

PERFORMANCE EVALUATION AND IMPACT ANALYSIS OF INTERMODAL TRANSPORT SYSTEM IN NIGERIA

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ABSTRACT

Intermodal transportation system is the backbone of industrial revolution in the world today. Almost 100% of produce are not consumed at the point of production, even when sold, they must be transported to the point of need. Economy of scale which is the mathematics of growing the gross domestic product (GDP) of a Nation, depend solely on intermodalism. The study aim at evaluating the performance and impact of intermodal transport system in sustaining the transportation network in Nigeria. This study was carried out by assessing and evaluating the performance of the available modes of transportation in Nigeria with a view for possible intermodal connection. Desktop method was used to collect data. Performance condition models were used to analyse data while descriptive statistical tool like the time series graph were used to present findings.. The results from various performance goals considered showed that, all available transportation modes in Nigeria need to be upgraded for a viable and sustainable intermodal system to function in Nigeria. The infrastructural condition of all modes of transportation in Nigeria needs urgent upgrading, private sector performance in transportation system development need to be inaugurated and periodic maintenance culture need to be inculcated.

Keywords: Intermodal, Transport, Performance, Mode, Infrastructure

1 INTRODUCTION

Intermodal transportation system is defined as the integrated management of various modes of transportation with improved efficiency in moving freight and passengers [1]. The coordinated interchange between two or more modes shows how seamless or otherwise the intermodal system is. Intermodal transportation network is a logically linked system using two or more transport modes with a single rate [2]. In today's world, intermodal transportation system forms the back-bone of world trade. Contrary to conventional transportation systems in which different modes of transportation operate in an independent manner, intermodal transportation aims at integrating various modes and services of transportation to improve the efficiency of the whole distribution process. Since the enactment of the Intermodal Transportation Efficiency Act (ISTEA) [3], and the Transportation Equity Act for the 21st Century (TEA-21) [4], in the U.S, the issue on how to evaluate an intermodal transportation system is getting more attention. The fundamental idea of intermodal transportation is to consolidate loads for efficient long-haul (for example, by rail or large ocean vessels), while taking advantage of the efficiency of local pick-up and delivery operations by truck. Intermodal transportation is not restricted, however, to containers and intercontinental exchanges. For instance, the transportation of express and regular mail is intermodal, involving air and land, long-haul transportation by rail or trucks, as well as local pick-up and delivery operation by truck [5]. Due to Nigeria's diversity, population growth rate and growth in commerce, it is very clear that a single mode of transportation cannot serve the need of the entire nation, the structure for managing and operating transportation system must be flexible and adaptable to local needs. Road transportation system has dominated the movement of freight and passengers in Nigeria to the detriment of other transportation modes yet without meeting the transport needs, [6]. A typical intermodal transportation system connection with required intermodal interchanges for freight and passenger movement is shown in Figure, is seriously needed for the sustenance of the entire transport system in Nigeria. The

seamless connection between road, rail and water seen in Figure 1, is as a result of the existing interchange at the point of connection of the modes, seen in shape of lifting crane, which is the aim of the study. The interchange helps in facilitating the transfer of both freight and passengers from one mode to the other so that expected total travel time is not exceeded. For this system to work effectively, all modes need to be in optimum performance condition. That means, no mode can bring about the delay of cargo or passengers due to infrastructural or operational failures.

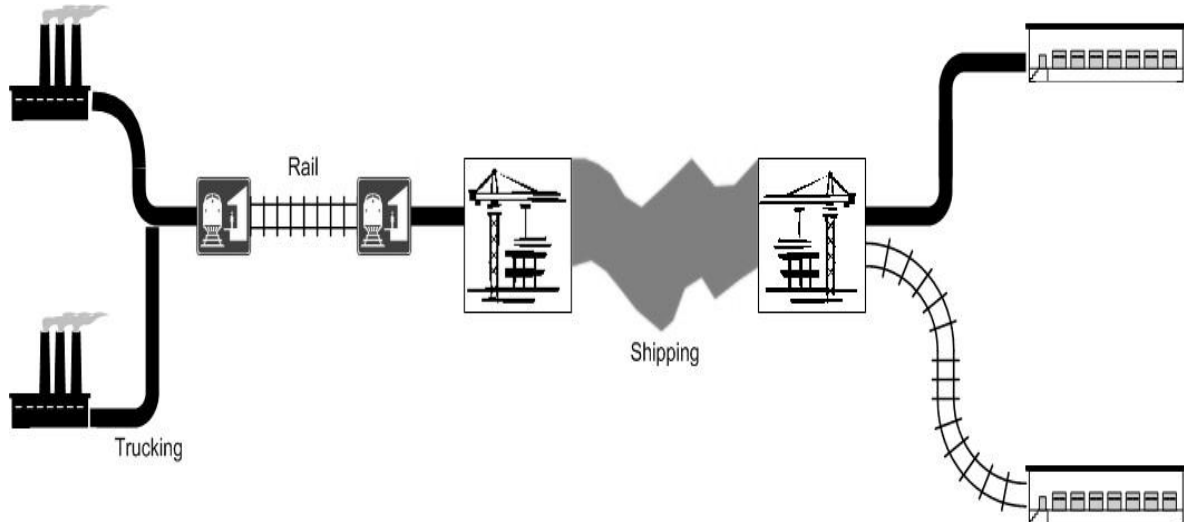


Figure 1. A typical intermodal connection [1]

2 METHODOLOGY

The research was carried out by assessing and evaluating the performance of available transportation modes in Nigeria for better understanding of their various advantages. The relationship between two or more modes of transportation is based solely on the way they complement each other in terms of shared advantages. Connectivity amongst modes was sort out from similarities and compatibility. The various transport system existing in Nigeria were analyzed in terms of capacity and safety performance for the possibility of an intermodal connection. Data on the capacity and performance of modes of transportation in Nigeria were collected from desktop studies including relevant journals, books and the internet. The data were analysed using basically the intermodal safety condition performance models below:

$$\text{If, } \frac{P}{x_1 + \dots + x_n} > (x_1 + \dots + x_n) \times Ca \quad (1)$$

The mode cannot be connected to an intermodal transportation system.

$$\text{If } \frac{P}{x_1 + \dots + x_n} < (x_1 + \dots + x_n) \times Ca \quad (2)$$

The mode is ready for connection as a part of an intermodal transportation system, using an interchange point.

Where:

P = Total number of accidents for the years considered $(x_1 + \dots + x_n)$ = Total number of years considered.

Ca = Factor of safety for accidents per mode for the years considered given by:

$$Ca = \frac{\text{Total number of incident}}{\text{Total number of fatality}} \quad (3)$$

Data were presented using simple statistical tool like the time series graphs.

3 RESULTS AND DISCUSSION

3.1 Transportation Operation and Performance in Nigeria

The performance of air transportation in Nigeria between 2004 and 2013

From available statistic on some performance variables, there has been increase in air transportation in Nigeria from the beginning of the Millennium 2000, [7]. The performance variables considered are passenger patronage, tonnage of freight and flight patronage. Table 1, shows the performance parameters and their indices from 2004 to 2013 [7]. It is noticed that a steady growth in both the loaded and unloaded freight indicate almost 100% increase on loaded freight between year 2004 and 2008, and a corresponding growth of up to 400% on the unloaded freight shows increase patronage of visitors and investors to and from Nigeria, respectively. The passenger movement increased by 21 percent, cargo movement rose by 744.6 percent and aircraft movement increased by 2.3 percent in the year 2008. In the year 2009 and 2010, air traffic figures showed a growth of 17.2 percent and air traffic figures increased by 12.3 percent, showing that air transportation is currently doing well in Nigeria. But, from the same figure it is seen that unloaded freight surpasses loaded freight with a very large margin about 250%. This shows that Nigeria’s air-facilities are operating only for the benefit of importers bringing goods into Nigeria, not for the export from Nigeria that is needed for international intermodalism. The statistical time series graph in Figure 2 shows the results of loaded and unloaded freight from 2004-2013 in Nigeria.

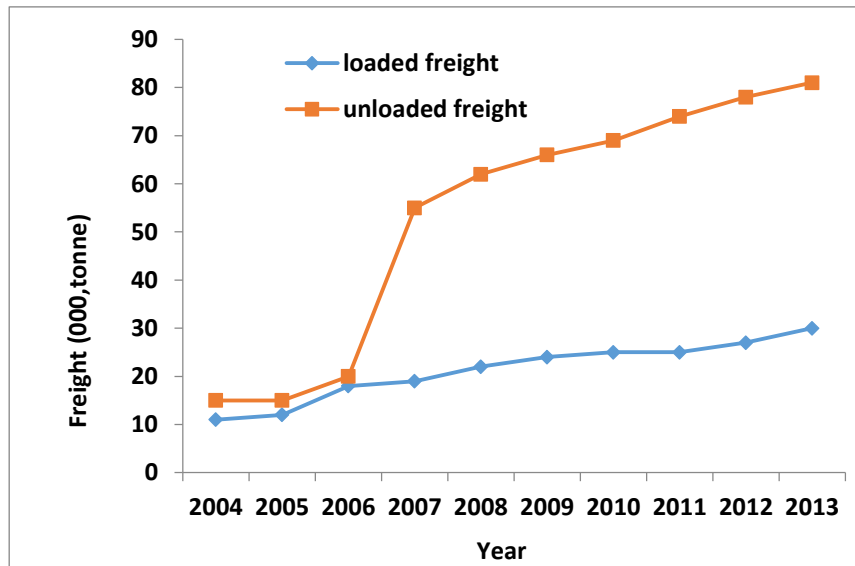


Figure 2. loaded and unloaded freight from year 2004-2013

Table 1. Air performance data from 2004-2013 [7]

Performance Parameter	Year									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Loaded Freight (000 tonnes)	11,923	12,726	18,052	19,972	22,518	24,214	25,119	25,784	27,609	30,106
Unloaded freight (000tonnes)	15,302	15,266	20,785	55,160	62,158	66,201	69,310	74,200	78,129	81,014
Passengers departing	533,525	624,174	652,019	646,777	733,445	782,300	809,161	848,400	900,000	961,342
Transiting passengers	163,776	139,503	91,344	31,260	27,857	25,049	21,428	18,604	15,852	12,400
Arriving passengers	519,987	609,984	614,307	614,307	711,781	767,200	849,119	978,124	1,200,400	1,542,670
Aircraft arriving	16,996	7,009	6,930	7,869	9,097	11,207	11,940	13,100	13,789	16,800

3.2 Rail Transportation

Today, Nigerian Railway Corporation operates a network of rail totaling 3,505 kilometers (2,178 miles) of single line tracks with 1,067mm gauge [8]. The Nigerian Railway Corporation as of 2002 carries annual freight traffic of less than 100,000 tons [8]. Nigeria has no railway lines to other neighboring countries, except for the proposed big gauge rail line from Kano-Maradi in Niger republic which is yet to see the light of day. The growth of the railway transport market in Nigeria is far much lower than the rest of the world. In Nigeria today, road had taken over the function of rail in freight and passenger transportation [9]. Table 2 shows a comparison between rail and road in freight transport from 2004-2013.

Table 2. Import cargo conveyed by rail and road in Nigeria from 2004-2013 [9]

Year	Import	Tonnage by rail	Percentage	Tonnage by road	Percentage
2004	4,690,585	4,832	0.10	4,685,755	99.89
2005	4,600,575	2,752	0.06	4,603,823	99.94
2006	4,326,542	2,752	0.66	4,323,790	99.94
2007	6,541,330	15,320	0.23	6,526,010	99.77
2008	7,271,662	18,381	0.24	7,702,241	99.76
2009	9,046,522	20,642	0.23	9,025,880	99.77
2010	10,201,011	20,124	0.20	10,180,887	99.80
2011	12,012,711	22,471	0.19	11,990,240	99.81
2012	12,788,412	20,701	0.16	12,767,711	99.84
2013	15,891,721	23,264	0.15	15,868,457	99.86

Using a time-series graph, the relationship between the tonnage of freight carried by rail and road is presented as shown in Figure 3. The steady decline in the tonnage carried by rail indicates an urgent need for rehabilitation of the railway sector to support the road that is being over stretched. Railway is design to carry more tonnage of freight as compared to road. A single 15-barge tow of a ship is equivalent to 225 rail-cars which in turn is equivalent to 870 trailer trucks. That means only two 112 rail car trains can carry the load of 870 trailers, relieving the road from unnecessary stress that could cause a lot of damage to the road.

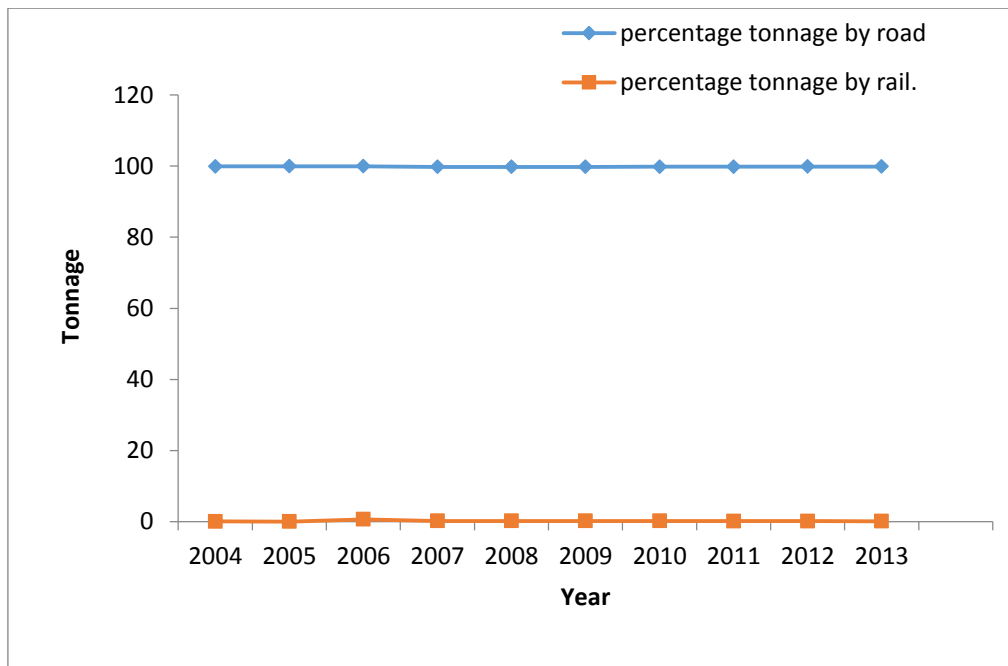


Figure 3. Percentage tonnage of freight carried by road and rail in Nigeria (2004-2013)

3.3 Analysis of Safety Performance of Road, Rail, Water and Air Transportation Based On Accident Data for Intermodal Connection in Nigeria

The analysis of safety performance goal of available modes of transportation for intermodal connection in Nigeria was strictly based on accidents and fatality data that occurred within a period of time. The accident data used in computing the summary of average values of mode accidents per year in Nigeria, were obtained from: 1) Road accident data from 1990-2012 [10]. 2) Rail accidents 1990-2005 from [11], this value is inclusive of number of derailment, collisions, washouts, broken rail and loss of control. 3) Boat and Ferry accidents in Port Harcourt waterways 2004-2010 and 2004-2016 respectively [12, 13]. 4) Air accidents 1969-2012 [14].

Table 3. Statistics of Road Traffic Accident in Nigeria 1990-2012 [10]

Year	RTA			Total	Casualty		Total
	Fatal	Serious	Minor		Killed	Injured	
1990	6140	8796	6998	21934	8154	22786	30940
1991	6719	8982	6845	22546	9525	24508	34033
1992	6986	9324	6554	22864	9620	25759	35379
1993	6735	8443	6281	21459	9454	24146	33600
1994	5407	7522	5275	18204	7440	17938	25378
1995	4701	7276	5053	17030	6647	14561	21208
1996	4790	6964	6488	18242	6364	15290	21654
1997	4800	7701	4987	17488	6500	10786	17286
1998	4757	7081	4300	16138	6538	17341	23879
1999	4621	6888	4356	15865	6797	17728	24523
2000	5287	6820	4499	16606	8473	20677	29150
2001	6966	8185	5379	20530	9946	23249	33195
2002	4029	7190	3325	14544	7407	22112	29519
2003	3910	7882	2572	14364	6452	18116	24568
2004	3275	6949	4051	14275	5351	16897	22249
2005	2299	4143	2620	9062	4515	15779	20298
2006	2600	5550	964	9114	4944	17390	22334
2007	2162	4812	1503	8477	4673	17794	22467
2008	3024	5671	2646	11341	6661	27980	34641
2009	2460	6024	2370	10854	5693	27270	32963
2010	1178	2819	1333	5330	4065	18095	22160
2011	1764	2485	516	4765	4372	17464	21836
2012	1953	3106	1210	6269	4260	20757	25017
Total	96563	150613	90125	337301	153853	454423	608277

Table 4. Statistics of Railroad Accidents in Nigeria: 1997-2005 [11]

Accident Type	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total Accident Type
Derailment	85	106	114	47	47	32	36	55	31	553
Collision	16	14	27	17	29	19	23	12	7	169
Washouts	8	11	12	24	4	6	9	4	3	81
Broken Rails	6	8	17	3	3	11	13	11	5	77
Loss of Control	-	25	17	16	6	16	3	2	5	90
Total Accident per Year	115	164	187	107	85	84	84	89	51	970

Table 5. Statistics of Waterway Accidents (boats) in Port-Harcourt Waterways, Nigeria: 2004-2010 [12]

Year	No of Boats involved	Non-fatal	Fatal
2004	78	44	34
2005	83	36	47
2006	64	38	26
2007	56	28	28
2008	39	7	32
2009	41	29	12
2010	26	22	4
Total	382	200	182

Table 6. Statistics of Ferry Accidents in Port-Harcourt Waterways.2004-2016 [13]

Year	No of Ferry Involved	Non-fatal accident	Fatal accident
2004	63	21	42
2005	48	48	0
2006	61	34	27
2007	46	17	29
2008	32	12	20
2009	35	10	25
2010	42	26	16
2011	26	21	5
2012	15	13	2
2013	21	19	2
2014	12	11	1
2015	8	6	2
2016	1	11	3
Total	402	249	174

Table 7. .Statistics of Air Accident (Planes and Helicopters) in Nigeria 1969-2012 [14]

Year	Plane	Place	Frequency	Dead	Survivors
1969	Nigeria Airways	-	1	87	-
1975	Royal Jordanian	Kano	1	5	166
1978	Nigerian Airways	Kano	1	16	-
1983	Nigerian Airways	Enugu	1	53	-
1988	Skypower Brandeironate	Illorin	1	All on board	-
1990	Okada Air	Sokoto	1	-	55
1991	British Helicopter	Akwa Ibom	1	9	-
1991	Cessna Citation	-	1	All on board	-
1991	Okada Air	Sokoto	1	3	50
1991	Nigeria Airways	Saudi Arabia	4	261	-
1992	Nigeria Airways	Lagos	1	200	-
1995	Harka Air Service	Lagos	1	16	-
1995	Nigeria Airways	Kaduna	2	9	-
1996	Ibrahim Abacha	Kano	1	14	-
1996	ADC Air	Lagos	2	151	-
1997	Skypower Airways	Express Yola	1	5	-
1997	NAF Dornier	Borno	2	-	10

2000	Skypower Express Air	Abuja	1	17	-
2000	Dornier Aircraft	Niger-Delta	2	-	6
2002	EAS Airlines	Kano	1	148	29
2004	Hydro Cargo Brussels	Bauchi	1	-	All on board
2004	PAA Helicopter	Delta State	1	4	-
2004	Kenya Airlines	Lagos	3	-	All on board
2005	ADC	Yola	1	-	All on board
2005	Bellview	Ogun State	1	117	-
2005	Chachangi Airlines	Lagos	1	-	53
2005	Chachangi Airlines	Jos	1	-	All on board
2005	Harka Air Services	Lagos	1	All on board	-
2005	Air France	Port-Harcourt	1	-	All on board
2005	Lufthansa Aircraft	Lagos	1	-	All on board
2005	Bellview	Ogun-State	1	117	-
2005	Sosoliso	Port-Harcourt	9	106	-
2006	18-Seater Dornier	Benue State	1	15	3
2006	ADC Airlines	Abuja	1	96	18
2011	Beach-Craft	Kaduna	1	1	-
2012	Police Chopper	Plateau St	1	4	-
2012	Dana Air plane	Lagos	2	153	-
Total	39		55		

From the results in Tables 3 to 7 of accidents that occurred on the various modes of transportation considered, the average values of mode accidents in Table 8, was computed.

Table 8. Summary of Average Values of Mode Accidents per year in Nigeria

Mode	No of years ($x_1 + \dots . x_n$)	Total number of accidents (P)	Average number of accidents per year (\bar{x})= $\frac{P}{x_1 + \dots + x_n}$
Road	22yrs(1990-2012)	337301	15332
Railway	9yrs(1990-2005)	970	108
Airway	43yrs(1969-2012)	55	1
Waterway- Boat	10yrs(2004-2014)	514	52
Ferry	10yrs(2004-2014)	350	35

3.4 Computation for Intermodal Connectivity Based On Safety (Accidents and Fatality) of Transportation Modes Considered

The intermodal safety condition performance index connectivity model derived by [15], was used to analyse the computed modes accidents data for proposed seamless intermodal connectivity for available modes of transportation in Nigeria. This safety connectivity condition models are given in equations 1 and 2 in the methodology.

Table 9. Computed values of safety factors (Ca) for considered modes of transportation

Mode	Total number of incident(I)	Total number of fatality(F)	Safety factor ($Ca = \frac{I}{F}$)
Road	337301	96563	3.5
Railway	970	970	1
Air	55	55	1
Water: Boat	387	183	2.1
Ferry	402	174	2.3

From results obtained for safety factors for the various modes of transportation in Nigeria as of now, the analysis was made using the safety condition models for proposed intermodal connections and the outcome is in Table 10.

Table 10. Results of Mode Intermodal Connectivity Condition Based on Safety (Acceptable number of accidents)

Mode	Condition for intermodalism	Remark
Road	$\frac{P}{X_1+\dots+X_n} > (x_1 + \dots + x_n) \times Ca$	Not ready, need upgrading to meet standard.
Railway	$\frac{P}{X_1+\dots+X_n} > (x_1 + \dots + x_n) \times Ca$	Not ready, need upgrading to meet standard.
Air	$\frac{P}{X_1+\dots+X_n} < (x_1 + \dots + x_n) \times Ca$	Ready but needs intermodal terminals.
Boat	$\frac{P}{X_1+\dots+X_n} > (x_1 + \dots + x_n) \times Ca$	Not ready, need upgrading to meet standard.
Ferry	$\frac{P}{X_1+\dots+X_n} > (x_1 + \dots + x_n) \times Ca$	Not ready, need upgrading to meet standard.

Due to Nigeria’s diversity, population growth rate and growth in commerce, it is very clear that a single mode of transportation cannot serve the need of the entire nation, the structure for managing and operating transportation system must be flexible and adaptable to local needs. Road transportation system has dominated the movement of freight and passengers in Nigeria to the detriment of other transportation modes yet without meeting the transport needs, [6]. It is very paramount at this critical stage were the government is interested in the diversification of Nigeria’s transportation modes to include rail, for intermodalism to be considered and implemented. Also it is known that train carries far greater freight than truck reducing the number of trucks in freight lifting and weight of load on the roads. It was discovered from the study using the safety condition models, that only air transport is ready based on safety for intermodal system but it has no viable intermodal interchange with other modes.

4 CONCLUSIONS

Based on the outcome of the study, it was discovered that the performance goals of individual mode of transportation in Nigeria do not meet up with conditions and standards for intermodal connections. The capacity of road in Nigeria is more than overstretched while the existing railway is almost abandoned and neglected. The air transportation is doing good in terms of passengers and freight but poor in infrastructure. A lot is required in terms of upgrading the infrastructural and operational conditions of the available modes of transportation in Nigeria to meet up with the required standards for intermodalism. The government should revitalize all inland water-ways by dredging and construction of harbors for easy access, also old and new railway should play there required role of carrying freight off the road. Annual performance records of all available transportation modes should help in facilitating intermodal integration of modes for sustainable transportation system.

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