for regression analysis using Fit model analysis to measure the variances between independent variables (Predictors) and dependent variables (respondents' demography characteristics). The model summary is presented in Table 17.

Table 17 provides R and R square (R^2) values. The result of R indicates a degree of correlation between dependent variables, respondents' age, i.e. R=0.665 (66.5%); gender, R=0.740 (74.0%); Education levels, R=0.726 (72.6%) and independent variables under this analysis. The R square (R^2 = 0.443 (respondents' age), R^2 = 0.547 (respondents' gender) and R2=0.527 (respondents' education levels) indicate how much of the total variation in the dependent variable can be explained by the five independent variables (constant).

Similarly, the results from ANOVA indicate a significant goodness of fit between the dependent variables and five independent variables under the study. The indicated F statistics (F=42.735, 59.982, and 20.159) were significant at a 95% confidence level (i.e. Sig. value, p=*0.000 < 0.05),* showing the model had predictive power. Therefore, a statistically significant relationship exists between the proposed mitigation measures to improve NICTBB restoration time. Thus, the variables were significant to be considered as strategies (Table 18).

Table 17: Model summary for Regression analysis

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate
Age	0.665	0.443	0.432	0.708
Gender	0.740	0.547	0.539	0.318
Education	0.726	0.527	0.518	0.586

Table 18: Significances of Regression Coefficients

Independent Variables	Dependent Variables				
	Coefficient Result: Sign value, p ≤ 0.05				
	Gender	**Age**	**Education Level**	**Designation**	**Working Experience**
Revise Management decision to prioritize NICTBB maintenance process	√			√	√
Improve availability of working tools and test gears at all maintenance centres		√	√	√	
Improve the availability of human capacity	√	√	√		√
Enhance availability of funds (Management support)	√	√	√		
Enhance NICTBB maintenance activities.				√	

Note: √ represents Significance variables for demographic characteristics.

CONCLUSIONS AND IMPLICATIONS OF THE STUDY

Concluding remarks

The study found that three main factors currently affect the NICTBB restoration time: locality and accessibility to fault location, availability and readiness of restoration team and unsatisfactory preventive maintenance services. The three variables contribute to the prolonged restoration time. The distance and topology of the breakdown from the maintenance centres and insufficient transport facilities covey the restoration team to the site. Most restoration staff trained during the establishment of NICTBB infrastructure (2008 -2015) had retired, while others quit TTCL.

The unavailability of a staff retention scheme and lack of motivation to work in various topologies also lead to delayed service restoration. Similarly, there is a close relationship between factor one (availability and readiness of restoration team) and the two variables of factor number two (the distance from maintenance centres (VAR1) and the environmental condition (VAR2), of which both require the availability of transport facilities to convey the team to the affected point for trouble localization and restoration, hence its absence delays restoration services.

Insufficient routine maintenance and the absence of frequent NICTBB route patrols contribute to prolonged restoration time. Threats detected or identified during a routine maintenance window or during normal patrols might have been fixed on time to minimize restoration time. Primary data analysis revealed that NICTBB services are being restored in more than six hours. However, there were some incidents where services restored through alternative routes showed that there was a free capacity to facilitate channel re-routings.

Analysis of secondary data revealed that out of 185 breakdowns recorded in 2021, only 40 breakdowns (21.6%) were restored in less than four (4) hours, while seven (7) breakdowns (3.78%) were restored in more than four (4) hours. The remaining 138 breakdowns (74.60%) were restored in more than 4 hours. Moreover, out of 138 incidents, 113 incidents were restored in more than 6 hours (61.08%). These results conform to respondents' views, where 98.9% of the respondents confirmed that more than 6 hours are taken to restore the NICTBB services.

Analysis of the proposed strategies discovered the need to enhance NICTBB operations and maintenance strategy. The strategy would enable the NICTBB Manager to align its internal processes with prioritizing NICTBB maintenance works and providing key resources, including funds, transport facilities, proper training, and working tools and test gears at all maintenance centres. The availability of these resources at the nearby maintenance centres will reduce the time needed to mobilize the restoration team and resources; hence, fault localization and restoration time will be minimal.

Implications of the Study

National Telecommunications Policy (1997) aims to establish reliable telecommunication infrastructure and ensure service interconnectivity nationally and internationally (Wangwe, 2010; Mbarawa, 2012; Byanyuma et al., 2017; Chingumbe, 2019). The National ICT Policy of 2016 specifies strategies 4 and 5 stems to ensure the availability of enhanced accessible, reliable and affordable broadband services. The ICT infrastructure should be interoperable and sustainable to support universal national connectivity (MWTC, 2016b). The same has been nailed under the Five-Year National ICT Policy Implementation Strategy of 2016/17 – 2020/2021 (MoFP, 2016).

It is anticipated that the outcome of this study will benefit TTCL as NICTBB Manager, Government as the owner of the infrastructure, policymakers, researchers and the general public in the following manner; firstly, the NICTBB manager (TTCL), who will be able to understand the factors affecting the prolonged delays to restore systems from breakdowns. The awareness of the factors will assist TTCL in utilizing the information researched for NICTBB maintenance improvement and promptly react to the challenges even before their occurrence. Secondly, to the responsible ministry, the study's outcome can be utilized as input during its planned review of the national ICT policy 2016 implementation strategies requirement. Furthermore, the gathered information will contribute to the inputs, especially during the review of the development vision 2025 part of the regular evaluation and monitoring exercise. Fourthly, for society, the availability of uninterrupted ICT services will facilitate access to various online and other services requiring broadband facilities at their fingertips. Lastly, the study will contribute the inputs to policymaking, especially in the NICTBB context, and it broaden the literature for future researchers on NICTBB contexts.

REFERENCES

Alliance for Affordable Internet. (2016). Affordable Internet in Ghana: The Status Quo and The Path Ahead. *Organisation for Economic Co-Operation and Development*, 1–14. Retrieved from: https://www.oecd.org/aidfortrade/casestories/casestories-2017/CS-03-A4AI-Affordable-Internet-in-Ghana.pdf. [Accessed on 14th May 2022].

Kowero, A. B. (2012). *Exploiting the Potentials of the National Information and Communication Technology Broadband Backbone (NICTBB).* Retrieved from: http://www.tanzania.go.tz/egov_uploads/documents/pj_sw.pdf. [Accessed on 7th June 2021].

Belassi, W., & Tukel, O. I. (1996). A new framework for determining critical success/failure factors in projects. *International Journal of Project Management*, **14**(3), 141–151. Retrieved from: https://doi.org/10.1016/0263-7863(95)00064-X. [Accessed on 9th February 2020].

Byanyuma, M., Yonah, Z. O., Simba, F., & Trojer, L. (2017). Overview of Broadband Connectivity for Rural Areas - Tanzania as a Case Study. *International Journal of Computer Science and Information Security (IJCSIS)*, **15**(4), 312–320. [Accessed on 24th March 2022].

Elder, L., Emdon, H., Fuchs, R., & Petrazzini, B. (2012). *Connecting ICTs to Development*. *Connecting ICTs to Development: The IDRC Experience*, 299. Retrieved from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84939802912&partnerID=40&md5=e430ce156d9cd4feaa34e17551782502. [Accessed on 20th June 2021].

Hoyle, R. H. (2000). Confirmatory Factor Analysis. In *Handbook of Applied Multivariate Statistics and Mathematical Modelling*, 465–497. Elsevier. Retrieved from: https://doi.org/10.1016/b978-012691360-6/50017-3. [Accessed on 20th May 2022].

Broadband Infraco. (2019). *Broadband Infraco: 2018/2019 Integrated Annual Report*. Retrieved from: https://infraco.co.za/ broadband-infraco-integrated-annual-report-2019/. [Accessed on 21st June 2021].

Broadband Infraco. (2020). *Broadband Infraco: Corporate Plan 2019/20 - 2023/24*. Retrieved from: https://infraco.co.za/broadband-infraco-integrated-annual-report-2020/. [Accessed on 21st June 2021].

Kiminza, M. M., & Were, S. (2016). Factors Affecting Successful Implementation of Fiber Optic Cable Projects in Kenya: A Case of Nairobi City County. *Developing Country Studies*, **6**(10), 52–59. [Accessed on 14th May 2022]. Retrieved from: https://core.ac.uk/download/pdf/234683085.pdf. [Accessed on 18th June 2021].

Kowero, A. B. (2012). *Exploiting the Potentials of the National Information and Communication Technology Broadband Backbone (NICTBB).* Retrieved from: http://www.tanzania.go.tz/egov_uploads/documents/pj_sw.pdf. [Accessed on 18th June 2021].

Kumar, D., Kumar, R., & Sharma, N. (2020). Dual link failure survivability with recovery time constraint: A Parallel cross connection backup route recovery strategy. Retrieved from: https://www.researchgate.net/publication/339737445_Dual_link_failure_survivability_with_recovery_time_constraint_A_Parallel_cross_connection_backup_route_recovery_strategy. [Accessed on 14th May 2022].

Masenya, C., Reweta, W., Magere, D., Temba, L., & Macha, D. (2018). Drivers of Economic Growth in Tanzania, **14**, 1–55. Retrieved from: https://www.bot.go.tz/Publications/Other/Working%20Papers%20Series/en/202002112248289O233.pdf. [Accessed on 20th June 2021].

Mbarawa, M. (2012). Investment in ICT in Tanzania. *The Southern African ICT for Education Summit*. Retrieved from: http://africanbrains.net/edusa/hon-prof-makame-mbarawa-minister-of-communication-science-technology-tanzania/. [Accessed on

Republic, U. (2005). Ministry of Communications and Transport. *Technical Report On Feasibility Study for Implementation of the National ICT Backbone Infrastructure (United Republic of Tanzania).* Retrieved from: http://www.tzonline.org/pdf/thenationalictbackboneinfrastructure.pdf. [Accessed on 21st June 2021].

MoFP (2016). Ministry of Finance and Planning. *'Nurturing Industrialization for Economic Transformation and Human Development'*. Retrieved from: https://repository.mof.go.tz/handle/123456789/136. [Accessed on 20th June 2021].

MoFP. (2020). MoFP ICT POLICY. *Revised Medium Term Strategic Plan 2017-18 2020 – 2021*. Retrieved from: http://repository.mof.go.tz/handle/123456789/129. [Accessed on 18th June 2021].

ITU, & UNESCO. (2020). *The State of Broadband 2020: Tackling digital inequalities - A decade for action. ITU Publications*, 11–44. Retrieved from: https://www.itu.int/en/myitu/Publications/2020/09/18/07/52/The-State-of-Broadband-2020. [Accessed on 14th May 2022].

MWTC. (2016). *Tanzania National Information and Communications Technology Policy 2016*. Retrieved from: https://www.ega.go.tz/uploads/publications/sw-1574848612-SERA%202016.pdf. [Accessed on 20th May 2021].

MWTC. (2016). National Information and Communications Technology Policy 2016 Implementation Strategy 2016/17 – 2020/21, 1–65. Retrieved from: https://nwf.go.tz/static/uploads/NATIONAL_ICT_POLICY_IMPLEMENATION_STRATEGY.pdf. [Accessed on 20th May 2021].

NITA - Uganda. (2017). *Uganda National Information Technology Authority: 2017 Statistical Abstract*. Retrieved from: www.nita.go.ug. [Accessed on 18th June 2021].

Governments, L. (2018). National IT Survey 2017/18 Report, (March), 1–58. Retrieved from: https://www.nita.go.ug/. [Accessed on 18th June 2021].

NITA. (2019). National information technology authority 2019. *NITA-U Statistical Abstract*. Retrieved from: https://www.nita.go.ug/. [Accessed on 14th May 2022].

Norusis, M. J. (1992). *SPSS for Windows TM: Professional Statistics TM, Release 5* (p. 348). Chicago: SPSS Inc. Retrieved from: https://openlibrary.org/authors/OL5481820A/M._J._Noru%C5%A1is. [Accessed on 31st August 2022].

Nunnally, J. (1978). Psychometric Theory, 2nd. edMcGraw-Hill. *New York*. Retrieved from: http://garfield.library.upenn.edu/classics1979/A1979HZ31300001.pdf. [Accessed on 31st August 2022].

Ofori-Kuragu, J. K., Baiden, B., & Badu, E. (2016, May 3). Critical success factors for Ghanaian contractors. *Benchmarking*. Emerald Group

Publishing Ltd. Retrieved from: https://doi.org/10.1108/BIJ-03-2014-0018. [Accessed on 31st August 2022].

Pazi, S., & Chatwin, C. (2014). 9997991. *World Academy of Science, Engineering and Technology International Journal of Economics and Management Engineering, Vol:8*(No: 3). The Impact of NICTBB in Facilitating the E- Services and M-Services in Tanzania. Retrieved from: http://www.iji-cs.org/. [Accessed on 24th July 2021].

Pazi, S. M., & Chatwin, C. R. (2013). Assessing the Economic Benefits and Challenges of Tanzania's National ICT Broadband Backbone (NICTBB). *International Journal of Information and Computer Science*, ***2***(7). Retrieved from: www.iji-cs.org. [Accessed on 10th February 2020].

Pazi, S. (2014). *Assessing the Economic Benefits and Challenges of Tanzania's National ICT Broadband Backbone (NICTBB) African Satellite Communications View Project Power Excitation Sources for EIT or Bio-Impedance System View project*. Retrieved from: www.iji-cs.org. [Accessed on 14th May 2022].

Pima, J. M., Adebayo, M., Iqbal, R., & Sedoyeka, E. (2016). Assessing the available ICT infrastructure for collaborative web technologies in a blended learning environment in Tanzania: A mixed methods research. *International Journal of Education & Development Using Information & Communication Technology*, **12**(1), 37–52. Retrieved from: https://www.semanticscholar.org/paper/Assessing-the-Available-ICT-Infrastructure-for-Web-Pima-Odetayo/8e6181ec4b2915db1d027dbec1e95aa5862de37f. [Accessed on 14th May 2022].

Prudon, P. (2015). Confirmatory Factor Analysis as a Tool in Research Using Questionnaires: A Critique. *Comprehensive Psychology*, *4*, 03. CP.4.10. Retrieved from https://doi.org/10.2466/03.cp.4.10. [Accessed on 20th May 2022].

ITU. (2019). Measuring Digital Development. *ITU Publications*, 1–15. Retrieved from: https://www.itu.int/en/mediacentre/Documents/MediaRelations/ITU Facts and Figures 2019 - Embargoed 5 November 1200 CET.pdf. [Accessed on 14th May 2022].

Gog. (2003). The Ghana ICT for Accelerated Development. *Economy and Society*, (June), 1–85. Retrieved from: http://www.ict.gov.gh. [Accessed on 14th May 2022].

Sarmento, R. P., & Costa, V. (2019). Confirmatory Factor Analysis -- A Case study. Retrieved from: http://arxiv.org/abs/1905.05598. [Accessed on 20th May 2022].

Sedoyeka6, E., & Sicilima, J. (2016). *Tanzania National Fibre Broadband Backbone: Challenges and Opportunities*. *International Journal of Computing and ICT Research*, **10**, 61–92. Retrieved from: http://www.ijcir.org/volume. [Accessed on 9th February 2020].

TCRA. (2020). *Quarterly Communications Statistics. July - September 2020*, 1–20. Retrieved from: https://www.tcra.go.tz/uploads/text-editor/files/september_1619156609.pdf. [Accessed on 14th May 2022].

TCRA. (2010). Report on Internet and Data Services in Tanzania a Supply-Side Survey, (September), 1–36. Retrieved from: http://tcra.go.tz/publications/InternetDataSurveyScd.pdf. [Accessed on 21st June 2021].

UNCTAD. (2020). *United Republic of Tanzania Rapid eTrade Readiness Assessment*. UN. Retrieved from: https://doi.org/10.18356/6a9ee652-en. [Accessed on 14th May 2022].

Wangwe, S. (2010). A Study on the Application of ICT in Improving Livelihood of the Poor and in Supporting Growth in General. *Ministry of Finance and Economic Affairs*, (June), 1–102.

Yonah, Z. (2007). Towards a Converged Multi-Service ICT Infrastructure: The Case of Emerging TTCL Network. Retrieved from: https://www.researchgate.net/

publication/317281853_Towards_a_Converged_Multi-Service_ICT_Infrastructure_The_Case_of_Emerging_TTCL_Network. [Accessed on 24th March 2022].

Yonazi, J. (2009). ICT4D: Facing the Challenges Head-on in Tanzania. *Thetha - Regional ICT Discussion Forum Project*, (July), 2–32. Retrieved from: https://www.comminit.com/content/thetha-ict-discussion-forum. [Accessed on 21st June 2021].

.