PART IV

ECONOMIC FEASIBILITY STUDY

Part IV Economic Feasibility Study

Chapter1 Existing Traffic Flow Patterns

1.1 Introduction

This chapter aims to analyze traffic flow patterns on the Study Road based on various information in order to conduct the appropriate traffic demand forecast.

This information is sourced by a) historical traffic data of ANE, b) statistical data for traffic in Niassa Province, c) traffic survey results conducted in this Study (e.g. traffic volume and origin-destination (OD) survey) and d) interview survey results to traffic related stakeholders and users.

From results of above information, current and potential traffic volume of passengers and freight traffic on Cuamba ~ Mandimba ~ Lichinga, and possible future traffic demands (generated traffic) are discussed in this chapter.

1.2 Previous Traffic Data Counted by ANE

1.2.1 Existing Traffic Data

For the purpose of the planning of road development, traffic management and road maintenance, the traffic counting survey has been conducted throughout Mozambique according to the "DNEP Traffic Counting System" established in 1996. The contracted consultant under the management of ANE provincial office operates the counting survey according to the schedule and locations prepared by ANE headquarters.

There are 74 road links including the national and provincial road and 25 counting posts in Niassa Province. 10 roads and four counting posts are located on the Project Road, R13, from Lichinga to Cuamba. The counting survey has been carried out every month based on the schedule, but the counting on seven consecutive days for 16 hours from 5a.m. to 10p.m. is conducted only at one point selected. On the other points, it is counted on one day per every three months on average. The method of counting is that the surveyor on the road edge counts the traffic number for two directions together per each categorized vehicle type manually, except motorbikes. After the survey, the original counting sheets are sent to ANE headquarters to input into the database.

During the site survey by the Study Team, the monthly traffic count data in Niassa for 2004 and aAverage annual daily traffic (AADT) on Nacala Corridor, Montepuezu Corridor, Beira Corridor and Quilimane Corridor for 2002 to 2007 were provided from ANE.

The road link map in Niassa Province and the list of road links on the Project Road are shown as follows.

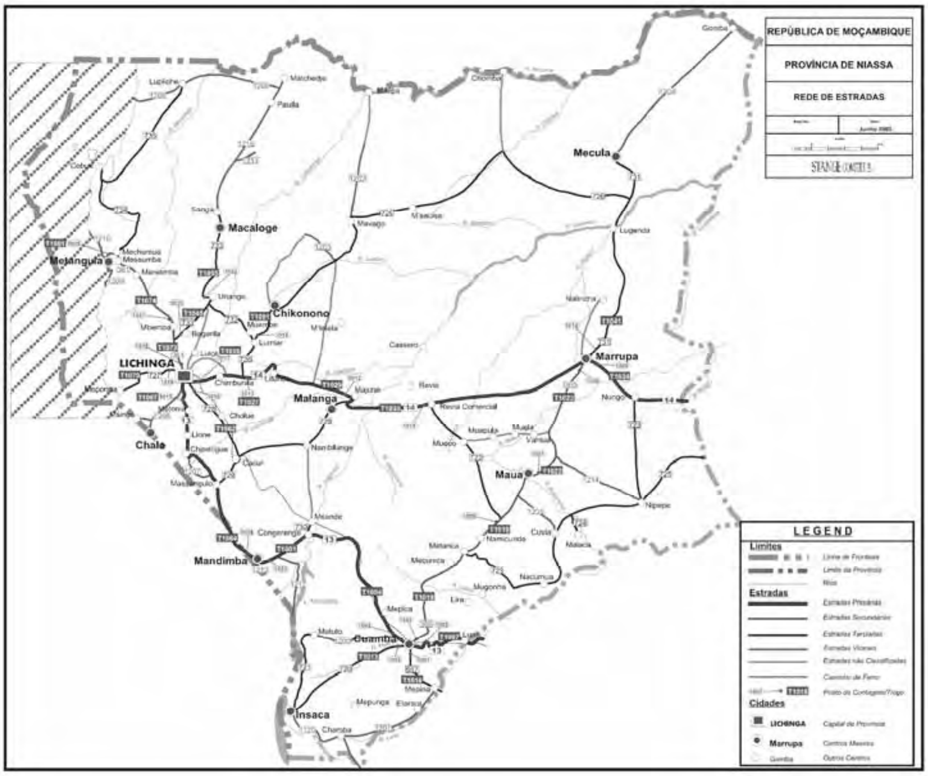


Figure 1.2.1 Road Link Map in Niassa Province

Table 1.2.1 List of Road Link from Lichinga to Cuamba

Section	Start	End	Distance (km)	Count Post	Location
T1068	Lichinga	Lumbe	12.6		
T1067	Lumbe	Fr.Ngauma	37.5	1015	19km from Chinengue
T1066	Fr.Ngauma	Massangulo	34.2		
T1065	Massangulo	Fr.Mandimba	19.4		
T1064	Fr.Mandimba	Mandimba	35.6	1024	17km from Mandimba
T1008	Fr.Malawi	Mandimba	4.2		
T1001	Mandimba	Muita	15.9	1023	8km from Muita
T1002	Muita	Congerene	18.7		
T1003	Congerene	Mississe	53.6		
T1004	Mississe	Cuamba	56.5	1004	9km from Cuamba

1.2.2 Average Annual Daily Traffic (AADT)

Average annual daily traffic (AADT) is estimated by Access Database, which was established in 1996, based on the traffic volume counted on site. According to AADT data, the range of traffic volume from 2002 to 2006 is from 80 to 120 vehicles per day on the Project Road, while the traffic volume around Lichinga is over 100 up to 170. In 2007, it increased on the entire section. The AADT and the large vehicle rate at Lichinga south from 2002 to 2007 on the Project Road is as follows.

Table 1.2.2 AADT for between Cuamba and Lichinga from 2002-2007

Section	Start	End	02	03	04	05	06	07
T1068	Lichinga	Lumbe	178	152	156	163	93	261
T1067	Lumbe	Fr.Ngauma	125	119	120	117	86	190
T1066	Fr.Ngauma	Massangulo	130	104	107	86	89	134
T1065	Massangulo	Fr.Mandimba	139	86	87	86	89	134
T1064	Fr.Mandimba	Mandimba	125	71	74	96	104	128
T1008	Fr.Malawi	Mandimba	67	74	78	96	116	136
T1001	Mandimba	Muita	48	78	90	102	123	143
T1002	Muita	Congerene		80	86	91	85	236
T1003	Congerene	Mississe	47	79	82	25	28	83
T1004	Mississe	Cuamba		80	80	86	96	275

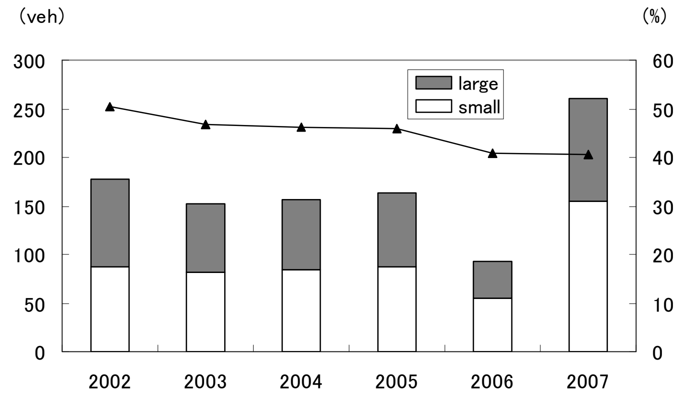


Figure 1.2.2 Large Vehicle Rate at Lichinga South (T1068)

Next, the figure below shows the traffic volume from Malawi borders to the port in Mozambique on relevant corridors. The traffic volume on Nacala Corridor is less than other corridors such as Beira Corridor and Quilimane Corridor.

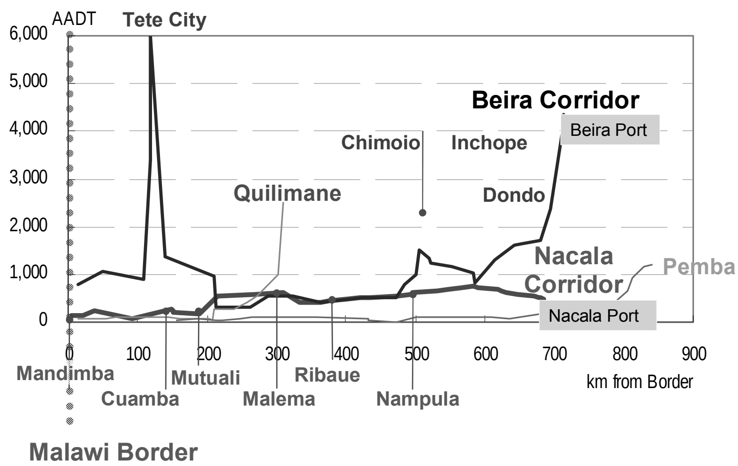


Figure 1.2.3 Traffic Volume on each Corridor

1.2.3 Analysis of Traffic Data

In 2004, the monthly traffic count survey was carried out at count post No. 1015. This data is analyzed on various aspects such as weekly and monthly variation and large vehicle rate. However, the data for March are missing.

There is not much difference on the weekly variation but the volume on Sunday tends to be lower than other days. For the monthly variation, the traffic seems to be concentrated in the dry season, July to September. The rate of large traffic is higher around the end of year.

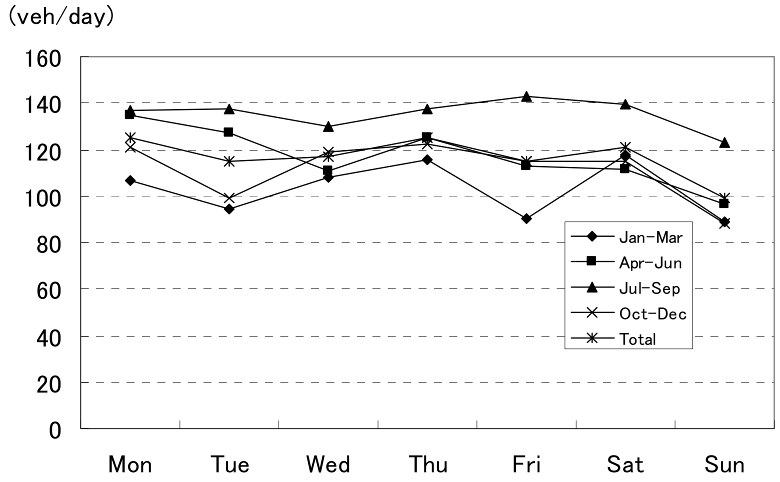


Figure 1.2.4 Weekly Variation for Traffic Volume

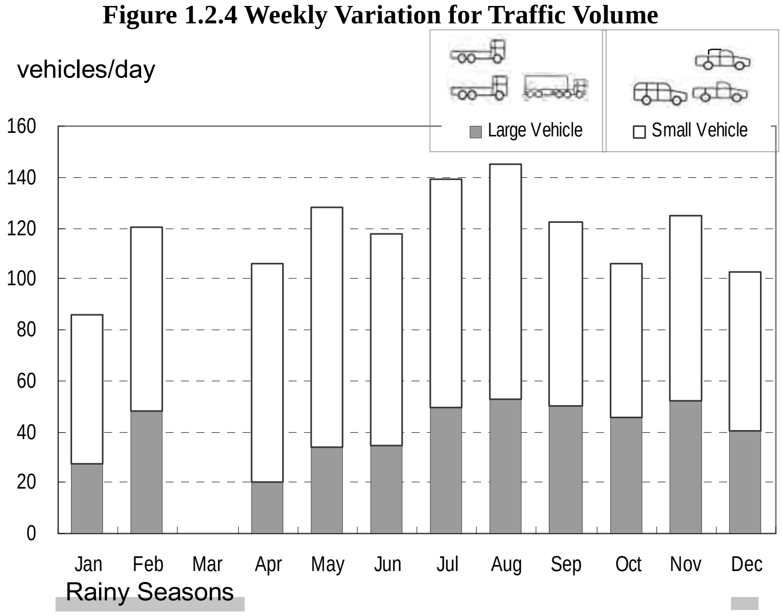


Figure 1.2.5 Monthly Variation for Traffic Volume (T1067, 2004)

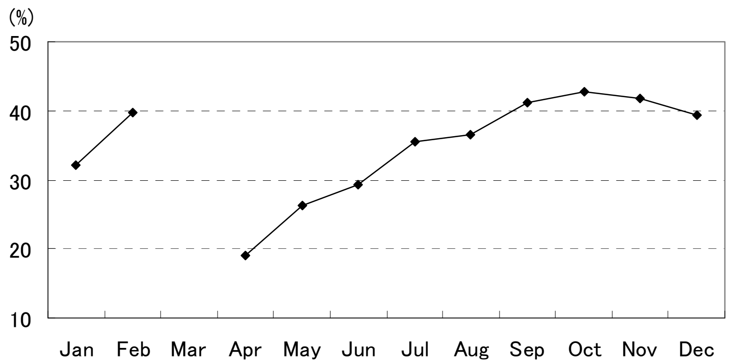


Figure 1.2.6 Monthly Rate for Large Vehicles

1.3 Traffic Related Statistics in Niassa Province

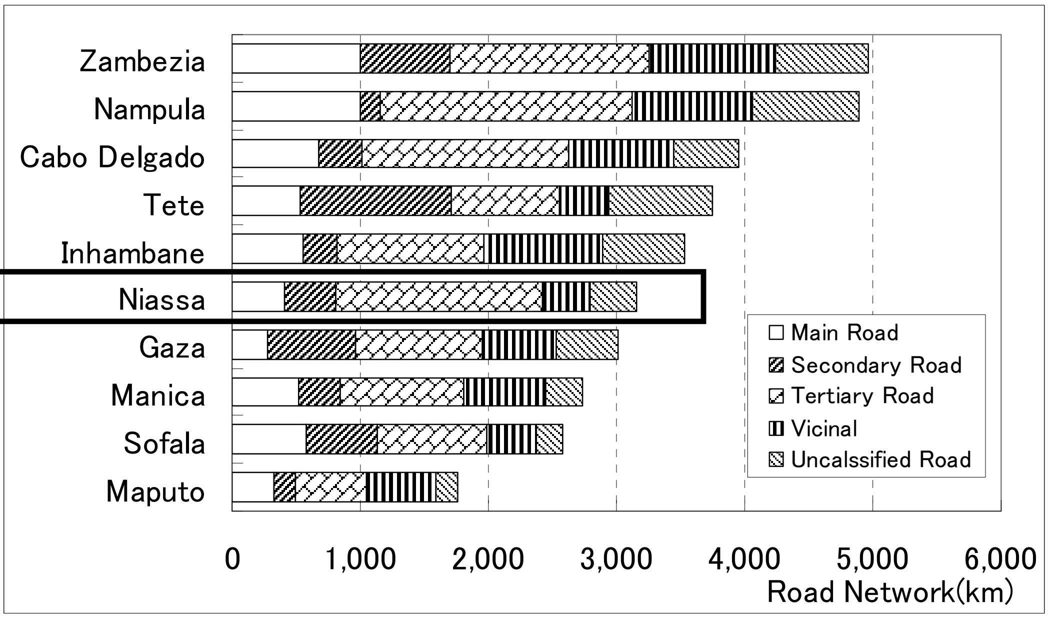
1.3.1 Introduction

Following section shows the results of literature review for provincial level statistics for traffic related data in order to identify the characteristics of Niassa Province compared by other province.

1.3.2 Characteristics of Niassa Province

(1) Road Network

Mozambique has a road network of about 34,000km as all classes, with about 5,870km road classified as primary road. According to the length of all class roads, Zambezia has longest network, Nampula has the next longest network. Both Zambezia and Nampula have road networks of more than 5,000km. Niassa has a road network of about 3,150km, the sixth longest province in Mozambique. Niassa has a primary road network of about 414km.

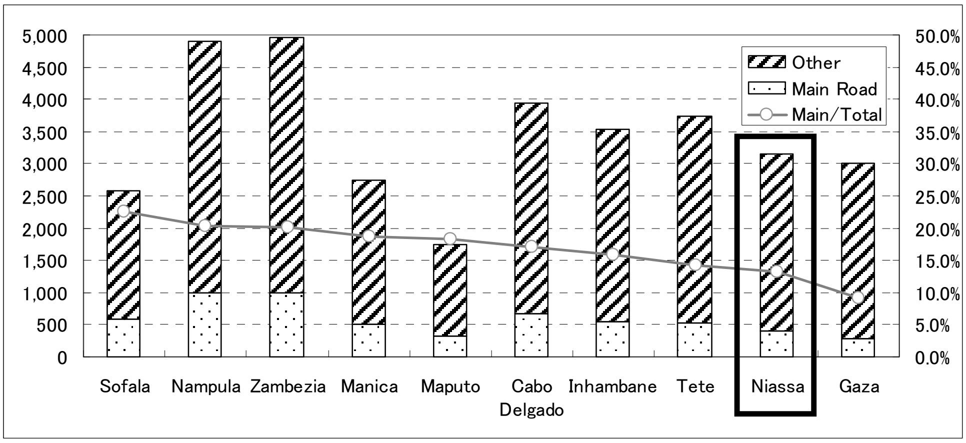


	Main Road	Secondary Road	Tertiary Road	Vicinal	Uncalssified Road	Total
Zambezia	1,001	698	1,552	995	718	4,964
Nampula	996	165	1,965	934	832	4,892
Cabo Delgado	675	337	1,609	824	502	3,947
Tete	530	1,186	833	392	803	3,744
Inhambane	558	265	1,140	930	642	3,535
Niassa	414	392	1,620	371	355	3,152
Gaza	276	690	988	573	491	3,018
Manica	513	336	960	635	294	2,738
Sofala	584	554	847	389	206	2,580
Maputo	323	169	557	547	162	1,758
Total	5,870	4,792	12,071	6,590	5,005	34,328

Source: Ministry of Transport and Communication, Dir. of Planning, 2007

Figure 1.3.1 Road Network Status for each Classification in Province

The ratio of primary road length is about 10 to 20% in all provinces, and the average ratio in all Mozambique is about 17%. The ratio of Niassa is about 13%, the lowest province next to Gaza in Mozambique.

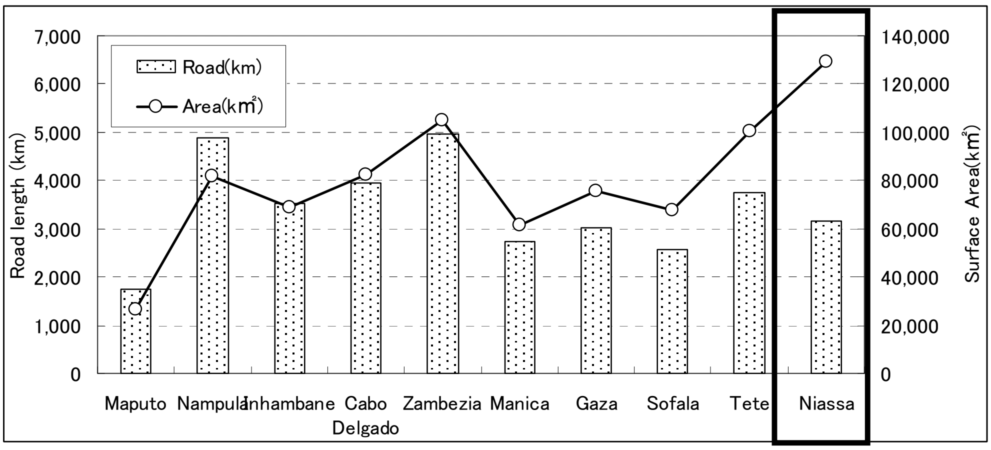


	Main Road	Other	Total	Main/Total
Sofala	584	1,996	2,580	22.6%
Nampula	996	3,896	4,892	20.4%
Zambezia	1,001	3,963	4,964	20.2%
Manica	513	2,225	2,738	18.7%
Maputo	323	1,435	1,758	18.4%
Cabo Delgado	675	3,272	3,947	17.1%
Inhambane	558	2,977	3,535	15.8%
Tete	530	3,214	3,744	14.2%
Niassa	414	2,738	3,152	13.1%
Gaza	276	2,742	3,018	9.1%
Total	5,870	28,458	34,328	17.1%

Source: Ministry of Transport and Communication, Dir. of Planning, 2007

Figure 1.3.2 Ratio of Primary Road Length in each Province

Although, Niassa has the largest area in Mozambique, the length of road network is short comparing other provinces. According to average road length per 1km square, the length of all Mozambique is about 430m, but the length of Niassa is 240m. It is almost half of all Mozambique's length, and the length of Niassa is shortest compared to other provinces.



	Road (km)	Area (km²)	Road in square KM
Maputo	1,758	26,358	0.067
Nampula	4,892	81,606	0.060
Inhambane	3,535	68,615	0.052
Cabo Delgado	3,947	82,625	0.048
Zambezia	4,964	105,008	0.047
Manica	2,738	61,656	0.044
Gaza	3,018	75,709	0.040
Sofala	2,580	68,018	0.038
Tete	3,744	100,724	0.037
Niassa	3,152	129,061	0.024
Total	34,328	799,380	0.043

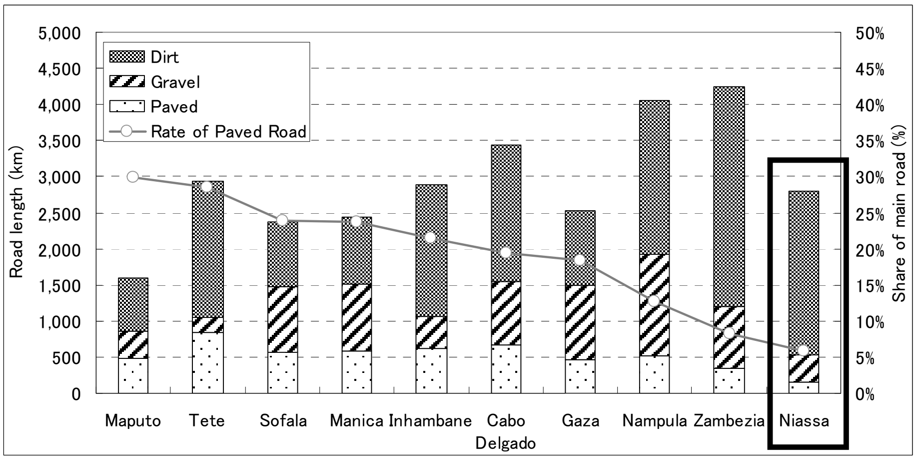
Source: Statistical Hand Book 2007, Ministry of Transport and Communication, Dir. of Planning, 2007

Figure 1.3.3 Road Density for each Province

(2) Pavement Condition

Mozambique has a road network of about 29,300km as classified road, and 5,250km paved road. The ratio of paved road length is about 18%. According to the ratio of paved road length, Maputo is the highest province having 30% paved road.

On the other hand, Niassa has less than 6% paved road, and is the lowest province in Mozambique. Comparing to the national average 18%, Niassa has 1/3 of the national average. It is clear that the process of paving is slower than other provinces in Niassa.



	Paved	Gravel	Dirt	Total	Rate of Paved Road
Maputo	478	378	740	1,596	29.9%
Tete	837	215	1,889	2,941	28.5%
Sofala	567	912	896	2,375	23.9%
Manica	581	924	939	2,444	23.8%
Inhambane	622	450	1,822	2,894	21.5%
Cabo Delgado	668	883	1,893	3,444	19.4%
Gaza	464	1,039	1,024	2,527	18.4%
Nampula	516	1,411	2,133	4,060	12.7%
Zambezia	351	858	3,037	4,246	8.3%
Niassa	161	379	2,257	2,797	5.8%
Total	5,245	7,449	16,630	29,324	17.9%

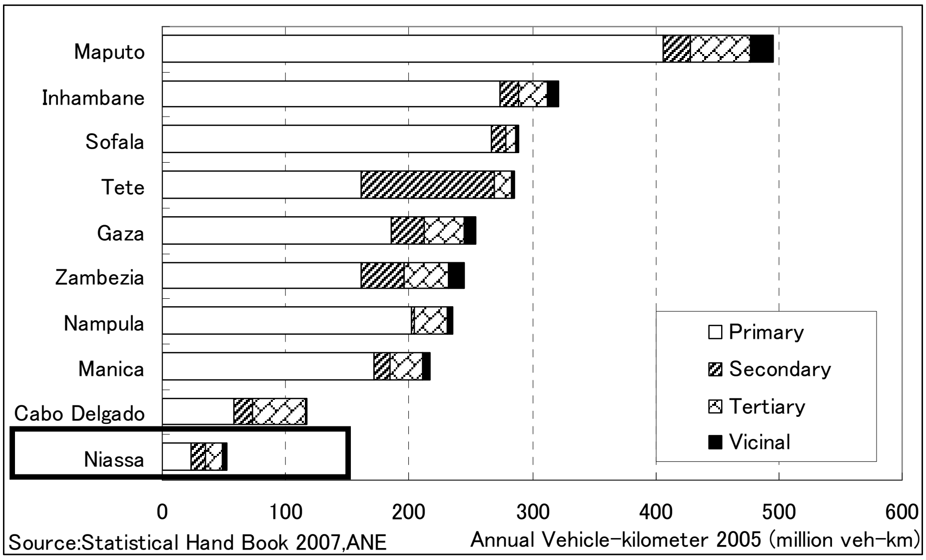
Source: Ministry of Transport and Communication, Dir. of Planning, 2007

Figure 1.3.4 Pavement Condition in each Province

(3) Vehicle-Kilometers

Traffic volume is about 2,513 million vehicle-km per year in 2005 in Mozambique, and traffic of about 1,910 million vehicle-km (76%) goes along primary roads. According to traffic volume, Maputo has the heaviest traffic volume in Mozambique, and Inhambane has the next heaviest traffic. Niassa has the least traffic volume in Mozambique, about 52million vehicle-km (2%).

In the provinces having large cities like Maputo or Sofala or Nampula, the ratio of primary roads is higher than the other class roads, on the other hand, in less developed provinces like Tete or Cabo Delgado or Niassa, the ratio of primary roads is less than in the other provinces.



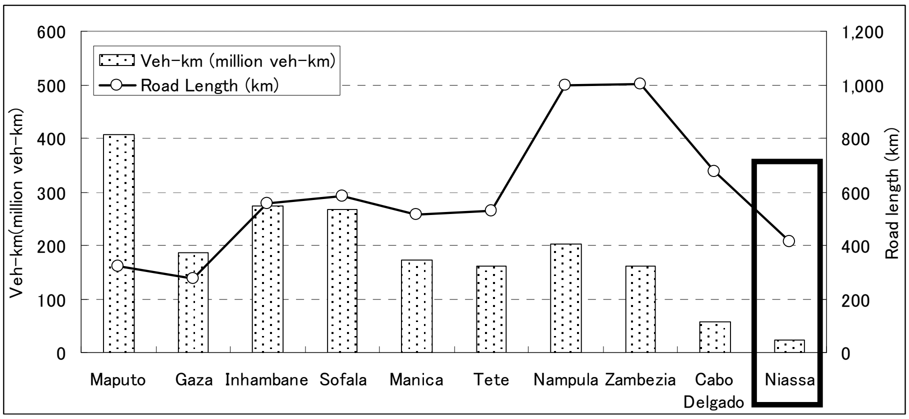
	Annual Vehicle-kilometer(2005 ; million veh-km)					Rate of Total
	Primary	Secondary	Tertiary	Vicinal	Total	
Maputo	406.1	22.7	48.2	18.5	495.5	19.7%
Inhambane	273.5	15.2	23.5	9.3	321.5	12.8%
Sofala	266.9	11.2	8.8	2.5	289.4	11.5%
Tete	161.4	107.3	14.9	2.2	285.8	11.4%
Gaza	185.4	26.5	33	9	253.9	10.1%
Zambezia	161.3	35.2	36.1	12.2	244.8	9.7%
Nampula	202	2.3	26.7	5	236	9.4%
Manica	171.8	13.3	25.9	5.6	216.6	8.6%
Cabo Delgado	57.9	15.5	42.8	1.5	117.7	4.7%
Niassa	23.2	11.9	13.7	3.6	52.4	2.1%
Total	1909.5	261.1	273.6	69.4	2513.6	100.0%

Source：Statistical Hand Book 2007, ANE

Figure 1.3.5 Vehicle-km for each Province

When paying attention to the primary roads, the average traffic volume is about 900 vehicles/day calculated by total traffic (vehicle-km) and total road length. (Calculated by as total traffic (vehicle-km) / road length (km) / 365(days))

Maputo has the heaviest traffic volume in Mozambique, over 3,000 vehicles per day. Niassa has the lightest volume in Mozambique, about 150 vehicles per day, less than 1/5 of the average.



	Veh-km (million veh-km)	Road length (km)	Average vehicle per day
Maputo	406.1	323	3,445
Gaza	185.4	276	1,840
Inhambane	273.5	558	1,343
Sofala	266.9	584	1,252
Manica	171.8	513	918
Tete	161.4	530	834
Nampula	202	996	556
Zambezia	161.3	1,001	441
Cabo Delgado	57.9	675	235
Niassa	23.2	414	154
Total	1909.5	5,870	891

Average vehicle per day is represent as "Veh-km / Road length / 365"

Figure 1.3.6 Vehicle Movement in each Province

(4) Passenger / Freight Traffic Volume in Niassa Province

Based on the provincial statistics collected by provincial government of transport and communications in Niasa, passenger and freight traffic volume is estimated by each traffic mode in the table below.

Table 1.3.1 Amount of Transportation of Cargo and Passengers in 2006

		Total		Niassa		Share of Niassa
		Volume	Share	Volume	Share	
Cargo (10^6TKM)	Rail Way	736	29.5%	0.478	55.7%	0.06%
	Road	1,535	61.5%	0.249	28.9%	0.02%
	Sea	218	8.7%	0.071	8.2%	0.03%
	Airplane	8	0.3%	0.062	7.2%	0.76%
subtotal		2,497	100.0%	0.859	100.0%	0.03%
Passenger (10^6PKM)	Rail Way	320	1.1%	–	–	
	Road	28,770	96.1%	47.047	84.0%	0.16%
	Sea	9	0.0%	5.216	9.3%	55.49%
	Airplane	846	2.8%	3.719	6.6%	0.44%
subtotal		29,944	100.0%	55.983	100.0%	0.19%

Source: Anuario Estatistico Statistical Yearbook 2007
Relatorio da Direccao Provincial dos Transportes e Communicacoes de Niassa (Latest Version)

Regarding freight transport, the mode share of road and railway transport in terms of national average is 62% and 30%, respectively. However, in Niassa Province, railway transportation accounts for 56% (road transport is 29%). This is caused by the operation of railways between Lichinga and Cuamba up to February 2009, and by including the statistics between Cuamba and IntreLagos which forms the international railway operation of Nacala – Nampula to Malawi.

On the other hand, for the passenger transportation, roads account for more than railways. Note that the transportation shares of airplane and sea in Niassa are more than the national average.

The share of traffic volume in Niassa Province against the whole country doesn't come up to as much as 0.2%. It means that the movement of persons and cargo in Niassa is still small.

(5) Mini-bus Registration and Operation

All the mini-buses operated in Niassa Province must be registered based on Lichinga or Cuamba origin. The largest number of registrations is 174 vehicles for operation between Lichinga - Cuamba which accounts for more than 80% of the whole. The next largest number of registrations is 10 for between Lichinga - Lago, and the third largest is eight for between Camba - Marrupa.

As a result of site investigation in the dry season in May, the operation between Lichinga - Cuamba was found to be about 20 round trips per day. Therefore, it is assumed that only a part of the number of registered vehicles can be operated. Moreover, there might be some operators registered as Lichinga - Cuamba who run only a part of the section.

Table 1.3.2 Minibus Registration in Niaasa Province

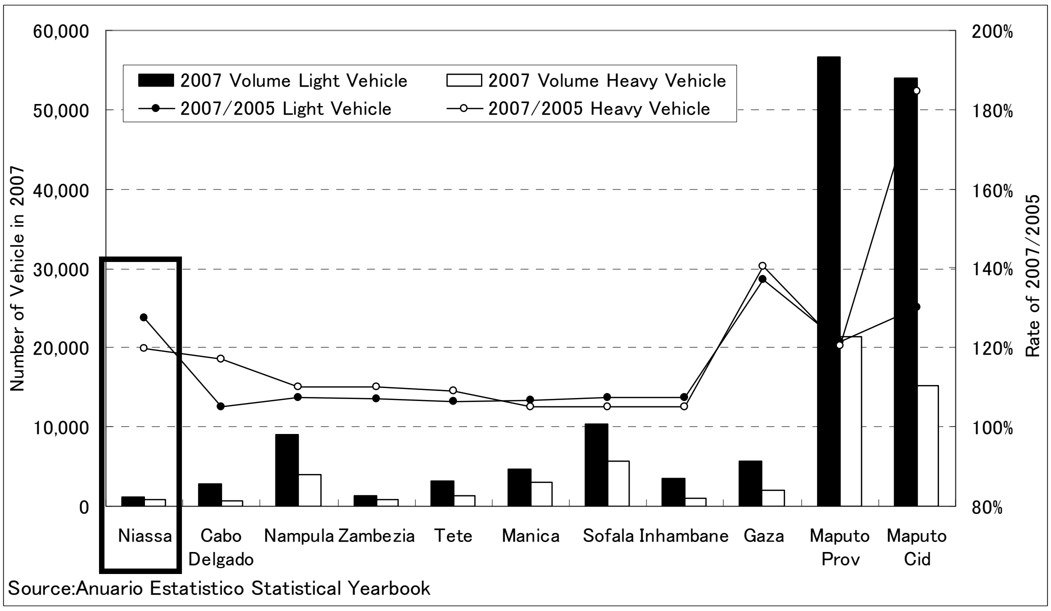
		Numer of Bus	Rate of Total
Lichinga	Cuamba	174	81.7%
	Lago	10	4.7%
	Mavago	2	0.9%
	Marrupa	5	2.3%
	Sanga	3	1.4%
	Majune	5	2.3%
	Matchedje	2	0.9%
Cuamba	Mecanhelas	4	1.9%
	Marrupa	8	3.8%
Total		213	100.0%

Source: Ministry of Transport and Communication in Lichinga

(6) Vehicle Registration

Regarding the number of vehicle registrations in 2007, 153,000 vehicles are registered as light vehicles, and 56,000 as heavy vehicles in Mozambique, and the number has been increased 20 to 30% since 2005.

According to the distribution of the number of vehicle registrations in each province, almost all of them belong to Maputo Province. Niassa Province has the fewest number of vehicle registrations, but the rate of increase between 2005 and 2007 ranks highest next to Maputo and Gaza, such as 27% for light vehicles, and 20% for heavy vehicles.



	2005		2006		2007		2007/2005	
	Light Vehicle	Heavy Vehicle	Light Vehicle	Heavy Vehicle	Light Vehicle	Heavy Vehicle	Light Vehicle	Heavy Vehicle
Niassa	925	728	999	787	1,178	872	1.27	1.20
Cabo Delgado	2,689	500	2,755	549	2,822	585	1.05	1.17
Nampula	8,333	3,598	8,553	3,773	8,946	3,958	1.07	1.10
Zambezia	1,305	757	1,367	798	1,398	833	1.07	1.10
Tete	3,009	1,245	3,068	1,324	3,203	1,358	1.06	1.09
Manica	4,428	2,862	4,499	2,908	4,733	3,009	1.07	1.05
Sofala	9,687	5,471	9,964	5,589	10,394	5,741	1.07	1.05
Inhambane	3,338	920	3,504	955	3,583	968	1.07	1.05
Gaza	4,148	1,418	5,520	1,874	5,689	1,991	1.37	1.40
Maputo Prov	46,716	17,818	50,351	19,075	56,668	21,447	1.21	1.20
Maputo Cid	41,450	8,256	50,593	13,917	53,922	15,248	1.30	1.85
Total	126,028	43,573	141,173	51,549	152,536	56,010	1.21	1.29

Source: Anuario Estatistico Statistical Yearbook 2005-2007

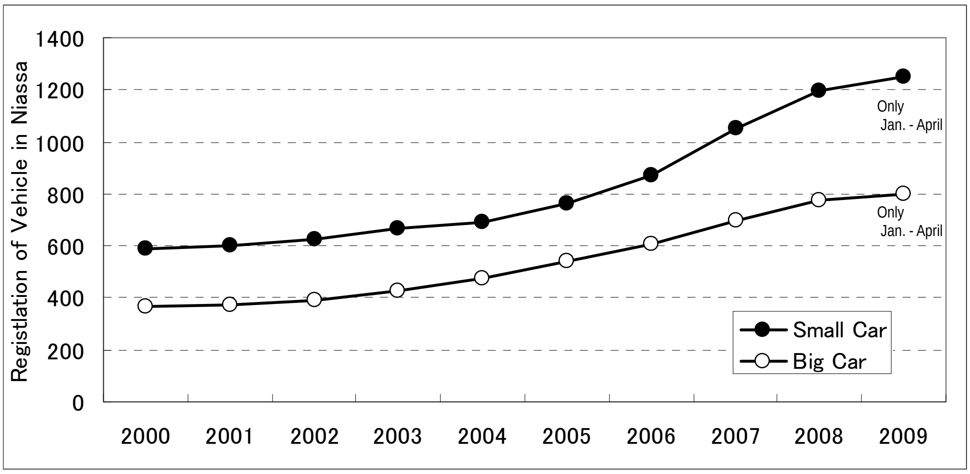
Figure 1.3.7 Vehicle Registration in each Province

Car ownership calculated by number of vehicle registrations and population in 2007 is shown in the table below. It is clear that Niassa Province has not reached national average but is still only 0.17%.

Table 1.3.3 Car Ownership in each Province

	Registration number in 2007		Total	Population in 2007	Vehicle per Population
	Light Vehicle	Heavy Vehicle			
Maputo Cid	53,922	15,248	69,170	1,099,102	6.29%
Maputo Prov	56,668	21,447	78,115	1,259,713	6.20%
Sofala	10,394	5,741	16,135	1,654,163	0.98%
Gaza	5,689	1,991	7,680	1,219,013	0.63%
Manica	4,733	3,009	7,742	1,418,927	0.55%
Inhambane	3,583	968	4,551	1,267,035	0.36%
Nampula	8,946	3,958	12,904	4,076,642	0.32%
Tete	3,203	1,358	4,561	1,832,339	0.25%
Cabo Delgado	2,822	585	3,407	1,632,809	0.21%
Niassa	1,178	872	2,050	1,178,117	0.17%
Zambezia	1,398	833	2,231	3,892,854	0.06%
Total	152,536	56,010	208,546	20,530,714	1.02%

According to the latest number of vehicle registrations in Niassa collected by Study Team interview since 2005, increment of new registrations has increased steadily as shown in the table below. It can be said that it is time the motorization began to progress rapidly.



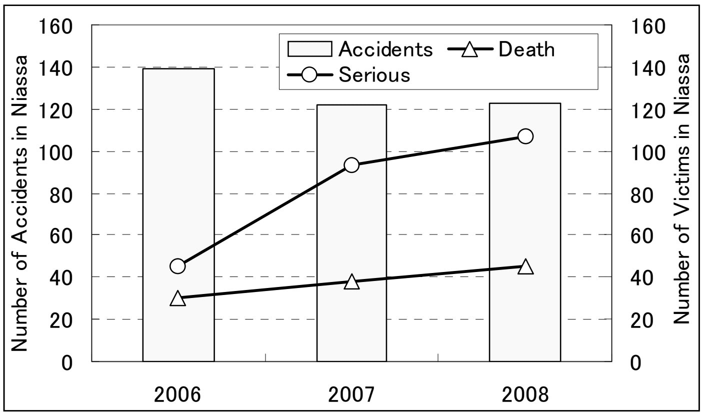
	Small Car		Big Car		Total	
	New Registration	Accumulation	New Registration	Accumulation	New Registration	Accumulation
2000	204	586	85	364	289	950
2001	16	602	7	371	23	973
2002	20	622	17	388	37	1010
2003	43	665	40	428	83	1093
2004	26	691	48	476	74	1167
2005	73	764	64	540	137	1304
2006	105	869	69	609	174	1478
2007	181	1050	89	698	270	1748
2008	144	1194	76	774	220	1968
2009	53	1247	28	802	81	2049

Source: INAV, Data in 2009 is since January to April

Figure 1.3.8 Trend of Car Ownership Increase in Niassa Province

(7) Traffic Accidents

Although the number accidents in Niassa decreased between 2006 and 2007, and was almost same level between 2007 and 2008, the number of deaths and injuries has increased. It means that traffic accidents have become more serious over the past three years. Especially, the number of serious injuries has increased almost three times between 2006 and 2008.



Source: MTC, Anuario Estatistico Statistical Yearbook 2007

Figure 1.3.9 Record of Traffic Accidents in Niassa Province

If we look at the situation of the accidents on national road 13 (N13), about 20% of total provincial accidents, 31% of total provincial deaths and 28% of total provincial serious injuries occurred on N13. This is evidence that N13 has high probability of death and serious injury than other roads. N13 also has a higher number of victims per accident as 1.76, compared with 1.10 on other roads.

Table 1.3.4 Record of Traffic Accidents on National Route No.13 (2008)

	2008			Victims per Accident
	Accidents	Death	Serious	
Niassa	123	45	107	1.24
N13	25	14	30	1.76
Other	98	31	77	1.10
Share of N13	20.3%	31.1%	28.0%	-

Source: MTC

1.4 Traffic Survey

1.4.1 Purpose of Survey

The traffic survey including the traffic count survey and the origin-destination (OD) survey was carried out on the Project Road to recognize the current traffic condition and to forecast the future traffic demand after the Project implementation. The survey was conducted twice in May and August

1.4.2 Survey Location

The location of both surveys was as follows.

Table 1.4.1 Survey Location

Traffic count survey	Total 5 points (10 directions) at 3 locations - Lichinga : 1 km to Mandimba - Mandimba : 0.5km to Lichinga 0.5km to Cuamba 0.3km to Border - Cuamba : 0.5km to Mandimba The survey was conducted at Mandimba border instead of above locations in Mandimba on 2nd survey
OD survey	Total 4 points (8 directions) at 3 locations - Lichinga : 1 km to Mandimba - Mandimba : 0.5km to Lichinga 0.3km to Border - Cuamba : 0.5km to Mandimba The survey was conducted at Mandimba border instead of at the above locations in Mandimba town on 2nd survey

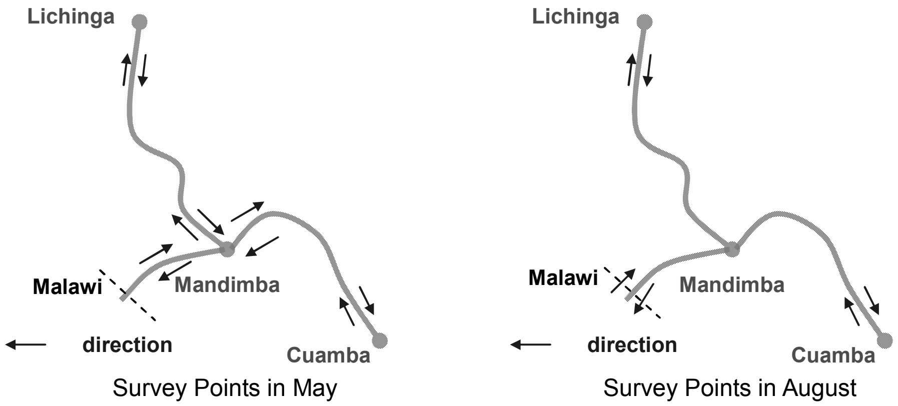


Figure 1.4.1 Traffic Survey Points

1.4.3 Methodology of Survey

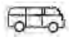
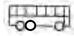
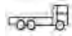
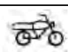
(1) Traffic Count Survey

The contents of the traffic count survey were as follows.

Table 1.4.2 Contents of Traffic Count Survey

Survey Date	(1st) Consecutive seven days from 10th May, Sunday, to 16th May 2009, Saturday (2nd) Consecutive four days from 9th August, Sunday, to 12th August 2009, Wednesday
Survey Hour	- 12 hours from 6:00 a.m. to 6:00 p.m. - 12 hours from 6:00 p.m. to 6:00 a.m. in the next morning only on 13th May, Wednesday
Count Interval	Every one hour
Vehicle Type	12 categories (Vehicle classification is followed by the ANE's classification and AfDB recommendations in table below.)
Survey Method	Manual count by surveyors at the roadside

Table 1.4.3 Vehicle Types

Category	No.	Vehicle Type	Illustration
Passenger Car	1	Medium Passenger Car	
	2	4-Wheel Vehicle	
Bus	3	Minibus/Light Bus (< 20seats)	 
	4	Medum/Large Bus (>20seats)	
Truck	5	Light Goods Vehicle	
	6	Medium Goods Vehicle (2-axles)	
	7	Heavy Goods Vehicle (3-axles Rigid)	
	8	Very Heavy Goods Vehicle (Articulated)	
Others	9	Agricultural Tractors	
	10	Motorcycle	
	11	Bicycle	
	12	Animal Cart	

(2) Origin-Destination (OD) Survey

The contents of the OD survey were as follows.

Table 1.4.4 Contents of Origin Destination Survey

Survey Date	(1st) Consecutive four days from 10th May, Sunday, to 13th May 2009, Wednesday (2nd) Consecutive four days from 9th August, Sunday, to 12th August 2009, Wednesday
Survey Hour	12 hours from 6:00 a.m. to 6:00 p.m.
Vehicle Type	Same as the traffic count survey excluding the bicycle
Survey Method	Interview to drivers by surveyors at the roadside
Survey Content (see the appendix)	- Number of plates - Number of passengers - Model - Type of vehicle - Origin and Destination of trip - Travel time - Purpose of trip - Trip frequency - Contents and volume of freight

Figure 1.4.2 Photo of Traffic Survey

The Project area and neighboring region are divided into 36 zones to define the location of origin and destination. The zone number and location are as follows.

Province	District	Zone No
NAMPULA	MURRUPULA	1
	NAMPULA	
	RIBAUE	2
	MALEMA	3
NIASSA	CUAMBA	4
NAMPULA	ANGOCHE	5
	ILHA_DE_MOZAMBIQUE	
	MECONTA	
	MOGINCUAL	
	MOGOVOLAS	
	MOMA	
	MONAPO	
	MOSSURIL	
	MUECATE	
	NACAROA	
	NACALA	6
	NACALA_A_VELHA	
	ERATI	7
	MEMBA	
	MECUBURI	8
	LALAUA	9
NIASSA	MARRUPA	10
	MECULA	
	MECANHELAS	11
	MANDIMBA	12
	NGAUMA	13
ZAMBEZIA	ALTO_MOLOCUE	14
	GILE	
	GURUE	
	ILE	
	LUGELA	
	NAMARROI	
	PEBANE	
TETE		15
ZAMBEZIA	QUELIMANE	16
	CHINDE	
	INHASSUNGE	
	MAGANJA_DA_COSTA	
	MOCUBA	
	MOPEIA	
	NAMACURRA	
	NICOADALA	
	MILANGE	17
	MORRUMBALA	
SOFALA	BEIRA	18
GAZA		19
INHAMBANE		
MANICA		
MAPUTO		
South of Malawi		20
North of Malawi		21
South Africa and Swaziland		22
North of Zimbabwe		23
South of Zimbabwe		24
Zambia		25
NIASSA	LICHINGA	26
	LAGO	27
	MAVAGO	
	MUEMBE	
	SANGA	
	METARICA	28
	MAUA	29
	NIPEPE	
	MAJUNE	30
CABO DELGADO		31
NAMPULA	CIDADE_DE_NAMPULA	32
NIASSA	CIDADE_DE_LICHINGA	33
Beira Port		34
Quelimane Port		35
Nacala Port		36

Figure 1.4.3 OD Zone and Zone Code Number

1.4.4 Results of Traffic Counts

The traffic count results were analyzed from various views such as the vehicle type, daily variation and large vehicle rate to figure out the traffic trend on the Project Road.

In 1st survey in May, the traffic volume for vehicle at Mandimba and Cuamba ranged from 50 to 90 for 12 hours. It is expected that many vehicles drive in short trip around Lichinga area because the traffic volume at Lichinga is much bigger than at other points. During the night from 6p.m. to 6 a.m. only less than 20 vehicles passed and traffic concentrated from 6p.m. to 9p.m. In the 2nd survey in August, the traffic volume was much lower than that in the 1st survey. It would appear that this was caused by the period of harvest season.

The number of bicycles shows that the bicycle is main traffic means around this area rather than the vehicles. Over one thousand bicycles per day passed in Mandimba.

Table 1.4.5 Result of Traffic Volume including Passenger Cars, Buses and Trucks

Location	Point	Direction	Daytime (6:00 – 18:00)		Night time (18-06)	24h/12h (1st)
			1st Survey in May (veh/12h)	2nd Survey in August (veh/12h)	1st Survey in May (veh/12h)	
Lichinga	Mandimba Side	To Mandimba	152	65	68	1.32
		To Lichinga	128	54		
Mandimba	Lichinga Side	To Mandimba	65	-	11	1.17
		To Lichinga	79	-	16	
	Cuamba Side	To Mandimba	56	-	-	-
		To Cuamba	76	-	-	
	Border Side	To Mandimba	54	-	6	1.16
		To Border	52	-	11	
Cuamba	Mandimba Side	To Mandimba	72	49	18	1.25
		To Cuamba	76	40	18	

Source: Study Team

Table 1.4.6 Result of Traffic Volume for Bicycles and Motorcycles (in May)

Location	Point	Direction	Bicycle		Motorbike	
			Weekday Average	Weekend Average	Weekday Average	Weekend Average
Lichinga	Mandimba Side	To Mandimba	438	522	55	51
		To Lichinga	562	428	57	42
Mandimba	Lichinga Side	To Mandimba	1,498	1,490	90	82
		To Lichinga	1,496	1,377	96	84
	Cuamba Side	To Mandimba	1,188	916	65	72
		To Cuamba	1,135	798	70	79
	Border Side	To Mandimba	1,159	1,359	57	56
		To Border	1,094	1,636	62	62
Cuamba	Mandimba Side	To Mandimba	825	947	148	130
		To Cuamba	873	1,081	142	136

Source: Study Team

In the view of the vehicle type, the proportion of trucks was relatively high. This is because the road is used mainly for the haulage of goods. The specific feature did not appear on the date variation. The traffic volume on Sundays was a little lower than other days as well as the result on traffic count survey done by ANE. The large vehicle rate on Mandimba was higher especially at the weekend. The definition of large vehicles consisted of the large bus and the heavy goods vehicle in this analysis.

Also, motorcycles and bicycles were counted at each point. There were a lot of bicycles used on Study Road more than 1,000 per day, and motorcycles were used in almost the same volume as vehicles.

Following figures show the situation described above.

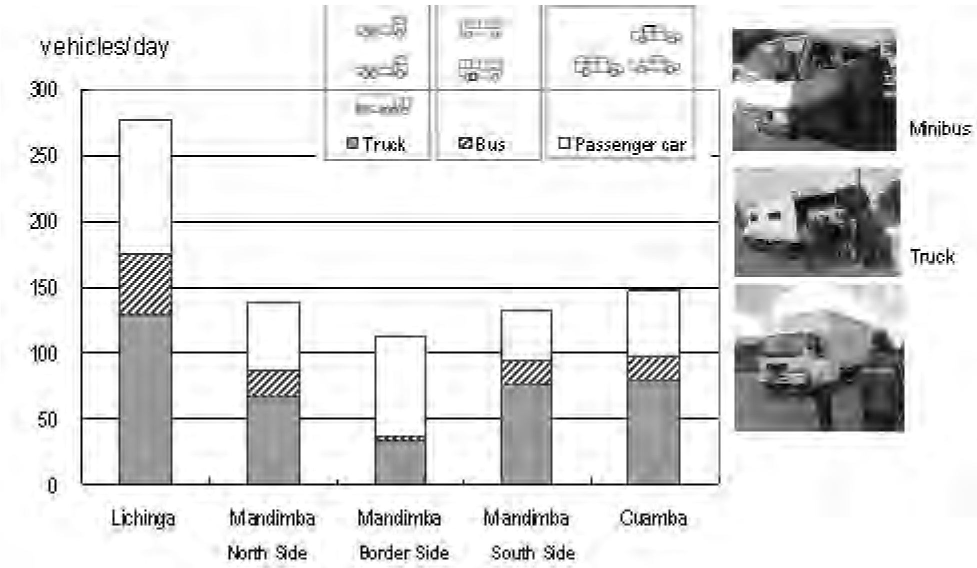


Figure 1.4.4 Traffic Volume per Vehicle Type

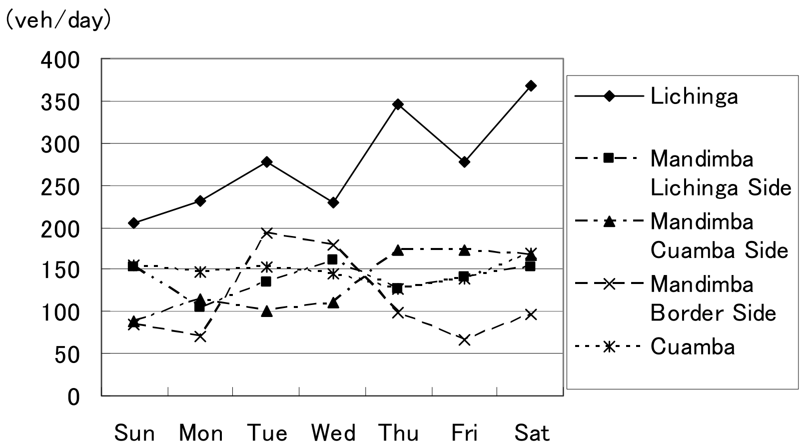


Figure 1.4.5 Daily Variation for the Passenger Cars, Buses and Trucks

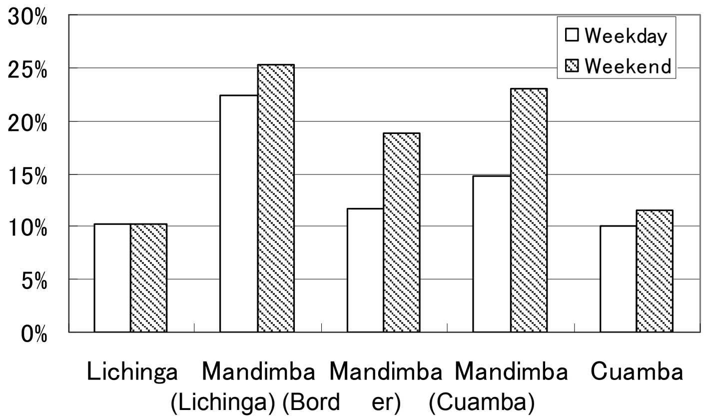


Figure 1.4.6 Large Vehicle Rate

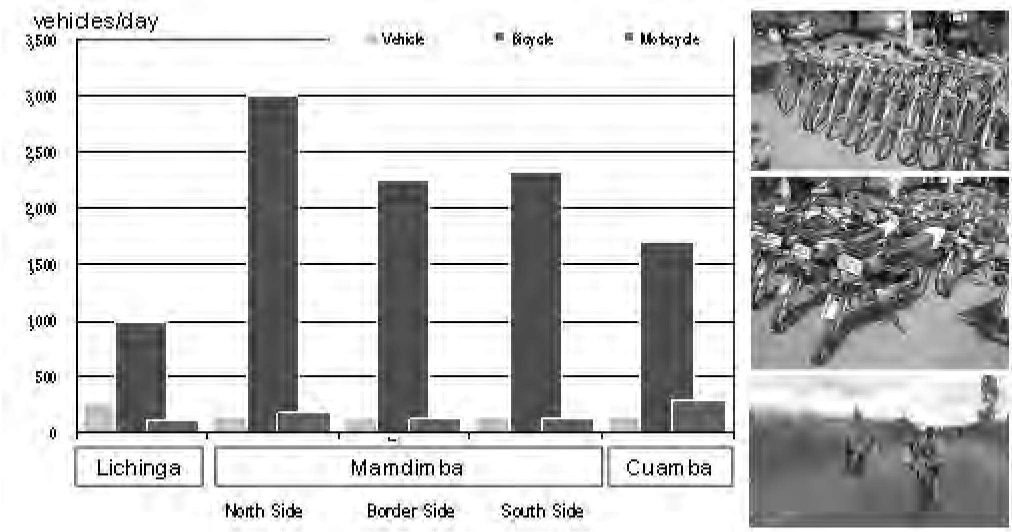


Figure 1.4.7 Motorcycles and Bicycles on Study Road

1.4.5 Results of Origin-Destination (OD) Survey

(1) Sample Rate

The sample rate of OD data for 1st survey remained relatively low with 37% and the result seems to contain some doubtful data. As the 2nd survey achieved a sample rate of 100% as a result of the experience in 1st survey, the data in 2nd survey was mainly analyzed in this Study.

(2) OD Table

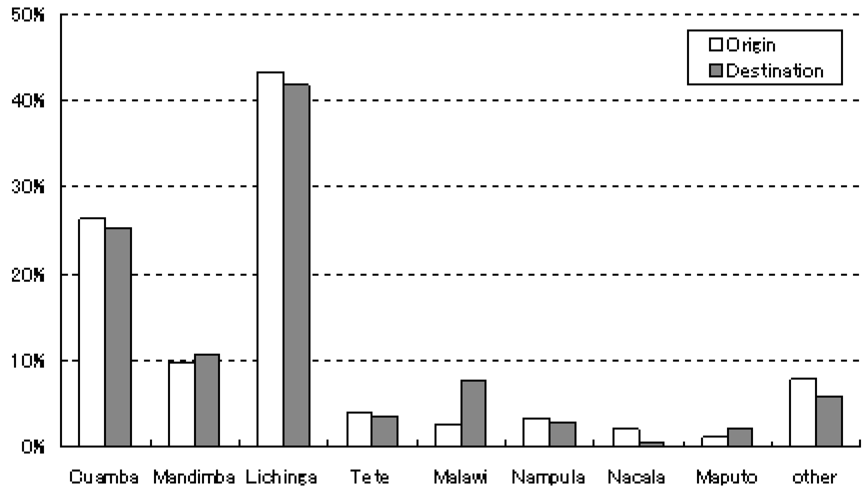
OD tables were produced based on the survey result. OD tables are attached in the Appendix.

(3) Summary of OD survey

853 vehicles were counted in the OD survey at threelocations, Lichinga, Cuamba and Mandimba border, for four consecutive days. It included the internal traffic which is 130 vehicles in Lichinga town and 75 vehicles in Cuamba town. The characteristics of traffic in this area are summarized as follows.

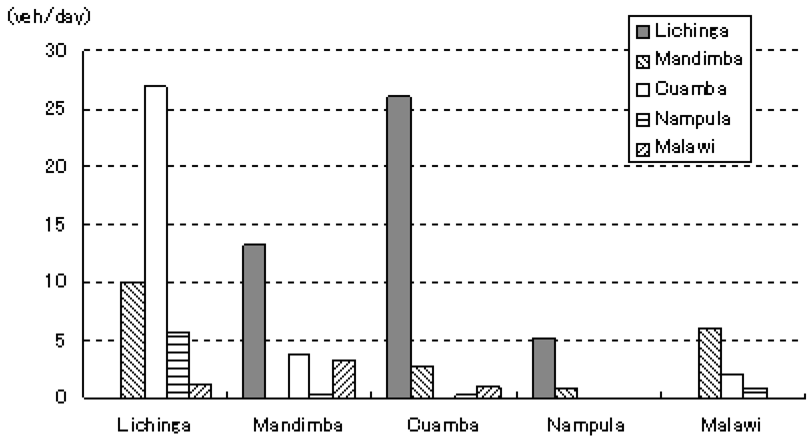
- Origin and Destination

The location of origin and destination of almost 80% of vehicles is either Lichinga or Mandimba or Cuamba. In particular, Lichinga is the main point as origin and destination, with half of the above traffic. It shows that the road is mainly used for the short trip traffic in the province at present, but some of traffic has places outside of Niassa Province such as Tete, Malawi, Nampula, Nacala and Maputo as the origin or destination. The vehicles which come and go to Tete, Maputo and South Africa appear to pass through Malawi because it is faster, safer and more accessible than through the rough roads in Northern Mozambique.



Source: Study Team

Figure 1.4.8 Rate of Traffic at Main Origin and Destination



Source: Study Team

Figure 1.4.9 Number of Vehicles between Main Origin and Destination

- Number of Passengers

Buses have the largest average number of passengers with about 14 people for minibus and 24 people for large bus. Average number of passengers in passenger cars, four-wheel vehicles and heavy goods vehicles is less than four people.

Table 1.4.7 Average Number of Passengers

Vehicle Category	Average Number of Passenger
Passenger car	3.7
Mini-bus	14.3
Large Bus	65.0

Source: Study Team

➢ Travel Time

Travel time from origin to destination was surveyed based on estimation and experience of drivers. Average travel time between Lichinga and Cuamba which is the most common trip in this area, is 10 hours. Travel time from Lichinga is 23 hours to Nampula, 43 hours to Nacala, 86 hours to Maputo and 150 hours to South Africa. It takes time between Malawi south and Mampula/Nacala, which seems to be caused by the trucks transporting a lot of goods.

Origin \ Destination	1	4	6	12	15	18	19	20	22	26
1		10.0	0	23.7	0	0	0	64.0	0	22.8
4			0	4.6	40.8	60.0	0	8.4	0	8.4
6				18.0	0	0	0	53.2	0	42.4
12					12.6	48.5	0	1.7	0	3.2
15						0	0	0	0	33.7
18							0	0	0	55.2
19								0	0	85.8
20									0	14.7
22										150.0
26										

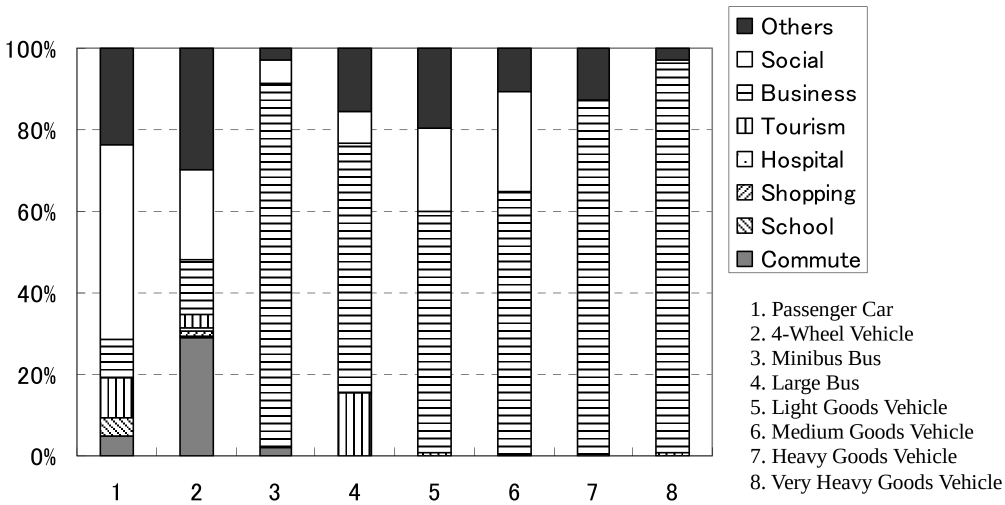
(Zone No.)
1. Nampula 12. Mandimba 19. Maputo 26. Lichinga
4. Cuamba 15. Tete 20. Malawi South
6. Nacala 18. Beira 22. South Africa

Source: Study Team

Figure 1.4.10 Travel Time between Main Origin and Destination (unit: hour)

➢ Purpose of Trip

Social is main purpose only for drivers of small vehicles. For other vehicles, over half of them are driven for business purposes. The purpose for tourism is included in the small vehicles and large buses.

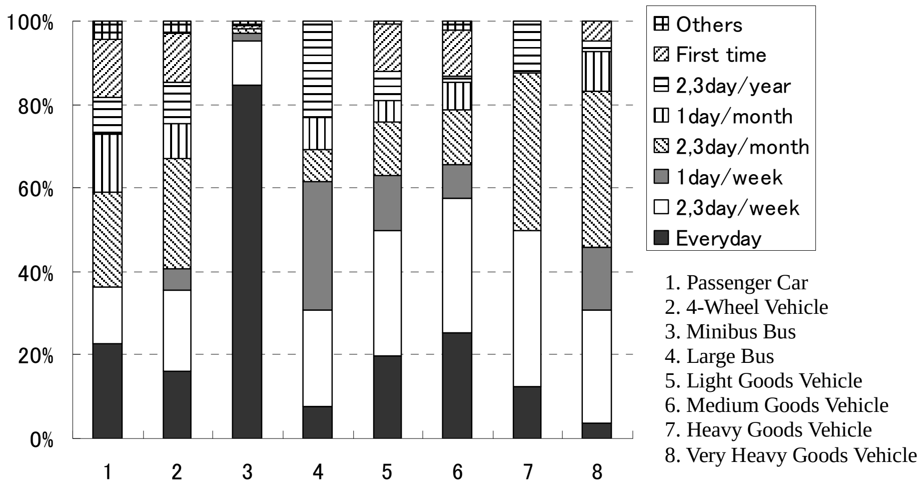


Source: Study Team

Figure 1.4.11 Trip Purpose

➢ Trip Frequency

The trend of trip frequency is mainly divided into two groups, less than a few days per week or a few days per month. More or less 40% of vehicles drive around this area 2, 3 days per week. In contrast, over 80% of mini buses are operated everyday. 20% of large trucks are driven a few days per month.



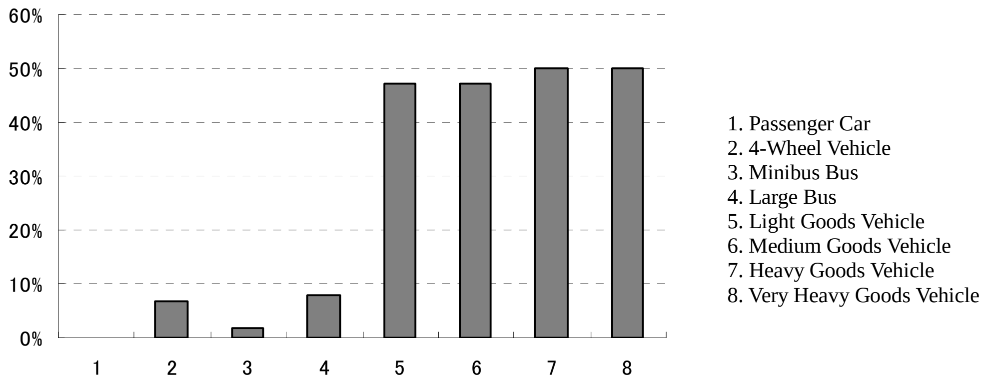
Source: Study Team

Figure 1.4.12 Trip Frequency

➢ Goods transportation

Almost half of the cargo trucks driving this area convey some kind of goods. But the proportion of loaded trucks against all trucks differs largely in each direction. In the direction from Cuamba to Lichinga, most vehicles carry the goods, especially 100% of large goods vehicles. In contrast, over half of vehicles are empty in the opposite way, from Lichinga to Cuamba, which shows that Lichinga relies on the goods from outside and has a few goods and products to distribute out of town.

The principal commodity transported is tobacco leaf, with one quarter of all transported goods. Tobacco leaf is mostly conveyed by the 30 tons trucks to the tobacco factories in Tete through Mandimba border. The next largest volume goods carried are maize with over 10%, followed by beans, cement, diesel and beer.



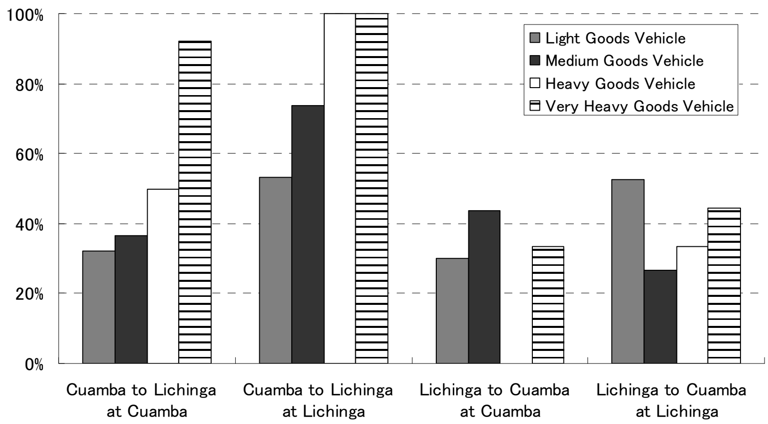
Source: Study Team

Figure 1.4.13 Rate of Goods Loaded

Table 1.4.8 Average Tonnage of Goods Transported

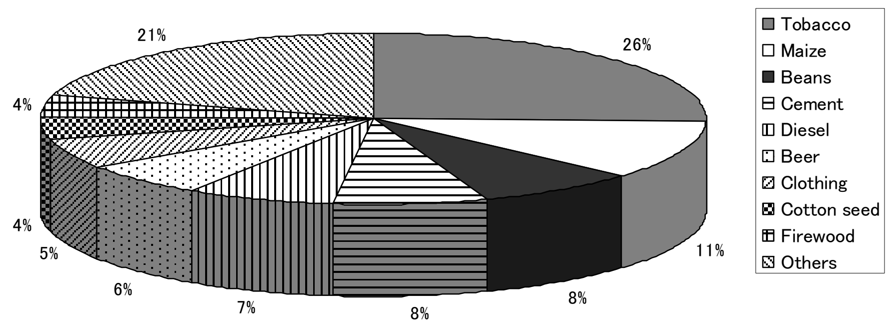
Vehicle Category	Average Tonnage per Vehicle (ton/vehicle)	
	Included All Vehicles	Only Loaded Vehicle
Light Truck	0.545	1.13
Medium Truck	2.6	5.5
Heavy Truck	5.5	11.0
Very Heavy Truck (Trailer)	11.0	22.4

Source: Study Team



Source: Study Team

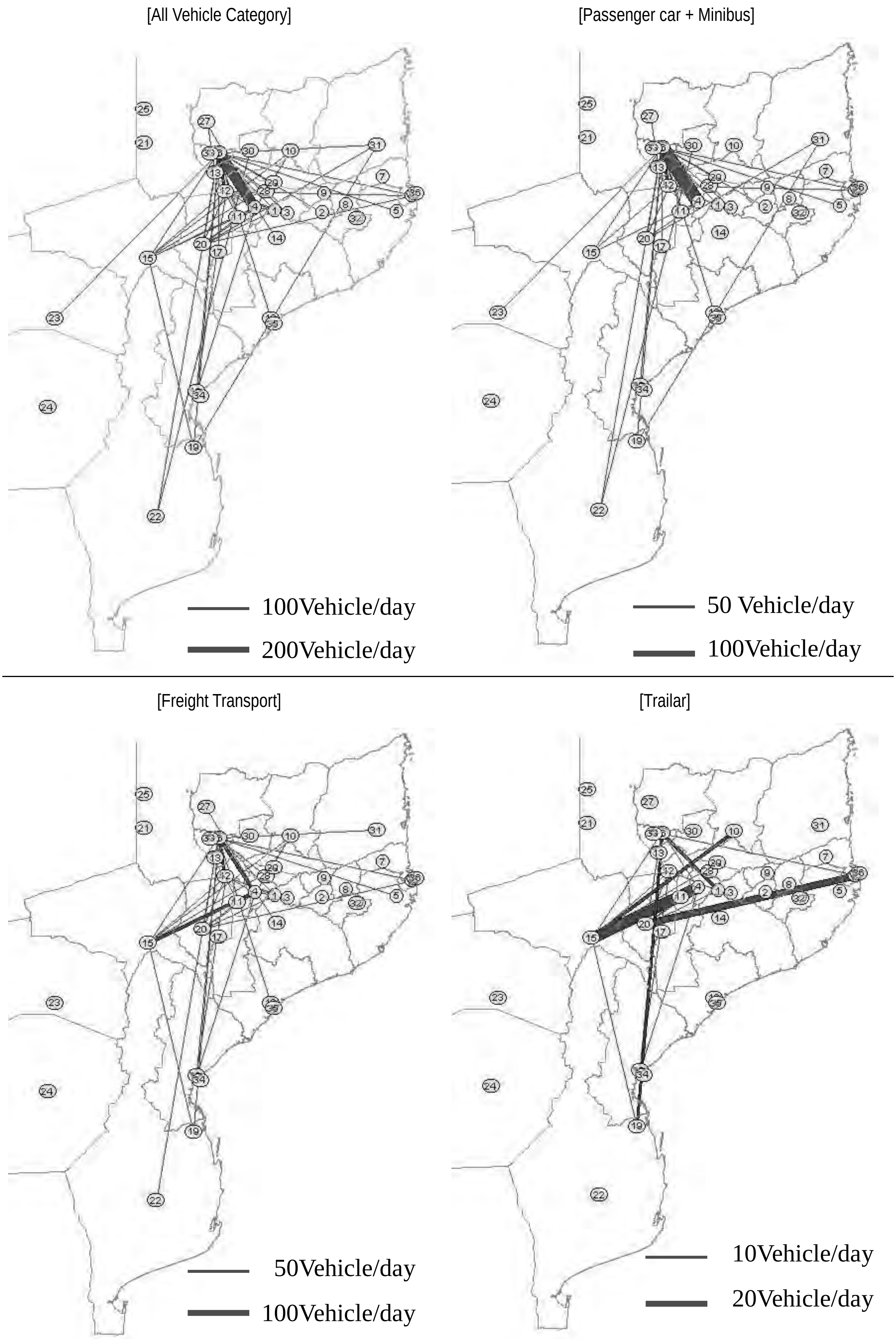
Figure 1.4.14 Rate of loaded truck at each section



Source: Study Team

Figure 1.4.15 Main Transported Goods

As described before, OD trip table is attached in the appendix of this report. Following figures show the trip desire line diagram for each vehicle category. In this figure, there are characteristics of strong relationship between Cuamba and Lichinga for passenger trip, while Lichinga is the major concentrated trip attraction/ generation point for freight transport.



Source: Study Team

Figure 1.4.16 Diagram for Trip Desire Line

1.5 Interview Surveys

1.5.1 List of interviewees

During the Study period, the Study Team interviewed the following organizations and companies concerned with traffic activities in the Study area.

Table 1.5.1 List of Interviewees

Field		Interviewee
Traffic	Public Transport Freight Transport Private / Motorcycle	Ministry of Transport & Communication in Niassa Road Transport Association in Niassa INAV (Instituto Nacional de Viacao) Minibus Manager Truck Driver Police Provincial in Cuamba
	Railways	Lichinga Railway Station, Chief, CDN Cuamba Railway Station Entre Lagos Railway Station, Chief Operator, CDN CFM-Norte Office CDN-Nampula Office CDN-Maputo H.Q.
	Aviation	ADM (Lichinga Airport)
Commercial	Daily Goods	Ministry of Industry & Trade in Niassa Ministry of Industry & Trade in Cuamba Whole Sale Shop (Lichinga) Stores on NH13
	Drinking	Mozambique Beer Company in Lichinga Handling LDA in Lichinca Handling LDA in Cumaba Whole Sale Shop (Mandimba)
	Fuel	Not yet interviewed
Industry, Manufacture	Cement/ Construction Materials	Whole Sale Shop (Mandimba) Construction Company (ONIOBRAS, ALVARO) MOPWH Provincial Office in Cuamba ECMEP Stange Consultant
Agriculture	Maize Cassava Beans Rice Wheat Nuts Sunflower	Malonda Foundation AMADER (Mozambique Association Rural Development) GED (Cabinet of Study for Strategy & Development) Rural Consult, Lda.
	Tobacco (Fertilizer)	Mozambique Leaf Tobacco (MLT) in Lichinga Mozambique Leaf Tobacco (MLT) in Cuamba Buying Centre in Melange for MLT
	Cotton	SAN Lda.
Livestock		Rural Consult, Lda.
Fisheries		Rural Consult, Lda.
Forestry	Timber Jatolopha	Malonda Foundation
Tourism	Niassa Lake Game Reserve	Rural Consult, Lda.

1.5.2 Interview results: General Description of Traffic Patterns on Study Road/ Area

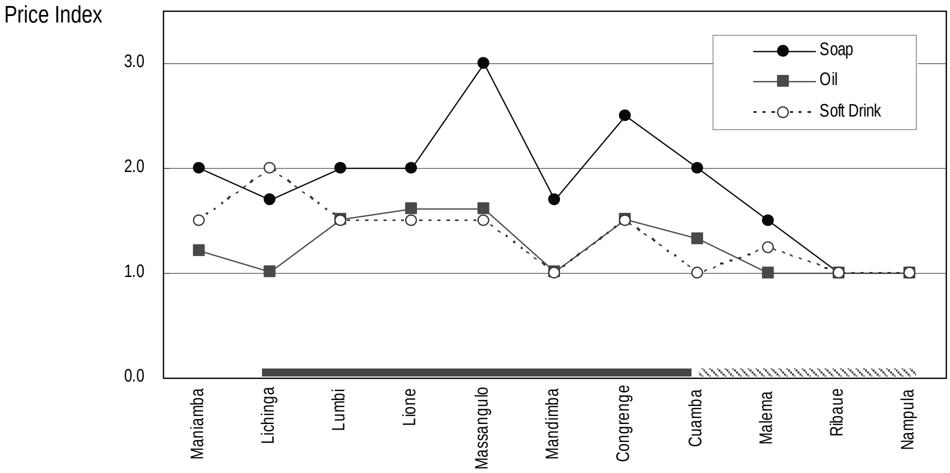
From the interview conducted during the last period, Study Team had grasped the characteristics of traffic patterns on the Study Road and area. The findings are summarized in each traffic category.

(1) Traffic Movement in General

The Study Road, where it connects Cuamba to Lichinga through Mandimba, is the essential road for transporting daily goods, communicating for social and private purposes with other provinces/ districts and supplying the agro-products to the markets.

The Study Road is earth road so it is only possible to drive appropriately in limited periods, while in the rainy season it sometimes becomes impassible. It is observed that potential traffic demands for various purposes are hidden in this area.

As one of the examples for describing the characteristics of this area, the Study Team conducted the price survey for daily goods along the Study Road. The figure below shows the results of this survey, which is affected by large transportation costs.



Note: Price index: Nampula = 1.0
Source: Study Team

Figure 1.5.1 Price Changes of Daily Goods on NH13

The railway connected between Cuamba to Lichinga is now operated only twice per month because of damaged condition of the railway. Therefore, the railway does not have enough capacity for transportation at this time. .

In Nacala Corridor, railway has been spread from Nacala Port to Cuamba up to Entre Lagos. Normally, long distance transportation both of passengers and goods uses the railway from/ to Nampula to Cuamba and uses the Study Road to Lichinga and other northern districts of Niassa. Note that railway operation is almost at full capacity for traffic throughput.

For another road network in this reagion, there are already improved roads between Lichinga to Marrupa, where it will be connected with Pemba Port and Montepuez, provincial capital of Cabo Delgado, however, they still prefer to connect Nampula and Nacala Port through Cuamba.

Niassa Province has high potential for agro-products, not only food crops (e.g. maize, rice and beans) but also cash crops (tobacco and cotton) and forestry products. It means that these potentials are now restricted because of low passing ability on the road and railway networks.

In the followings section, the characteristics of movement for each category are summarized.

(2) Passenger Movement

Passengers pass though the Study Road mostly by mini-bus and covered truck between Cuamba and Lichinga. Normally, it takes about six hours between Lichinga and Cuamba for a fee of 350MTN per person by minibus (Lichinga to Mandimba is 160MTN). This fee is regulated by ministry as 1.10MTN per person per km. It is not fixed scheduled operation, normally three buses are dispatched in the morning, two at noon and three in the afternoon from one side. Number of passengers in minibus (one box-type vehicle or covered truck, photo below) is regulated to provide seats and roofs, so that only 18 persons are allowed to sit in one bus. At this moment, it is impossible to operate a return trip within one day.

Figure 1.5.2 Photo of Minibus and Truck

The route of Cuamba to Lichinga is a trunk network for minibus transportation in Niassa, while the other routes connected to another district in Niassa should be started from Lichinga or Cuamba towns because of road conditions. For example, if passengers from near Lichinga want to travel to Maua located just near Marrupa, they have to travel to Cuamba first, then change to another minibus for Maua.

The long-distance bus for Maputo is operated twice per month with 56 to 60 seats for 2,300 ~ 2,500 MTN. It takes about 3 or 5 days.

There is a small number of private vehicles. At the nearer towns such as Cuamba, Lichinga and Mandimba, motorcycles are used for traveling to neighboring districts. Note that bicycles are used for local transportation delivering firewood small businesses.

(3) Goods Movement

Freight transportation can be divided into following items which have different characteristics of movement:

- Food Crops (Maize, Beans other Farm Products)
- Cash Crops (Tobacco and Cotton)
- Daily Goods (Drinks, Plastics and Equipments,)
- Fuel
- Construction Materials (Cement, Timber)

(a) Food Crops (Maize, Beans, Rice and other Products)

Niassa Province has an advantage of food production because of its suitable climate and lands so that it provides not only in Niassa but also distributes to the whole of country, especially the large consumption area in Nampula. The following are described for typical movement of food crops.

Table 1.5.2 Goods Movement for Food Crops

Maize	Most of the farm surplus of maize (about 80%) is transported to Nampula through railways from Cuamba. Other 20% is for Malawi and Beira. These towns have milling factories and distribute their products. 
Beans	Beans harvested in Niassa are distributed to Maputo and Beira with 70% and to Nampula with 30%. Niassa's beans are preferred to Swaziland's because of their good taste. 
Other Harvests	At this moment, most of other harvest is consumed within their district because of transportation difficulties. Recently, rice production is starting to be boomed in Mecanhelas, it has a potential to distribute in whole of country in future.

(b) Cash Crops (Tobacco and Cotton)

Cash crops are now booming as new business in Niassa, especially the tobacco industry has grown up over the past few years. These movements needs long distance to the processing plants as described below.

Table 1.5.3 Goods Movement for Cash Crops

Tobacco	Tobacco leaves and fertilizer are transported between "Buying Centers" which are dotted in Niassa and "Processing Factories" in Tete through Malawi by 30t truck. Tobacco leaves (from Niassa to Tete) are delivered from February to June. Fertilizers are distributed from Tete to Niassa in September. 
Cotton	Cotton is processed in factories in Cuamba, Cotton fiber is transported to Nacala Port by railway and cotton seeds are transported to Malawi by road and railways for exporting. Railways: bound for Blantyre and Lilongwe via Entre Lagos from Cuamba Road: bound for Blantyre and Lilongwe via Mandimba from Cuamba 

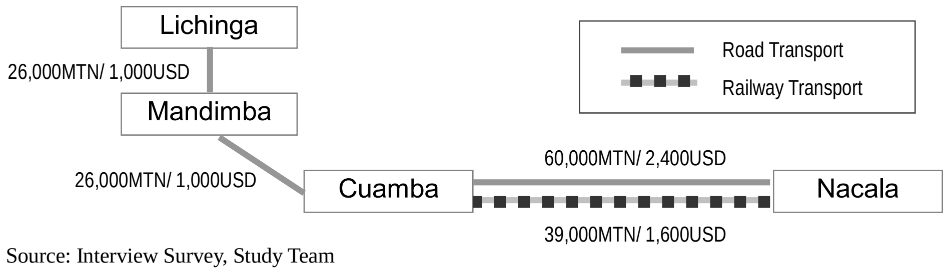
(c) Daily Goods, Fuel and Construction Materials

As explained before, Niassa Province is far from other major towns and ports, so that there are limited transport routes and measures. The following are summarized for each movement to Niassa. Normally, they are transported to Lichinga or Cuamba first, then distributed to various places in Niassa Province.

Table 1.5.4 Goods Movement for Daily Consumed Goods

Daily Goods	**Processed foods, oil, snacks and miscellaneous goods**: each retailer hires the truck from various towns by various transport measure as below; From Nacala: Normally, it is transported from Nacala to Cuamba by railway, then rest of route is by truck From Beira and Maputo: Directly from there by truck via Gurue and Cuamba (only in rainy season, Malawi route is selected) **Bicycles** (2,000~2,500MTN) and **motorcycles** (16,000MTN) are popular sale items.     
	Beer: At this moment, beer breweries are located in Beira and Maputo. Maputo's beer is shipped to Beira Port, and transported together with Beira's beer by 30t trucks through Mawali to Lichinga. After arriving in Lichinga, they are distributed in Niassa Province. One of two major distributers in Lichinga said that five trucks per week is normal transportation. Note that coming October in 2009 a new beer brewery will be opened in Nampula. It is considered to be transported by truck.
	Soft Drinks: At this moment, a factory is located in Nampula. It distributes by railway from Nampula at 05:00 to Cuamba at 19:00. Normally, two wagons are transported per day (one wagon = 30t = 2,015crates). Soft drink company said that it would prefer to shift to truck transportation if road condition will be improved because railway transportation has a lot of time loss.
Fuel/ Petrol	Petrol is transported from Beira by tank truck which has 40,000 liter capacity, to Lichinga. Normally, it is transported three or four times per month. After arriving at Lichinga, it is distributed to any other district in Niassa.
Construction Materials	There is a cement factory near Nacala Port. Transportation is used by 10 ~ 20t truck from Nacala directly. If a large amount of cement is distributed by client, railway can be used for containers. For example, price of cement is normally 350MTN/50kg in Cuamba, instead of 100MTN/50kg in Nacala. During rainy season, it will be increased up to 450~500MTN/50kg. 

From the results of interview to retailers at Mandimba, transportation costs when 40 feet container is transported by railway or road truck are summarized below.



Source: Interview Survey, Study Team

Figure 1.5.3 Transportation Cost from Nacala to Lichinga

At this moment, road condition is bad that transporters charge a lot of fees to clients. It is expected when the road will be rehabilitated many retailers will purchase own trucks and start distributing more than now.

1.6 Summary for Existing Traffic Flow Patterns

Through above information researched by data collection, interview and traffic volume and OD survey, study team recognized the trip characteristics for each section, which tend to be different types of trip patterns. It is summarized in the table below. These characteristics will be considered for the traffic demand estimation in Chapter 3.

Table 1.6.1 Characteristics of rip Pattern for Each Section

Category	Lichinga - Mandimaba	Mandimba - Cuamba
Characteristics in General	▪ This section is the only route for delivering consumer goods to Lichinga which is the provincial capital of Niassa, where is the base for distributing to northern part. This section can be said the lifeline for northern area. ▪ Majority of social and official movement is the OD-pair between Lichinga and Cuamba. ▪ Some agro-products are generated from Northen side to south side of Mozambique and Malawi through Mandimba.	▪ This section is used for passenger movement from Lichinga and other district in Niaasa to connect railway or Numpula province. ▪ Some consumer goods are dispatched from Cuamba to Lichinga. On the other hand, most consumer goods for Cuamba city are come from Nampula side mainly by railway. ▪ Some trailers with empty container are found which delivers to Nacala port from Malawi. ▪ Some agro-products generated around Cuamba to transport to Malawi or Tete province.
Vehicle Type	▪ More than half of vehicles are trucks including medium and trailer. ▪ Minibus is major for passenger movement.	▪ More than half of vehicles are trucks with mainly trailer and large truck. ▪ Minibus is major for passenger movement.
Average Trip Length (time) without internal zone trip	▪ **16.8** hours (All Vehicles) ▪ 11.5 hours (Passenger Car + Bus) ▪ 25.2 hours (Trucks) ▪ 2.86 days (Trailer)	▪ **19.3** hours (All Vehicles) ▪ 11.4 hours (Passenger Car + Bus) ▪ 28.5 hours (Trucks) ▪ 1.99 days (Trailer)

Chapter 2 International Goods Transportation Though Nacala Corridor

2.1 Introduction

This chapter aims to discuss the current condition of international goods transportation through Nacala Corridor in order to estimate future traffic demand on the Study Road.

This information is summarized by a) statistical data, b) cross-border OD survey and c) interview survey to traffic related stakeholders and road users.

Based on this information, future possible diverted goods traffic to Nacala Corridor generated from Malawi are discussed.

2.2 International Corridor Condition: Nacala and Beira Corridor

2.2.1 General Information of Both Corridor (Nacala and Beira)

Nacala and Beira Corridors are recognized as essential corridors connecting the land-locked countries of Malawi, Zimbabwe and Zambia with ports. However, due to civil war, low investment and insufficient maintenance, the roads and railways do not function adequately and this presents difficulties for the development of these regions.

The figure on the right shows both corridor networks. Since 2000, the "Nacala Development Corridor (NDC)" was officially launched1 and indicated wider cross border regional area. The Beira Corridor has been formed since independence.

Nacala Corridor has a road and railway network connecting Nacala Port in Mozambique with Malawi and Zambia. The railway service is inadequate, especially the section between Cuamba to Entre-Lagos.

The road network between Nampula and Malawi border (N13) is still unpaved although it is the national primary road. According to NDC mapping, the road between Cuamba and Lichinga is also included with its corridor.

Beira Corridor has a road and railway network; however, the railway service is considered so poor. Details for railway and port are described from next section.

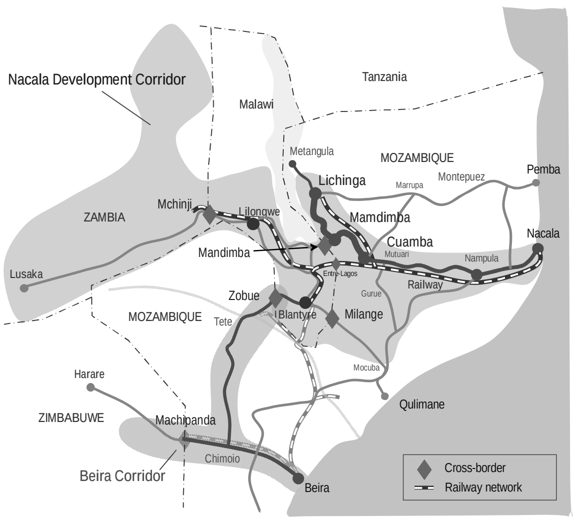


Figure 2.2.1 Corridor Network

[1] Nacala Development Corridor: Webpage; http://www.nacalacorridor.com/

2.2.2 Basic Information for Port and Railway Infrastructure in Nacala Corridor

(1) Railway Infrastructure and Operation

The railway lines of the Nacala Corridor consist of three different lines.

- The Nacala – Cuamba – Entre-Lagos line, 610km, to the border of Malawi, fully rehabilitated in 1996
- The Cuamba – Lichinga Line, 262km
- The Lumbo – Monapo line, 42km, not operational

A "Study on the Institutional and Management Reform of the Nacala Corridor" was carried out by the EU in 1997-1998 and its conclusions were adopted by the Government.

<u>Current Operation</u>

The Nacala Corridor, consisting of Malawi's railway and the Nacala Port and railway in Mozambique, was concessioned in stages, beginning with the creation of Central East African Railways (CEAR) in 1999 in Malawi and continuing with the concessioning of the Nacala Port and railway in 2005. Together these represented the first private sector integration of ports and railways for general cargo in recent history. It is operated by CDN, a joint venture between CFM and private sector entities, comprising RDC, ERL and various Mozambican private investors under the concession of a fully commercial agreement with no public sector financial support. In addition to rail freight service, the Nacala Corridor provides passenger service in selected markets in both Mozambique and Malawi.

Following is a brief explanation of the major links of the Nacala railways:

<u>Nacala – Cuamba (533km)</u>

During the civil war, this section was completely rehabilitated with funds from France, Portugal and the European Union. This undertaking was also financed, in local currency, by the Government, the Bank of Mozambique and CFM. In the section, normally three trains run each day in both directions.


Iapala Station, Ribaue District, Nampula Province

<u>Cuamba – Entre Lagos (77km)</u>

CDN has been doing constant maintenance work on this section to improve safety and avoid derailments. Wooden sleepers are being replaced by steel sleepers to increase its efficiency.

<u>Cuamba – Lichinga (262km)</u>

Mixed passenger/cargo trains circulate regularly once or twice a month. This track is essential for the development of Niassa Province and it is now undergoing consolidation works.

The operation of this line is susceptible to flooding. In 2008, Nacala railway line was closed from 31 December 2007 to 7 January following flood damage and was disrupted again on 26 January when heavy rains washed out a 30 meter stretch of track and destroyed a culvert. The line was cut in the district of Nampula-Rapale, west of the provincial capital Nampula, halting all trains.

The delay is seriously affecting Malawi farmers, who import fertilizer through Nacala - a commodity badly needed for the planting season. Container loads of Malawian tobacco for export are also held up, as are produce consignments for markets in Nampula and Nacala. The disruption of agricultural traffic from the districts of Ribaue and Malema to Nampula results in shortages of tomatoes, potatoes, cabbage and other vegetables.

The current train transit is as follows;

Table 2.2.1 Current Train Transit Data

Line	Length (km)	Speed(km/h)	Time (hours)	Max. practical train weight (ton)
Nacala - Cuamba	533	50	10.7	800
Cuamba to Border	77	20 (15 in rainy season)	3.9	800

The current freight level is around 0.3 million tons per year (0.32 in 2002, 0.287 in 2003 and 0.274 in 2004), which is equivalent to about one train per day. However, the demand is not distributed evenly, and three or four trains per day are required during harvest season.

The availability of the CFM locomotive fleet is poor. Total travel time into Malawi is 8 to 20 days. Passenger trains run only once every two days and are mixed with freight goods under locomotive capacity.

(2) Port Infrastructure and Operation [Nacala Port]

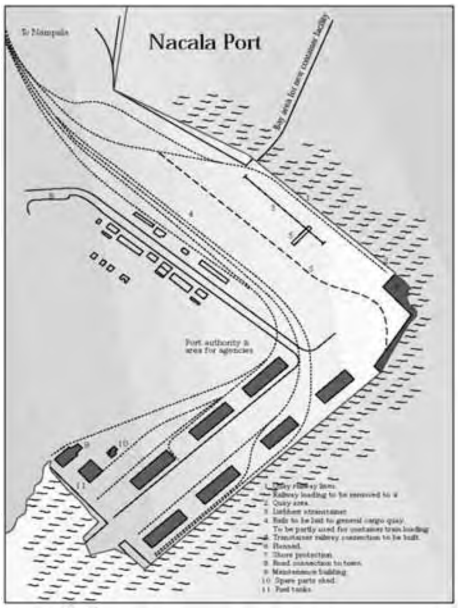
Nacala Port has one of the best natural deep-water harbors on the East Coast of Africa. The port operation concession was granted to CDN in January 2005 as part of a joint concession that included the railway.

The port quay length, alongside depths and existing annual capacity are summarized below.

Table 2.2.2 Port physical characteristics

Type of Cargo	Number	Length (m)	Alongside depth (m)	Existing annual capacity
General Cargo	2	675	7-10	1,000,000 ton
Containers	1	372	14	40,000 TEU

The layout of Nacala Port is shown in the figure at right.



The typical handling rate[1] for containers in 2005 was 7 moves/hours. Dwell[2] time for containers averaged 24 days for imports, 9 days for exports in 2005.

The following tables show the volume of containers and un-containerized cargo handled at Nacala Port in 2004.

(a) Containers handled at Nacala (2004)

Of the 400,000 tons (about 31,000 TEU) of containers handled in 2004, 290,000 tons (72.5%) was for Mozambique and 110,000 tons (27.5%) was for Malawi. It is about 12.8 ton per TEU.

Table 2.2.3 Containers handled at Nacala (TEU) (2005)

Source	Import Embark	Export Disembark	Total	Difference between 2004 and 2005
National	2,699	2,256	4,955	-11.9% Emb.: -2.6%, Dis: -21.0%
International from Mozambique	10,708	10,983	21,691	+15.0% Emb.: +17.1%, Dis: +12.9%
International Transit from Malawi	2,230	1,928	4,158	-19.3% Emb.: -10.2%, Dis: -27.8%
Transshipment			314	-45.7%
Total	15,637	15,167	31,118	+3.0%

(b) Un-containerized tonnage by commodity at Nacala (thousand ton) (2005)

Nacala Port handles about 400,000 tons of un-containerized cargo as shown below (2004). According to the 2005 annual report, 69% was for Mozambique, 23% was for

[1] Container handling rate: One indicator for port productivity is how many containers can be loaded /off loaded by crane.
[2] Dwell time: Time elapsed from the time the cargo arrives in the port to the time the goods leave the port premises after all permits and clearances have been obtained

Malawi and 8% coastal.

Table 2.2.4 Un-containerized tonnage by commodity at Nacala (thousand ton) (2004)

Commodity	Import and exports		Total
	Mozambique	Malawi	
Rice	43	-	43
Wheat	76	-	76
Sugar and Products	-	19	19
Fuel	112	24	112
Clinker	105	-	105
Fertilizer	-	32	32
Cashews	37	-	37

Table 2.2.5 shows the traffic that could be attracted to the Nacala rail corridor from neighboring countries.

Table 2.2.5 Potential Traffic that could be attracted to Nacala Corridor (thousand ton)

Commodity	Source/ currently used corridor	Annual Ton (thousand)
Mozambique Export		
Mozambican Tobacco	Lilongwe – Durban	20
Tantalum	Marrua (Pebane Dist. Zambezia Prov.)	2
Phosphates	Evate (Nampula Prov.)	339
Timber	Lichinga (Niassa Prov.)	1,930
Malawi Exports		
Tobacco	Beira	16
Tobacco	Johannesburg – Durban	65
Sugar	Beira	30
Tea	Beira	5
Tea	Johannesburg – Durban	15
Beans & Peas	South Africa	5
Groundnuts	South Africa	10
Titanium oxide	Chipoka, Mawali (Niasa Lake)	1,240
Pig iron	Chipoka, Mawali (Niasa Lake)	1,165
Feldspar	Chipoka, Mawali (Niasa Lake)	80
Mozambique Import		
Mozambican Tobacco	Lichinga – Lilongwe	32
Acids and Ammonium	Nampula	527
Malawi Imports		
Fertilizer	South Africa	58
Fertilizer	Beira	42
Petrol, oil and Lubricants	Beira	150
Wheat & Flour	Beira	12
Vegetable oils	Brita	11
Salt	Zimbabwe – Botswana	25
Clinker	India	150
Coal	Chipoka, Malawi (Niasa Lake)	48
Total		5,977

Source: Overview of economic benefits accruing from the operation of a seamless Nacala development corridor, DBSA, 2004

2.2.3 Basic Information for Port and Railway Infrastructure in Beira Corridor

(1) Railway Infrastructure and Operation

The Beira Corridor has three railway lines.

- The Machipanda line, 317km, linking Beira Port to the network of the National Railways of Zimbabwe
- The SENA Line, 578km, not operational (331km linking Beira Port to the Malawi border at Vila Nova de Frontiera, 247km linking to Moatize coal fields)
- The Imhamitanga – Marromeu line, 88km, not operational

<u>Current Operation</u>

The Beira Railway Co (BRC) is a joint venture entity formed to operate the Beira railway corridor. It is owned 51% by Indian concessionaires Rites and Ircon and 49% by CFM.

Table 2.2.6 Current train transit data

Line	Length (km)	Speed (km/h)	Time (hours)	Max. practical train weight (ton)
Machipanda	319	25	12.8	1,200
Sena	520	N/A	N/A	N/A

The level of traffic on the Machipanda line was around 0.8 million tons per year in 2003 and about 0.6 million tons in 2004 because of reductions in cereal transport.

Machipanda line experiences poor service reliability. The Maersk timetable indicates that freight delivery from Harare to Beira requires 10 days by railway and three days by road.

(2) Port Infrastructure and Operation [Beira Port]

Beira Port is situated on the Pungoe River estuary and is the second largest port in Mozambique.

The 25-year concession for the container and general cargo terminals was issued in October 1998 to Cornelder de Mozambique SARL, a Dutch owned company which has a 70% shareholding (CFM: 30%).

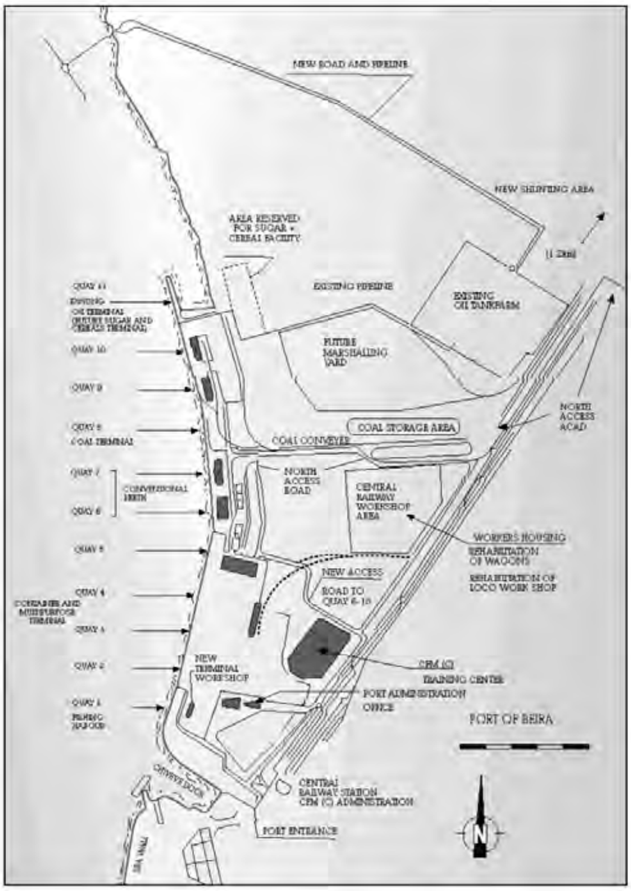
The concession only covers containers and break bulk (general) cargo. The cold stone, “coal appearance” and oil terminal remain with CFM. The State, through CFM, continues to own the port and CFM is the port authority. CFM also retains responsibility for dredging. Cornelder agreed to invest US$15 million during the first five years of its concession.

The port quay length, alongside depths and existing annual capacity are summarized below.

Table 2.2.7 Physical Characteristics of Beira Port

Type of Cargo	Number	Length (m)	Alongside depth (m)	Existing annual capacity
General Cargo	5	670	6.5–7.0, 6.5–8.5	1,700,000 ton
Containers	4	646	9.0–11.0	100,000 TEU
Coal	1	188	9.0	300,000 ton
Oil and Products	2	480	11.8	2,000,000 ton

The layout of Beira Port is shown in the figure right.



The Beira petroleum terminal has been rehabilitated with financial assistance from Norway.

The port obtained Danish development assistance to fund a new high capacity dredger in 2005.

The typical handling rate [1] for containers is 8 box moves/hour/crane.

The dwell[2] time is 30 days.

In general, 95% of Malawi imports enter the country by road.

Following tables show the volume of containers and un-containerized commodities for Beira Port in 2004.

(a) Containers handled at Beira

Of the 528,000 tons (about 46,800TEU) of containers handled in 2004, 15,600 tons (33.3%) wasere bound for Mozambique and 26,100 tons (55.8%) were for Malawi and Zimbabwe. About 20% of transit containers were empty (about 14.0 tons per TEU).

[1] Container handling rate: One indicator for port productively how many containers can be loaded /off loaded by crane.
[2] Dwell time: Time elapsed from the time the cargo arrives in the port to the time the goods leave the port premises after all permits and clearances have been obtained

Table 2.2.8 Containers handled at Beira (TEU) (2004)

Source	Import	Export	Empty	Total
International	8,100	2,200	5,300	15,600
Transit	13,500	11,400	1,200	26,100
Cabotage	1,300	1,400	2,400	5,100
Total	22,900	15,000	8,900	46,800

Table 2.2.9 Containerized tonnage by commodity at Beira (thousand tons) (2004)

Commodity	Import and exports				Total
	Mozambique	Malawi	Zimbabwe	Zambia	
Consumer goods	99	75	46	2	222
Sugar and products	1	26			27
Prawns	6				6
Cotton	5		4		9
Timber	6				6
Tea/coffee		24	2		26
Tobacco		49	20		69
Total	117	174	72	2	363

(b) Un-containerized tonnage by commodity at Beira

Beira Port handled about 1,597,000 tons of un-containerized freight in 2004, as shown in the table below. Of this, 30% was bound for Mozambique, 31% for Malawi and 39% for Zimbabwe.

Table 2.2.10 Un-containerized tonnage by commodity at Beira (thousand tons) (2004)

Commodity	Import and exports			Total
	Mozambique	Malawi	Zimbabwe	
Rice	69		11	80
Wheat	43		37	80
Sugar and Products		77		77
Fuel	231	355	281	867
Ferro-chrome			29	29
Granite			150	150
Clinker	105			105
Steel			63	63
Fertilizer	26	56	64	146
Total	474	488	635	1,597

2.3 International Freight Transport Cost/ Time [Literature Review]

The Study Team collected several research documents for international transport costs between Mozambique and Malawi. Since 2001, various researches have been conducted as shown below. In this section, the situation will be summarized based on the literature review of these researches. Note that the results of interview survey conducted to stakeholders in Mozambique and Malawi will be discussed in 2.4.

- SATN Comparative Transit Transport Cost Analysis, 2001
- Malawi Diagnostic Trade Integration Study, 2002
- Transport Cost Study, Technical Annex, 2005, Mozambique
- SADAC for Trade Facilitation Audit, 2004
- Trade and Transport Facilitation Audit, WB, 2004
- Corridor Performance Report, PMAESA 2004

The cost survey in 2001 included the port charges border costs such as third party insurance, cross-border permit fee, and border toll. This comparison could only find the different O-D basis cost in Nacala/ Beira Corridor. However, it shows the general components of international transportation cost.

Table 2.3.1 Transport Charges for Containers from Beira and Nacala Port to Malawi, 2001

Port	No. of borders	Non-distance related US$/container/corridor		Distance related US$/container/corridor				Total	
		Port Charges	Border Post*1	Haulage	Border Post*2	Toll Fees	Others*3	US$ /cont /km	US$ /cont/ corridor
Beira									
Beira – Blantyre (via Tete) By Road	1	430	69	1,143 (1.458)	55	20	35	2.234	1,751
Beira – Blantyre (via Nsanje) By Road	1	430	69	828 (1.458)	55	0	25	2.477	1,407
Beira – Blantyre (via Nsanje) By Rail	0	430	0	603 (1.040)	0	0	26	1.827	1,060
Nacala									
Nacala – Lusaka (via Lilongwe) By road	2	430	96	2,466 (1.390)	125	0	48	1.784	3,165
Nacala – Lusaka (via Lilongwe) By multimodal*4	1	430	28 + Trans-shipment: 60	2,224 (1.390)	70	0	77	1.656	2,889

Note:
Beira – Blantyre (via Tete) by road, 674 km (Mozambique), 110 km (Malawi): total 784 km
Beira – Blantyre (via Nsanje) by road, 321 km (Mozambique), 247 km (Malawi): total 568 km
Beira – Blantyre (via Nsanje) by rail, 328 km (Mozambique), 252 km (Malawi): total 580 km
Nacala – Lusaka (via Lilongwe) by road, 676 km (Mozambique), 494 km (Malawi), 604 km (Zambia): total 1,774 km
*1 Third party insurance, *2 Road use charges (transit fees), *3 Insurance + Facilitation fees + Stocks-in-transit, *4 Multimodal of Nacala – Lusaka (via Lilongwe) passes though a) Nacala – Balaka (720 km) by rail, Balaka – Lilongwe – Chipata (420 km) by rail and Chipata – Lusaka (604 km) by road, total 1,744 km .
Note: Haulage cost in blanket means US$ per container per km.

Source: SATN Comparative Transit Transport Cost Analysis, 2001

The figure below illustrates the cost components of transportation from Beira – Blantyre and from Nacala – Lusaka taken from the data in Table 2.2.1. For Malawi transportation, port charges make up 25% of the total costs, and all other costs except haulage make up 10%. This only examines direct costs and not indirect and opportunity costs such as i) delays at border posts, ii) slow travel speeds, iii) road condition affected by road operational costs, iv) low volumes (inefficient vehicle utilization) and v) various additional charges per border post.

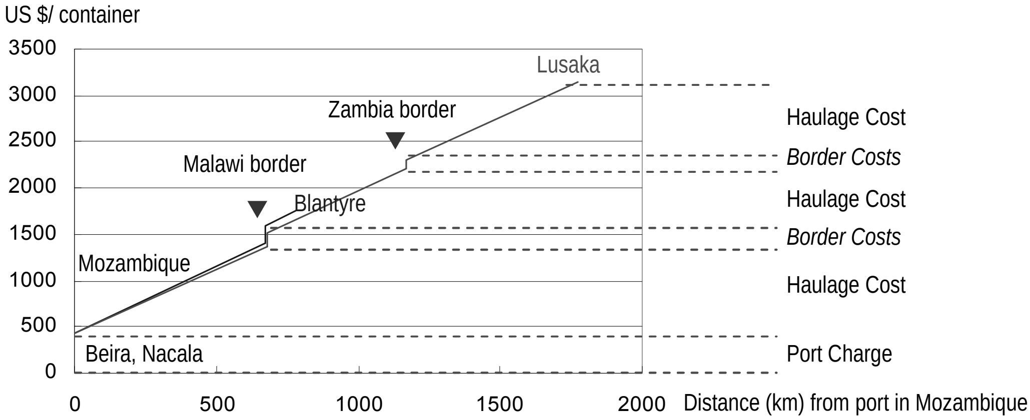


Figure 2.3.1 Transport Cost Components from Mozambique's Port

According to collected previous research documents, the summarized transport costs in each corridor are shown in Table 2.2.3. Although the costs of railway transport are almost similar such as 7.2 to 7.7cents/ton-km, the costs of road transport fluctuate more widely between 6.0 to 10.4cents/ton-km. It is because it is difficult to standardize conditions (i.e. insurance, including or excluding of return way, premiums) when acquiring quotations for road transportation costs. In order to compare corridors by transportation costs, it may be necessary to think more for the time required and reliability for transit time and border crossing times.

Table 2.3.2 Summarized Transport Costs for Road / Railways

	Road		Railway		
	Distance	US cents/ton-km	Distance	US cents/ton-km	Within Mozambique US cents/ton-km
Nacala Port Charge 430US$/cont.	960km	6.3[*1] (Sugar)	806km	7.4[*2] (Nacala-Blantyre)	8.6[*4] (Nacala – Entre Lagos)
	750km	Import 7.6[*3] Export 4.8[*3] (Nacala-Blantyre)			
	1,774km	9.9[*5] (Nacala-Lusaka)	1,774km	9.9[*5] (Nacala-Lusaka) Note: multi-modal	
Beira Port Charge 430US$/cont.	830km	6.8[*1] (Fertilizer)	593km	7.7[*2] (Beira-Harare)	4.7[*4] (Beira -Machipanda)
	830km	Import 8.4[*3] Export 4.7[*3] (Beira-Blantyre)			
	784km (Tete) 568km (Nsanje)	10.4[*5] (via Tete, Nsanje)	580km	7.2[*5] (Beira-Blantyre) Via Nsange	
	1,056km	6.0[*6] (Beira-Lilongwe)			
	856km	7.0[*6] (Beira-Blantyre)			

Regarding time-based comparison for international transportation, border post delays of the Beira Corridor were examined in 1999 at the Machipanda and Zobue borders.

Delays of about 24 hours to cross these borders were discovered at that time. (Source: Imani Capricorn and World Bank staff, based on interviews with users)

The table below shows the transit time for the Beira and Nacala Corridors. Average speeds for both are only 10 to 12km/h, compared with the Durban – Johannesburg (Road: 60km/h, Rail: 29km/h) and Maputo – Johannesburg routes (Road: 30km/h, Rail: 8km/h).

Table 2.3.3 Road and Rail Transport: Average Transit Times and Trip Speeds, 1999

Corridor	Road			Rail		
	Approx. distance (km)	Average Transit times (hrs.)	Average Speed (km/h)	Approx. distance (km)	Average Transit times (hrs.)	Average Speed (km/h)
Beira						
Beira – Lilongwe	850	70	12.1			
Nacala						
Nacala – Lilongwe				1,014	96	10.5

Source: SATN Comparative Transit Transport Cost Analysis, 2001

Note that above information has been compiled from the previous research results, so each data is slightly different because of survey year and assumptions. It can be used for understanding the grasp of international transportation circumstances.

2.4 Current Characteristics for International Transportation

2.4.1 Interview Survey

(1) List of Interviewees

The Study Team conducted interview survey both in Mozambique and Malawi in order to grasp international transportation on Nacala/ Beira Corridors. In Mozambique, Study Team interviewed following organizations/ companies during April to May 2009.

Table 2.4.1 List of Interviewee in Mozambique

Field	Interviewee
Corridor Development	Unidade Coordenacio dos Corredones (UCCD), Min. of Transport & Communication
Railway	CDN-Maputo H.Q. CDN-Nampula CFM-Norte
Port	CDN-Nacala
Import Agent	MAERSK MANICA MSC MoCargo
Customs	Autoridade Tributaria H.Q. Lichinga Entre-Lagos Custom Office Mandimba Custom Office Provincial Custom Office (NIassa, Lichinga)
Immigration	Mandimba Immigration Office Entre-Lagos Immigration Office Provincial Immigration Office (Niassa, Lichinga)
Transport Association	FEMATRO Road Transportation Association in Niassa Road Transportation Association in Nampula (TRANSROD, ASTRA)

For Malawi's transportation condition, the Study Team visited Lilongwe, Blantyre and five different border posts, and conducted interview survey during June to July with relevant stakeholders described below. Also, interview items are summarized in this table. More detailed list is in the appendix.

Table 2.4.2 List of Interviewees in Malawi

Interviewee	Interview Items
Governmental Offices	・Progress of road development project ・Traffic volume ・Volume of import/export ・Progress of OSBP meeting
Customs/Immigration	・Facilities ・Operation hour ・The number of staff ・Traffic volume ・Cost for levies, administration fee and other expense per import, export and transit ・Prohibited goods of import/export ・Time taken to pass the border

	・Goods inspection ・Quarantine
Import/ Export Transporter	・Transported goods for import / export ・Route, means and destination of import /export and the reason for its selection ・Cost for the port, road, railway and cross border ・Spent time to/from the destination per each route and means ・Issues of cross border and import/export
Improt/ Exprot Agent	・Procedure at border clearance ・Cost for levies, administration fee and port tax per import, export and transit
Railway	・Transported goods for import / export ・Railway network (passenger and freight) ・Transportation cost and time
Insurance Company	・Insurance system ・Purchase of Insurance at border

(2) Interview Results

From the interviews conducted in both countries, the Study Team grasped the characteristics of international transportation on Nacala/ Beira Corridors.

The followings are categorized summaries which were collected by interview.

- Situation on Malawi Trade [Trade Data and Transportation Route]…. (a)
- Malawi Trade by Railway Transportation …………………………… (b)
- Malawi Trade by Nacala Port ……………………….……………… (c)
- Summary of Malawi Trade Transportation ………… ….………….. (d)
- Comparative Transportation Cost/ Required Time …………………… (e)

(a) Situation on Malawi Trade [Trade Data and Transportation Route]

Malawi which is a landlocked country, depends on neighboring countries' ports such as Mozambique, South Africa and Tanzania for importing goods. Main goods for import are fuel, fertilizer, wheat and salt, and for export are tobacco, sugar, tea and cotton. There are mainly road network to ports, however only Lilongwe and Blantyre to Nacala have a railway network. Figure 2.4.1 shows the main route for international transport in Malawi.

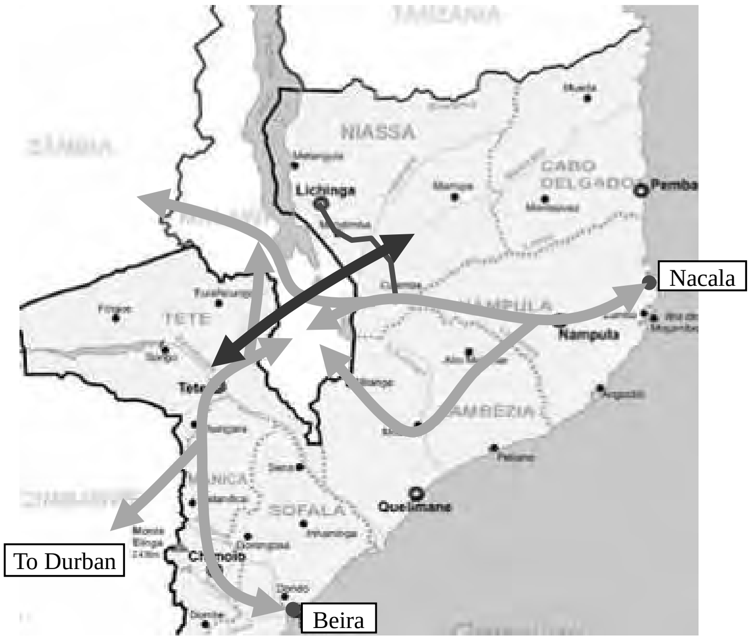


Figure 2.4.1 Typical Transportation Route for International Transportation

The historical data of main commodities for Malawi's trade are shown in the table below. There has been much fluctuation in the last four years.

Table 2.4.3 Main Commodities for Import and Export

Unit: ton

	Commodity	2004	2005	2006	2007
Import	Fuel	-	298,307	298,757	181,037
	Fertilizer	-	243,878	178,074	117,824
	Salt	-	184,248	213,478	275,205
	Wheat	-	49,155	29,242	1,568
	Total	-	**775,588**	**719,551**	**575,634**
Export	Tobacco	89,767	124,895	177,630	165,165
	Sugar	222,400	104,149	82,235	113,830
	Tea, Coffee	50,149	47,690	47,148	56,732
	Cereal	298,436	15,530	78,624	194,867
	Cotton	25,930	14,730	16,450	21,345
	Total	**686,682**	**306,994**	**402,087**	**551,939**

Source: Ministry of Industry, Malawi

Regarding the share of trade traffic volume through Malawi's border posts in 2002, the Malawi Transport Cost Study in 2004 prepared the researched data as shown in the table below. About 60% of trade volume passes through Muwanza (Zobue in Mozambique) on Beira Corridor and RSA (Durban port and RSA original), and 23% passes through Nayuchi (Entre Lagos in Mozambique) on Nacala Corridor by railway network. It should be noted that Beira Port-related trade traffic accounts for about one third of volume from Nayuchi border.

Table 2.4.4 Share of Trade Traffic at Border Posts in Malawi (2002)

Border Post	Country Corridor	Export		Import		Total	
		Volume (000ton)	Share (%)	Volume (000ton)	Share (%)	Volume (000ton)	Share (%)
Mchinji	to/from Zambia	19.0	5.3%	79.5	9.0%	98.5	7.9%
Mwanza	to/from Moz. **Beira** Corr., RSA	168.2	46.7%	560.6	63.8%	728.8	58.8%
Nayuchi (Rail)	to/from Moz. **Nacala** Corr.	93.7	26.0%	186.0	21.2%	279.7	22.6%
Songwe	to/from Tanzania	79.5	22.1%	52.8	6.0%	132.3	10.7%

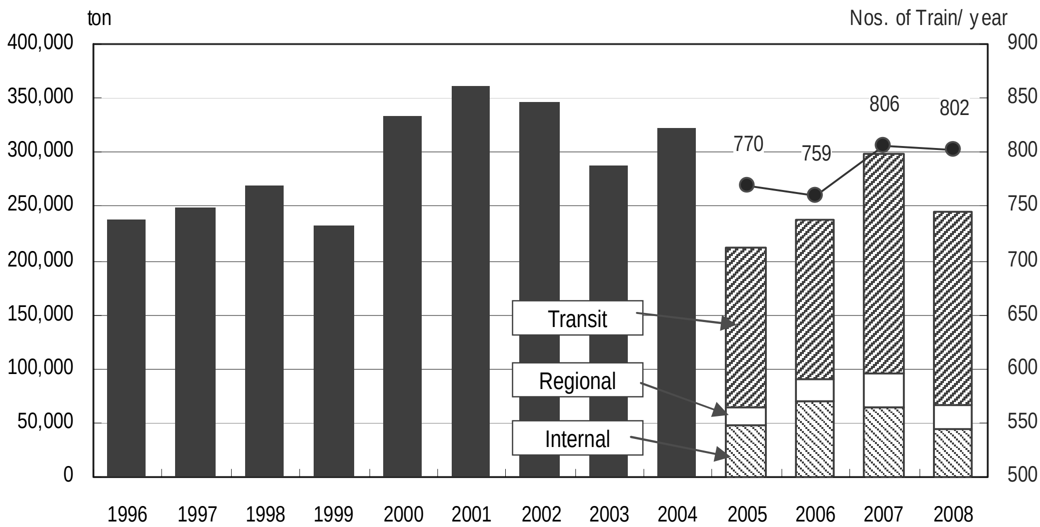
Source: Malawi Transport Cost Study, TERA International, 2004

(b) Malawi Trade by Railway Transportation

Traffic Throughput on Nacala Railway

The historical cargo traffic volume data has been collected from the railway operator Corridor de Desenvolviment do Norte (CDN). The figure below shows the summary of data from 1996 to 2008. It should be noted that CDN started in 2005 so detailed information is available for the last five years.

It is observed that cargo volume of 200,000 to 300,000 tons is transported annually and it has been static since 1996 because of limited locomotive and wagons. About 800 trains are moved in a year.



Source: CDN (1999-2008), CFM-Norte (1996-1998)

Figure 2.4.2 Cargo Transportation on Nacala Railway (1996-2008)

The cargo volume data from 2005 are broken down into three different types of transportation (internal, regional and transit) as shown below.

- **Internal**: within Mozambique or from Nacala Port as import/export
- **Regional**: between Mozambique to Malawi
- **Transit**: transported directly between Malawi and Nacala Port as Malawi's import/export

The component of internal, regional and transit is 18%, 9% and 73% in 2008, respectively. It means about 70% of Nacala railway is used for international transportation to Malawi. If we see the difference between ascending and descending traffic, there is evidence of imbalanced transit transportation.

Table 2.4.5 Cargo Transportation by Nacala Railway by Destination (ton)

Year	Internal	Regional	Transit	Total
2005	47,023	17,262	147,640	211,925
2006	69,650	20,354	147,826	237,830
2007	65,179 *Asc: 41,088* *Des: 24,091*	31,449 *Asc: 17,244* *Des: 14,202*	201,073 *Asc:107,924* *Des: 93,149*	297,701 *Asc:166,256* *Des: 131,442*
2008	44,910 *Asc:34,478* *Des:10.432*	21,177 *Asc: 11,558* *Des: 9,619*	17,8847 *Asc: 122,508* *Des: 56,339*	244,934 *Asc: 168,544* *Des: 76,390*

Note: Asc.: Ascending (e.g. Import for Malawi), Des.: Descending (e.g. Export from Malawi)
Source: CDN

Condition of Malawi Railways (CEAR)

In Malawi, The Central East African Railway Company Ltd. (CEAR) has operated the whole railway line since it was privatized in 1992. The network spreads to Mchinji on the border with Zambia in the west and Maruka in the south, however, a bridge was washed out because of flooding, so the network is only to Bangla at this moment.

CEAR has now 12 locomotives, however, four of these are under repair and only five locomotives can be used for cargo and one for passengers. One more locomotive will be purchased soon. Regarding wagons, there are 182 container carrying types, 95 ballast wagons, 46 high sided wagons for clinker and 64 oil tank cars.

Cargo transportation is operated based on client's requests, not regular scheduled. Normally, there are two trains per day bound for Blantyre, and two or three trains per week for Lilongwe.

Transit Transportation from/ to Malawi

Required time for transportation from border (Entre Lagos) to Blantyre and Lilongwe is eight hours and 12 hours, respectively (from border to Nacala Port may need 30 hours). For the customs clearance, one hour is required for Mozambique side at Entre Lagos and two hours at Lionde including inspection and two hours at Nayuchi for document checking. Due to the lack of locomotives in Malawi, it takes 24~48 hours waiting for the Malawi locomotive. Therefore, the normal schedule for one turn-round is expected as 12 days, however, in reality only one time per month can be operated. It is observed that about 550 containers are always waiting for railway transportation; some of these containers have been there since last January (interviewed on 5th May, 2009).

Average speed is about 20km/hour due to a lot of steep curves and slopes especially only half of all cargo can drive because of steep slopes before Blantyre and Cuamba. The 77 km section between Entre Lagos and Cuamba requires rehabilitation.

Regarding locomotives, before there were not enough locomotives in Mozambique, so Malawi's locomotives were used for direct operation to Nacala Port. After Mozambique purchased four more locomotives, all locomotives came to be changed at the border. From the interview results, one locomotive can carry 25 wagons because its capacity is 750 ton. Due to the lack of locomotives, operation capacity is less than the demand for transportation. (One operation company officer said that only 25% of demand can be transported under current condition).

Following tables show the volume of major export/import commodities transported by CEAR line for the last five years. Volume of exports is 60~70% less than volume of imports. As a result of interview, some empty containers are transported to Lilongwe to be made full, and are then transported to Beira, Durban or Dal es Slaam.

Table 2.4.6 Volume of Imports by CEAR (unit: ton)

	2003	2004	2005	2006	2007
Fertilizer	49,006	35,939	38,201	36,496	50,036
Maize	9,390	3,615	4,743	7,022	900
Palm Oil	2,635	2,340	2,906	3,055	2,873
Salt	2,842	2,714	9,271	13,638	7,564
Fuel	27,948	18,841	-	2,444	-
General	45,272	44,120	42,245	45,714	47,553
Others	12,947	26,978	12,502	5,955	12,579
Total	150,040	134,547	109,868	114,324	121,505

Source: CEAR

Table 2.4.7 Volume of Exports by CEAR (unit: ton)

	2003	2004	2005	2006	2007
Beans	16,204	20,096	1,548	7,150	16,091
Sugar	52,429	51,981	2,270	35,595	50,690
Tea	4,157	6,093	50,342	4,947	4,097
Tobacco	704	1,677	293	50	6,549
General	2,023	2,244	2,270	2,454	3,108
Others	7,786	6,396	5,027	6,920	13,871
Total	83,303	88,487	60,984	57,141	94,406

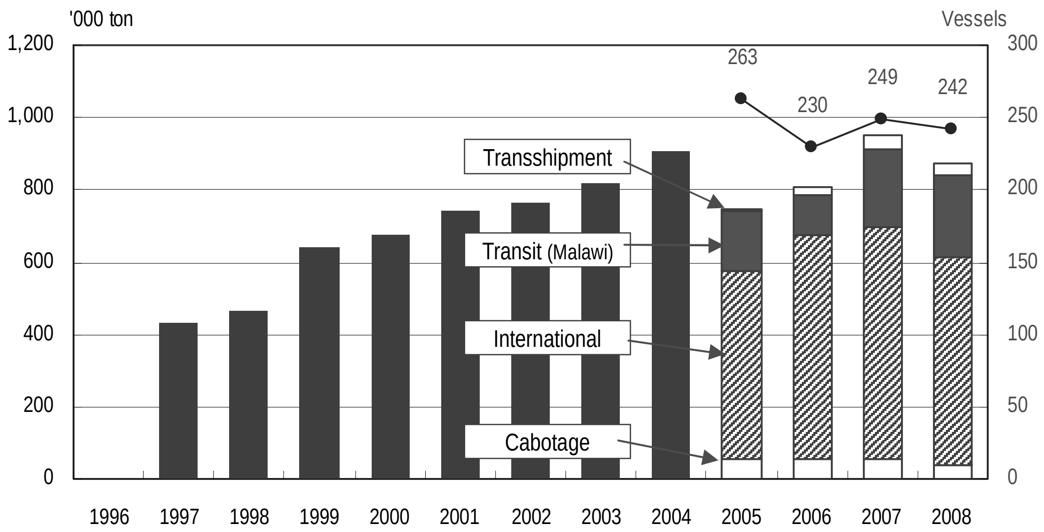
Source: CEAR

(c) Malawi Trade by Nacala Port

Although basic conditions have been already described in 2.2.2 and 2.2.3, this section discusses the current port handling and capacity based on the interview results.

Nacala Port is the first port in Africa where ISO14000 was authorized last year (fifth port in the world). And, it has been certified under ISO18001 and ISPS (port security). Because of its natural deep sea, Nacala has much potential for handling of general cargo and containers. On the other hand, Beira Port requires dredging.

Following figure summarizes historical throughput data for general cargo and containers. General cargo seems to be matured because of limited hinterland transportation. In general, about 30% of general cargo is for transit to Malawi and about 70% is for Mozambique. There is little transshipment and cabotage.

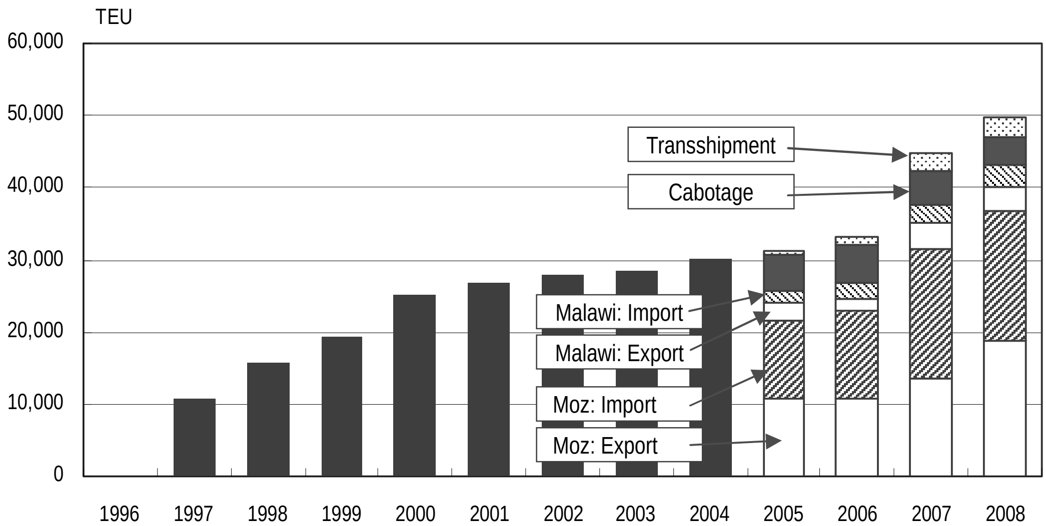


Source: CDN Porto de Nacala

Figure 2.4.3 General Cargo Handled by Nacala Port (1997-2008)

- **Cabotage**: Trade transit of vessels along the coast (coastal trading), from Nacala Port to another port within the same country.
- **International**: Import/Export from Mozambique to other countries through Nacala Port.
- **Transit**: Import/Export from Malawi to other countries through Nacala Port.
- **Transshipment**: containers or other cargo transferred from one vessel to another in Nacala Port.

Container handled volume is steadily increasing, and it has already reached the capacity of container handling. Therefore, there is not enough equipments such as cranes and lifts. CDN has already started development of facilities independently.



Source: CDN Porto de Nacala

Figure 2.4.4 Containers Handled by Nacala Port (1997-2008)

According to the results of interview on agent in Nacala, normally only 48 hours are required to obtain clearance for importing. However, due to lack of cranes/ lifts and wagons for railway transportation, dwelling time is said to be on average 24 days for imports and nine days for exports in 2005. On the other hand, in Beira Port, the dwelling time is about 30 days including the documentation process which requires about 12 days.

(d) Summary of Malawi Trade Transportation

For the international transportation between Malawi and Mozambique, rail and ports have been described. Although the trunk roads in Malawi from Lilongwe and Blantyre to its border have been already paved, there are plans for improving and rehabilitating these networks as below.

- In July 2009, implementation of bypass route construction for Lilongwe was started as "Nacala Development Corridor Phase 1".
- Rehabilitation on national highway No.1 between Lilongwe and Bacala (160km) has been started under funding from the World Bank.
- Rehabilitation on national highway No.3 between Mangochi and Liondwe will be implemented as "Nacala Development Corridor Phase 3" in future.

At this moment, most hauling firms select their international route according to the road condition in Mozambique. Therefore, traffic volume is concentrated in Beira Corridor and Durban route through Muwanza and Teza border posts. The road network on Nacala Corridor is not used as international transport because of unpaved section from Nampula to Mandimba/ Chiponde.

Figure below shows the conceptual condition of international transport in both Nacala and Beira Corridor.

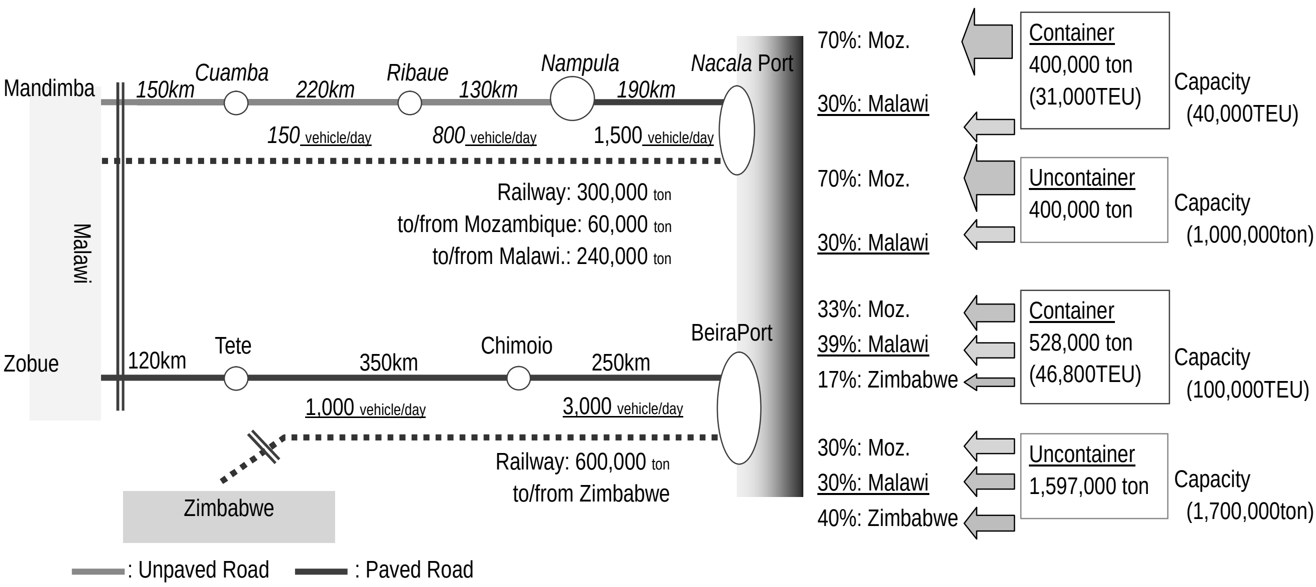


Figure 2.4.5 Conceptual Conditions for International Transportation

2.4.2 Current Transport Costs/ Required Time

In the discussion on 2.4.1, theStudy Team collected several international costs researched by previous study. During this study, the Study Team tried collecting the current transport costs and required time for international transportation based on the various interviews with stakeholders (e.g. transporters, forwarders). The following describe the results of the interviews. Note that different stakeholders who were interviewed had their own information/ quotations, so these differences should taken into account.

(1) Results of Interview for Malawi Transporters

General transportation cost and required time from Blantyre in Malawi to Nacala/ Beira Ports are described below. At this moment, the most reasonable route is Beira route by road transport, and then railway to Nacala is the cheapest route but it takes more time.

Table 2.4.8 Transportation cost and time between Blantyre and ports

Port	Means of Transportation	Transportation Time	Transportation Cost (40t)	Route via
Beira	Road	2-3 days	2,400US$	Tete, Mwanza
Nacala	Road	3-5 days	2,500US$	Mocuba, Muloza
Nacala	Railway	3-4 days	1,500US$	Nampula, Nayuchi
Darban	Road	5-7 days	3,600US$	Tete
Dar Es Salaam	Road	3-5 days	3,200US$	Songue, Karonga

Source: Interview from Freight Agent in Malawi

One of the indexes for port competiveness is the port charge and dwelling time for Nacala and Beira Ports. The following table shows the perception of Malawi’s transporters at this moment.

Table 2.4.9 Port Charge and Dwelling Time for each Port

	Port Charge (US$)		Dwelling time
	20tf	40ft	
Nacala Port	525	746	1-4 months
Beira Port	535	806	1-3 weeks

Source: Interview Survey to Malawi Transporter, 2009

(2) Results of Interview for Railway Company in Malawi

As the results of interview with Malawi railway company (CEAR), railway costs for transit from/to Nacala Port are summarized in table below. Cost for importing is more expensive than exporting, and empty 20 feet containers are less than half of loaded containers. For considering to road transportation, only transportation from Nacala to Cuamba is requires 2,400US$ for 40 feet container. It costs two times as much as the railway. The cost competitiveness is an advantage for railway transportation for international transit apart from the time requirements and flexible schedule.

Table 2.4.10 Railway Cost from Blantyre to Nacala Port (unit: US$)

		20ft (<12.5t)	20ft (>12.5t)	40ft	20ft (Empty)	Bulk (Light)
Import	Malawi	334.10	358.48	668.20	136.87	27.69/t
	Mozambique	613.47	708.40	1,226.94	289.80	66.92/t
Total		**945.57**	**1,066.88**	**1,895.14**	**426.67**	**94.61/t**
Export	Malawi	192.15	210.79	384.30	65.18	9.52/t
	Mozambique	400.95	440.62	801.90	161.00	39.80/t
Total		**593.10**	**651.41**	**1,160.20**	**226.13**	**49.32/t**

Source: CEAR

(3) Results of Interview with Forwarders Operating at Nacala/ Beira Ports

The following table shows the current cost/ required time for transporting from/ to each port, summarized from the interview/ questionnaire to major forwarder companies (trade agents) operating at both Nacala and Beira Ports.

According to the results, the transport cost of Nacala Corridor is up to four times higher than Beira's one, also it takes six days by Nacala Corridor compared to only two days by Beira Corridor.

Table 2.4.11 Transport Charges and Time Required for Containers from Beira and Nacala Port to Malawi

1. Import to/ Export from Blantyre

Port

Port		Port Charge per Box US$	Port Clearance	Container Uplifting Fee (US$)	Agency Fee (US$)	Dwell time (Days)
Imports to Malawi						
Beira	20'	225	0.0% of FOB value	70	85	2~3
	40'	405		126		
Nacala	20'	205	0.0% of FOB value	65	85	24
	40'	369		117	85	
Expors from Malawi						
Beira	20'	180	0.0% of FOB value	70	85	2~3
	40'	324		126		
Nacala	20'	205	0.0% of FOB value	65	85	9
	40'	369		117	85	

By Railway Transportation

Port		km	Cost: Hauling Cost (US$/box)	Cost: Border Cost (US&)	Time Required: Loading /Offloading at Port	Time Required: Hauling Time In Moz	Time Required: Hauling Time In Malawi	Time Required: Waiting Time at border
Imports to Malawi								
Beira	20'	N/A						
	40'							
Nacala	20'	809	1,067	N/A	1day	3days	3days	Max. 2days
	40'		2,134	N/A	1day	3days	3days	Max. 2days
Expors from Malawi								
Beira	20'	N/A						
	40'							
Nacala	20'	806	751	N/A	1day	3days	3days	Max. 2days
	40'		1,502	N/A	1day	3days	3days	Max. 2days

By Road Transportation

Port		km	Cost: Hauling Cost (US$/box) In Moz	Cost: Hauling Cost (US$/box) In Malawi	Cost: Border Cost (US&)	Cost: Road Users Charge (US$)	Cost: Others (US$)	Time Required: Loading /Offloading at Port	Time Required: Hauling Time In Moz	Time Required: Hauling Time In Malawi	Time Required: Waiting Time at border
Imports to Malawi											
Beira	20'	856	75USD/ton including Border Cost, Road Users Charge and Others (938~1,500USD; 12.5~20.0ton/20' container)					48 Hrs. in 24hrs. in Moz, 12hrs. in Malawi			
	40'										
Nacala	20'	750	3,000	3500	including left cost			2days	2days	1day	Max.1day
	40'		4,500	7000	including left cost			2days	2days	1day	Max.1day
Expors from Malawi											
Beira	20'	856	75USD/ton including Border Cost, Road Users Charge and Others (938~1,500USD; 12.5~20.0ton/20' container)					48 Hrs. in 24hrs. in Moz, 12hrs. in Malawi			
	40'										
Nacala	20'	750	3,000	3500	including left cost			2days	2days	1day	Max.1day
	40'		4,500	7000	including left cost			2days	2days	1day	Max.1day

Note: Border Charges: Third Party Insurance, Road Users Charges: Transit Fees, Road Toll Fees, Others: Insurance + Facilitation Fees + Stocks-in-transit

2. Import to/ Export from Lilongwe

Port

Port		Port Charge per Box US$	Port Clearance	Container Uplifting Fee (US$)	Agency Fee (US$)	Dwell time (Days)
Imports to Malawi						
Beira	20'	225	0.0% of FOB value	70	85	2~3
	40'	405		126		
Nacala	20'	205	0.0% of FOB value	65	85	24
	40'	369		117	85	
Expors from Malawi						
Beira	20'	180	0.0% of FOB value	70	85	2~3
	40'	324		126		
Nacala	20'	205	0.0% of FOB value	65	85	9
	40'	369		117	85	

By Railway Transportation

Port		km	Cost: Hauling Cost (US$/box)	Cost: Border Cost (US&)	Time Required: Loading /Offloading at Port	Time Required: Hauling Time In Moz	Time Required: Hauling Time In Malawi	Time Required: Waiting Time at border
Imports to Malawi								
Beira	20'	N/A 1056						
	40'							
Nacala	20'	1014	1,185	N/A	2days	3days	5days	Max. 2days
	40'		2,370	N/A	2days	3days	5days	Max. 2days
Expors from Malawi								
Beira	20'	N/A 1056						
	40'							
Nacala	20'	1014	671	N/A	2days	3days	5days	Max. 2days
	40'		1,342	N/A	2days	3days	5days	Max. 2days

By Road Transportation

Port		km	Cost: Hauling Cost (US$/box) In Moz	Cost: Hauling Cost (US$/box) In Malawi	Cost: Border Cost (US&)	Cost: Road Users Charge (US$)	Cost: Others (US$)	Time Required: Loading /Offloading at Port	Time Required: Hauling Time In Moz	Time Required: Hauling Time In Malawi	Time Required: Waiting Time at border
Imports to Malawi											
Beira	20'		80USD/ton including Border Cost, Road Users Charge and Others (1,000~1,600USD; 12.5~20.0ton/20' container)					48 Hrs. in 24hrs. in Moz, 12hrs. in Malawi			
	40'										
Nacala	20'	***	3,000	3,900	including left cost			2days 2s	ays	2days	1day
	40'		4,500	7,300	including left cost			2days 2s	ays	2days	1day
Expors from Malawi											
Beira	20'		80USD/ton including Border Cost, Road Users Charge and Others (1,000~1,600USD; 12.5~20.0ton/20' container)					48 Hrs. in 24hrs. in Moz, 12hrs. in Malawi			
	40'										
Nacala	20'	***	3,000	3,900	including left cost			2days 2s	ays	2days	1day
	40'		4,500	7,300	including left cost			2days 2s	ays	2days	1day

Note: Border Charges: Third Party Insurance, Road Users Charges: Transit Fees, Road Toll Fees, Others: Insurance + Facilitation Fees + Stocks-in-transit

[For Empty Container]

Port		Port Charge (USD)	From/ To Blantyre (USD)		From/ To Lilongwe (USD)	
Beira	20'	40	500		600	
	40'	40	500		600	
Nacala	20'	60	427 (Ncala - Blantyre)	224 (Blantyre - Nacala)	854 (Ncala - Lilongwe)	283 (Lilongwe - Nacala)
	40'	108	854 (Ncala - Blantyre)	448 (Blantyre - Nacala)	1,076 (Ncala - Lilongwe)	556 (Lilongwe - Nacala)

2.4.3 Traffic Surveys at Four Cross-borders

(1) Purpose of Traffic Survey

In order to grasp the trend of international transport movement on Nacala Development Corridor, traffic count survey and origin-destination (OD) survey were conducted at four border posts. These borders are summarized as follows.

- Zobue/Mwanza border post has the biggest capacity in Mozambique/Malawi; it is located east of Blantyre, which is connecting to Tete in Mozambique.
- Milange/Muloza border is located in the southeast of Malawi 120km from Blantyre, one of biggest commercial cities in Malawi, connecting to Gurue in Mozambique.
- Mchinji is the border between Malawi and Zambia located east of Lilongwe, and the road connecting this border is categorized the part of Nacala Development Corridor.
- Mandimba/Chiponde border is on the Nacala Development Corridor and the targeted border of this Study to be improved as One Stop Border Post.

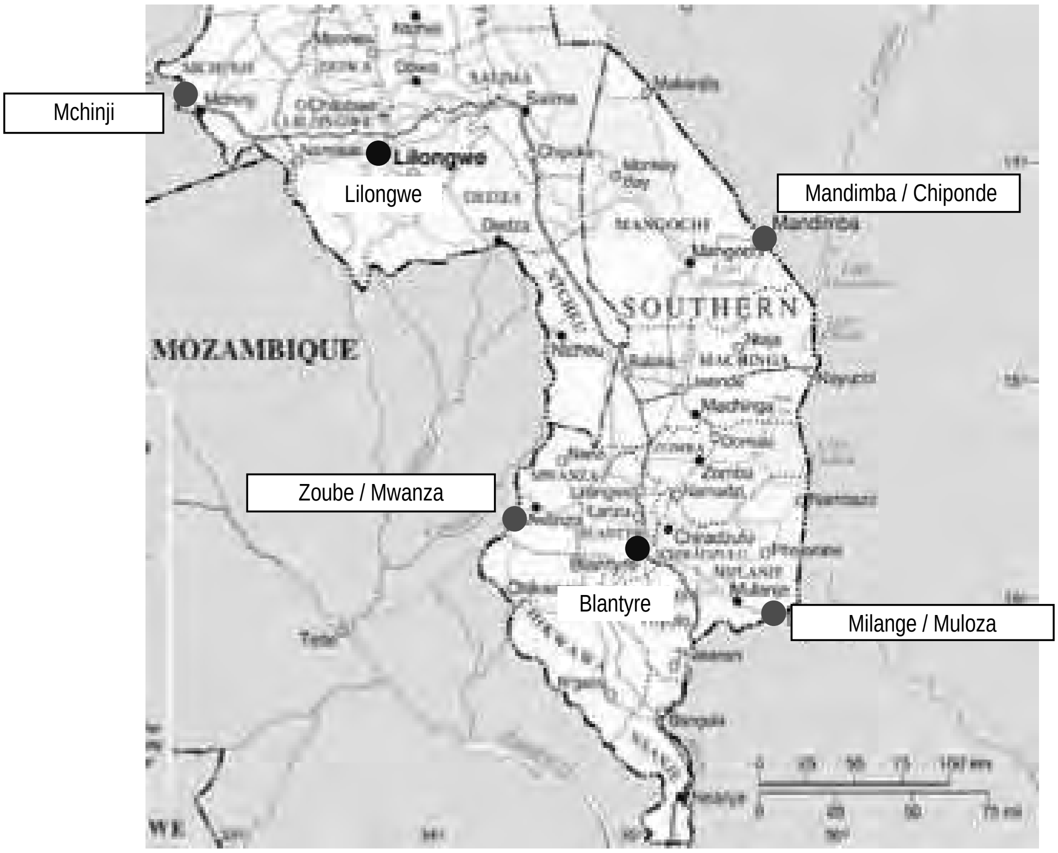


Figure 2.4.6 OD Survey Points

(2) Conditions of traffic survey

At the above border posts, traffic survey was conducted in condition with the following contents.

Table 2.4.12 Contents of Traffic Count and OD Survey

Survey Location	- Mchinji (with Zambia) - Milange/Muloza - Zobue/Mwanza - Mandimba/Chiponde	12th July 2009, Mon 24th July 2009, Fri 27th July 2009, Mon From 9th August, Sun to 12th August 2009, Wed
Survey Hour	12 hours from 6:00 a.m. to 6:00 p.m.	
Count Interval	Every one hour	
Vehicle Type	12 categories (same as the traffic survey on Study Road)	
Survey Method	- Manual count by surveyor for each direction - Interview to driver by surveyor for each direction	
OD Survey Content (see the appendix)	- Number of plate - Number of passengers - Type of vehicle, model - Origin and destination of trip - Travel time - Purpose of trip - Trip frequency - Contents and volume of freight - Time spend for border crossing	

Classification of vehicle types and OD zones (TAZ) were the same as in the OD survey conducted on the Study Road, and are described in 1.4.3.

(3) Results of Traffic Survey

(a) Traffic Volume

There were over 200 vehicles for both directions counted at Zobue/Mwanza border while less than 100 vehicles were recorded at the other borders. At Zobue/Mwanza border, over half of vehicles were commercial trucks and some international buses were also included. At Milange/Muloza border, the proportion of passenger car in the total traffic volume was relatively low. On the other hand, more passenger cars went across Mchinji border rather than the trucks. Mandimba/Chiponde border had the least traffic with less than 30 vehicles per day. Motorbikes were not major transportation means for cross border traffic at any borders. The traffic volume per the vehicle type was as follows.

Table 2.4.13 Result of Traffic Count Survey

Vehicles/day

Border	Direction	Passenger car	Bus	Truck	Motor cycle	Total
Zobue/ Mwanza	From Malawi	38	1	54	2	95
	To Malawi	40	7	79	2	128
Milange/M uloza	From Malawi	13	0	32	4	49
	To Malawi	14	0	13	3	30
Mchinji	From Malawi	35	3	15	0	53
	To Malawi	30	1	13	0	44
Mandimba/ Chiponde	From Malawi	7	1	16	4	28
	To Malawi	6	1	9	8	24

Source: Study Team, 2009

(b) OD survey

The interview for OD survey in August was conducted with all drivers passing the border during the survey period, thus the number of OD sample was equivalent to the traffic volume which means the sample rate was 100%. OD pattern gained from the survey showed different characteristic at each border, caused by its location and condition. The analysis of survey focused on in particular the international transportation by trucks. The characteristic and OD pattern of trucks for each border post were as follows.

- Zobue/Mwanza

The travel distance for the vehicles entering into Malawi through Zobue/Mwanza border tended to be longer than that through other borders. Approximately 40% of passengers cars came from South Africa or Zimbabwe. Similarly, most of buses came from South Africa as the international transportation. Besides, much of the traffic between Malawi and Beira Port was included in the traffic through this border.

- Milange/Muloza

Milange/Muloza border was mainly used by the vehicles driving in short trips around the border area. There were some trucks going to the ports in Nacala and Quilimane for export to overseas. It is considered that the route to Nacala Port through Milange/Muloza is more convenient than the route through Mandimba due to the road condition.

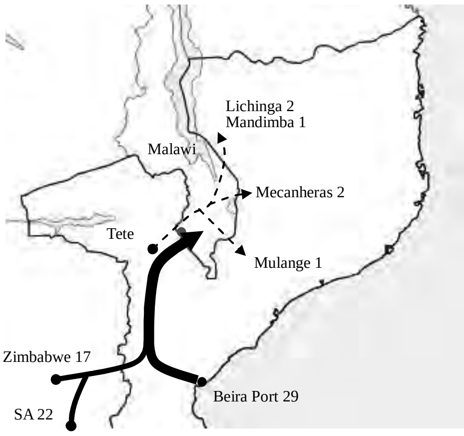
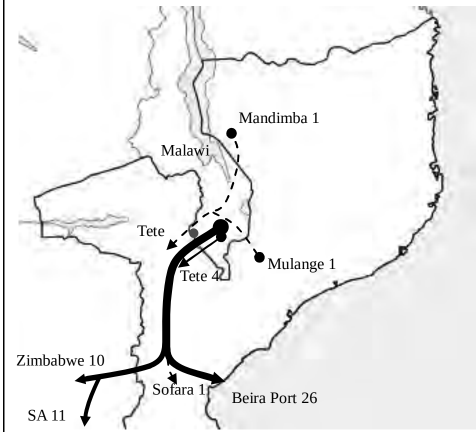
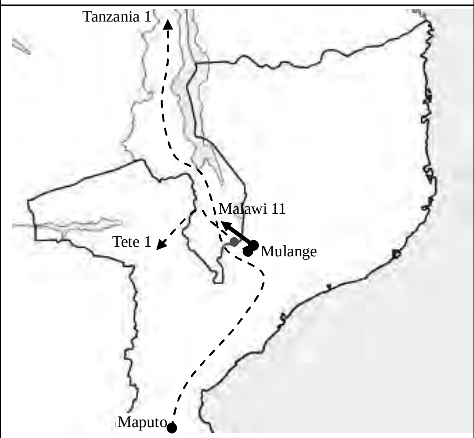
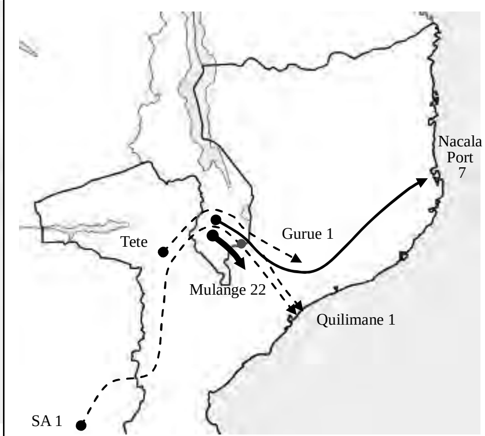
- Mchinji

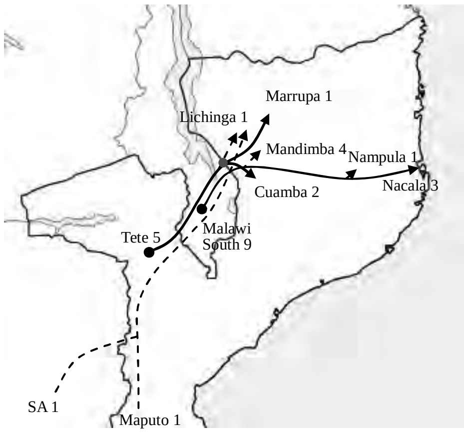
Almost all trucks through Mchinji border drove between Malawi and Zambia. No trucks coming from or going to Mozambique’s ports such as Beira and Nacala were counted during the survey time. In terms of passenger cars, it seems that tourist cars, visiting South Luangwa National Park, the east of Zambia, from Lilongwe in Malawi, were largely included in this traffic.

- Mamdinba/Chiponde

The traffic volume at Mandimba/Chiponde border was least among the surveyed borders. Most trucks were provided from the tobacco company to transport the tobacco leaf grown in Niassa Province to Tete. Although trip length is relatively short to go out from Mozambique, some trucks with long distance such as from South Africa to Namplula and Nacala were included going into Mozambique.

Table 2.4.14 OD Pattern of Trucks at Each Border

	To Malawi	From Malawi
Zobue/ Mwanza	 Main traffic comes from Beira Port, SA and Zimbabwe. A few trucks pass through Malawi as transit.	 Beira Port is main destination through border. The transit traffic through Malawi is relatively low.
Milange /Muloza	 Border is mainly used by the short trip traffic. A few trucks pass at this border for transit.	 Border is mainly used by the short trip traffic. Some trucks pass the border to go to Nacala Port for exportation.
Mchinji	 There is only one type of trip from Zambia to Southern of Malawi.	 Most of traffic is coming from Malawi to Zambia. No traffic coming from Mozambique.

<table>
<tr>
<td>Mandimiba
/Chiponde</td>
<td>

Main traffic is between Niassa and Tete. There are some trucks to go to Nampula and Nacala Port.</td>
<td>

Most of vehicles carry the tobacco from Niassa to Tete. There is no truck driving further distance at this border.</td>
</tr>
</table>

Source: Study Team, 2009

The rate of loaded trucks showed that more trucks entering into Malawi carried the goods but many trucks exiting from Malawi were empty. Comparing with the Mchinji border, the average weight of freight was heavier on Zobue and Milange borders.

Table 2.4.15 Freight of Cargo

Vehicle/day

Border	Direction	Nos. of truck	Nos. of heavy truck	Nos. of loaded heavy truck	Rate of loaded truck (%)	Average weight of freight (t)
Zobue/ Mwanza	From Malawi	54	49	16	32.7	25.0
	To Malawi	79	68	64	94.1	24.7
Milange /Muloza	From Malawi	32	13	5	38.5	30.3
	To Malawi	13	5	4	80.0	24.5
Mchinji	From Malawi	15	10	2	20.0	18.0
	To Malawi	13	8	7	87.5	15.8
Mandimba /Chiponde	From Malawi	16	11	5	45.5	26.1
	To Malawi	9	7	6	85.7	17.2

Source: Study Team, 2009

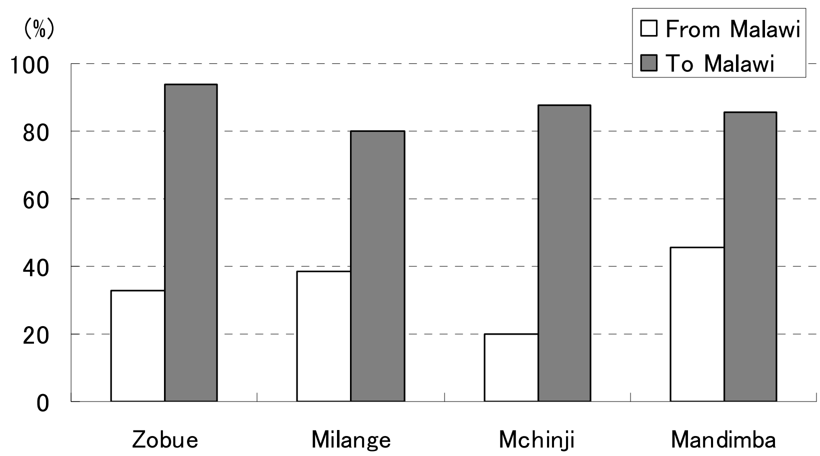


Figure 2.4.7 Rate of Loaded Freight Cargo

Source: Study Team, 2009

Time spent for border crossing was also considerably different at each border. It tookon average more than seven hours to pass through Mchinji and Zobue border to enter Malawi. In contrast, vehicles could get through Mandimba border within one hour. Except for Milange border, entering Malawi took more time than going out from Malawi.

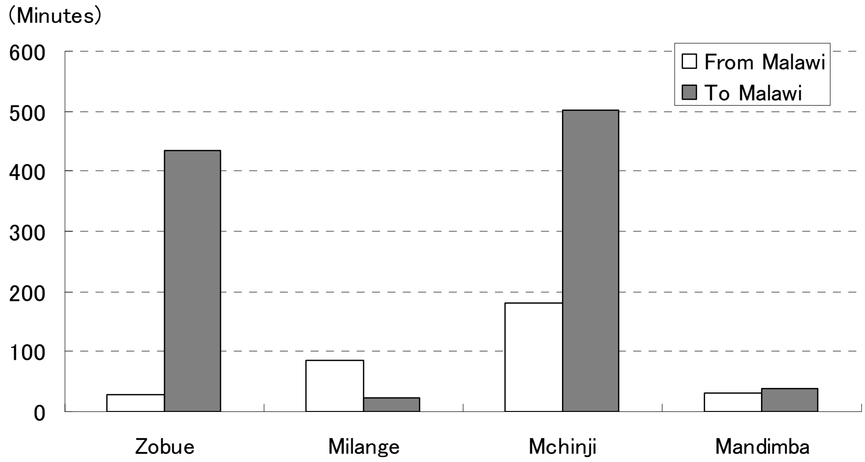


Figure 2.4.8 Time for Border Crossing per Border

Source: Study Team, 2009

Regarding the vehicles type, the large trucks which transport the goods and need to be declared took 12 hours on average. The large buses which come from South Africa also took a long time owing to the passengers who declared their belongings one by one.

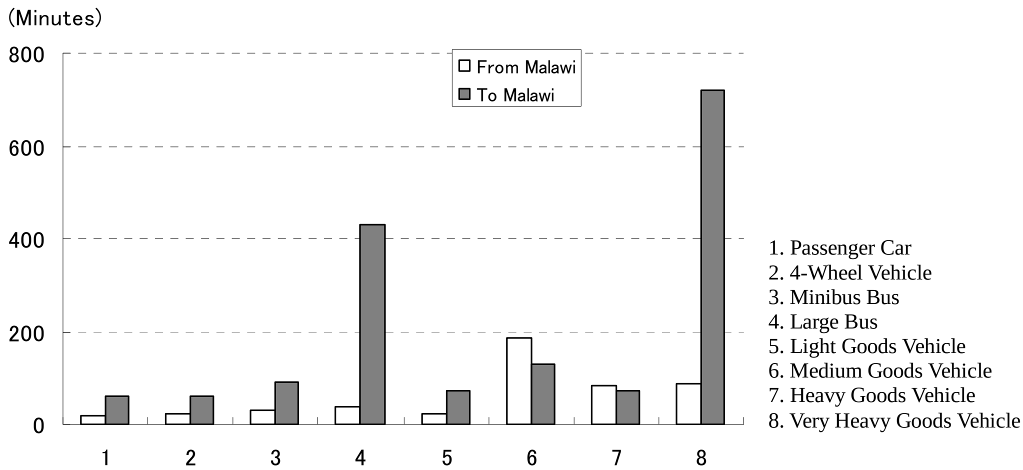


Figure 2.4.9 Time for Border Crossing per Vehicle Type

Source: Study Team, 2009

The transported goods were different at each border. The type of transported goods and the volume are as follows.

Table 2.4.16 Main Transported Goods (unit: kg)

Zobue		Milange		Mchinji		Mandimba	
Clinker	406140	Pigeon Pees	165000	Tobacco	67000	Tobacco	100660
Fertilizer	348000	Maize	124000	Timber	58000	Beer	59000
Sugar	180000	Flower	25000	Milk	26000	Clothes	1650
Papers	84000	Tobacco	13000				
Tobacco	68000	Potato	10000				
Oil	59000						
Tea	49000						

Source: Study Team, 2009

These results show traffic movement for international goods which will be used for the traffic demand forecasting in next section.

Chapter 3 Traffic Demand Forecast

3.1 Macro-Economic Background

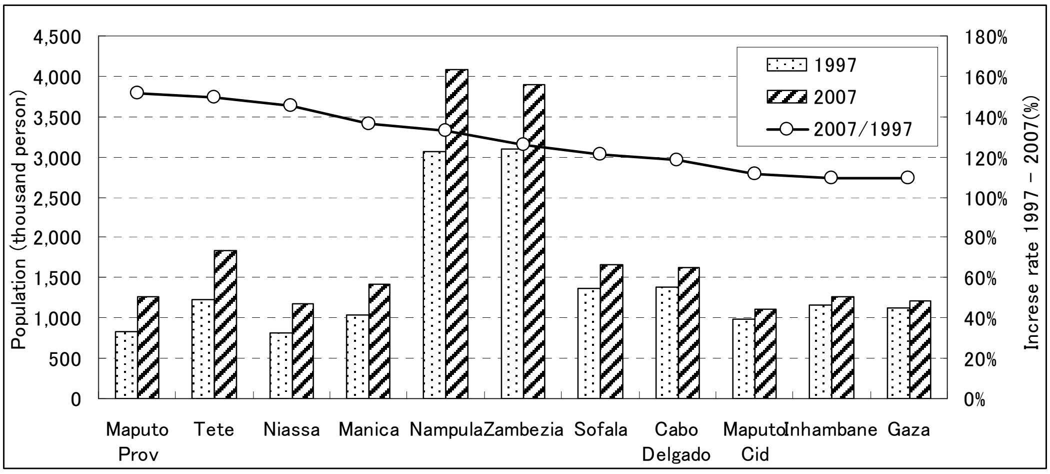
3.1.1 Current Population and Growth Scenario

(1) Population in Census Data (Comparison between 1999 and 2007)

The population in Mozambique increased from 16 million in 1997 to 21 million in 2007, resulting in an 28% increase over the last decade.

On the provincial level, each Nampula and Zambezia province accounts for about 20% of national population. Niassa Province accounted for only 5.0% of total in 1997 and 5.7% in 2007.

Looking at population growth in the last decade, Niassa Province has one of the highest population growth rates with 46% (1997: 8.1 million, 2007: 11.8 million).



	1997		2007		2007/1997
	Population	Rate	Population	Rate	
Niassa	808,572	5.0%	1,178,117	5.7%	145.7%
Cabo Delgado	1,380,202	8.6%	1,632,809	8.0%	118.3%
Nampula	3,063,456	19.1%	4,076,642	19.9%	133.1%
Zambezia	3,096,400	19.3%	3,892,854	19.0%	125.7%
Tete	1,226,008	7.6%	1,832,339	8.9%	149.5%
Manica	1,039,463	6.5%	1,418,927	6.9%	136.5%
Sofala	1,368,671	8.5%	1,654,163	8.1%	120.9%
Inhambane	1,157,182	7.2%	1,267,035	6.2%	109.5%
Gaza	1,116,903	6.9%	1,219,013	5.9%	109.1%
Maputo Prov	830,908	5.2%	1,259,713	6.1%	151.6%
Maputo Cid	987,943	6.1%	1,099,102	5.4%	111.3%
Total	16,075,708	100.0%	20,530,714	100.0%	127.7%

Source: INE

Figure 3.1.1 Population in Each Province

The figure below shows the current population in each district and transport networks in Niassa Province and other neighboring towns. The size of population is indicated as the magnitude of circle in this diagram. It shows that Licinga - Cuamba road connects the two largest towns in Niassa, and there are not so many larger towns in neighboring areas.

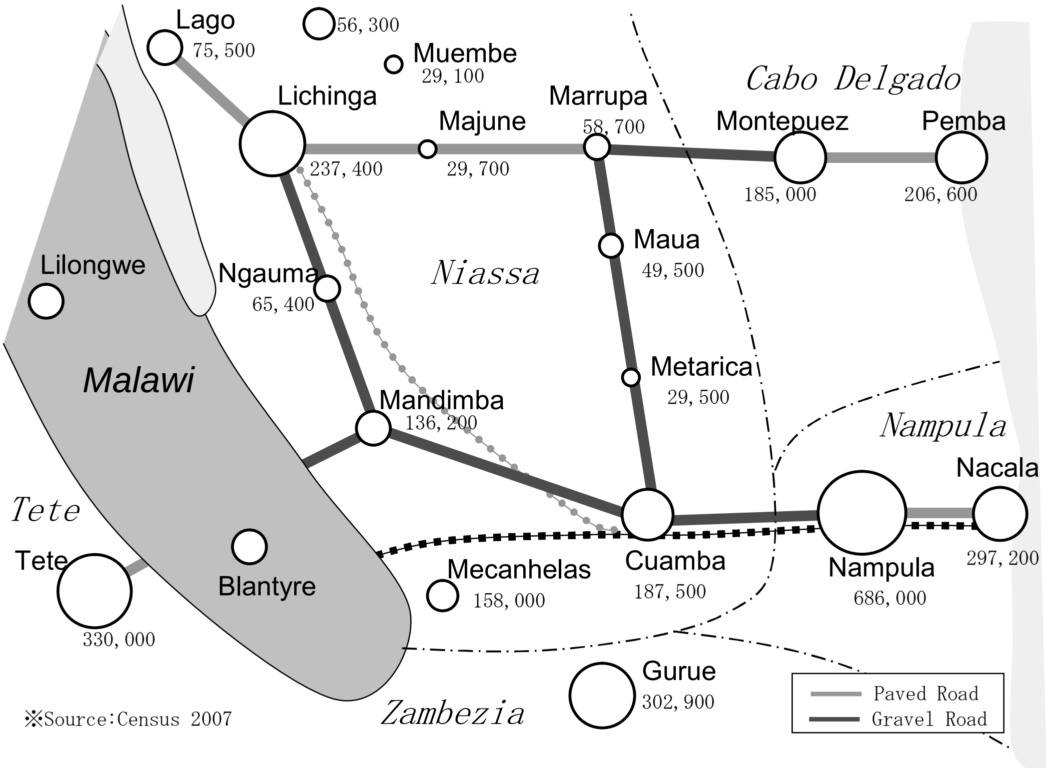


Figure 3.1.2 Population of Each Town at Study Area

(2) Population Growth Scenario in Niassa Province

There are two sources for population growth framework in Niassa Province. One is estimated by the "Plano Estrategico Provincial (PEP), Niassa 2017" which is conducted as a provincial study, and the other is estimated by national statistic organization (INE).

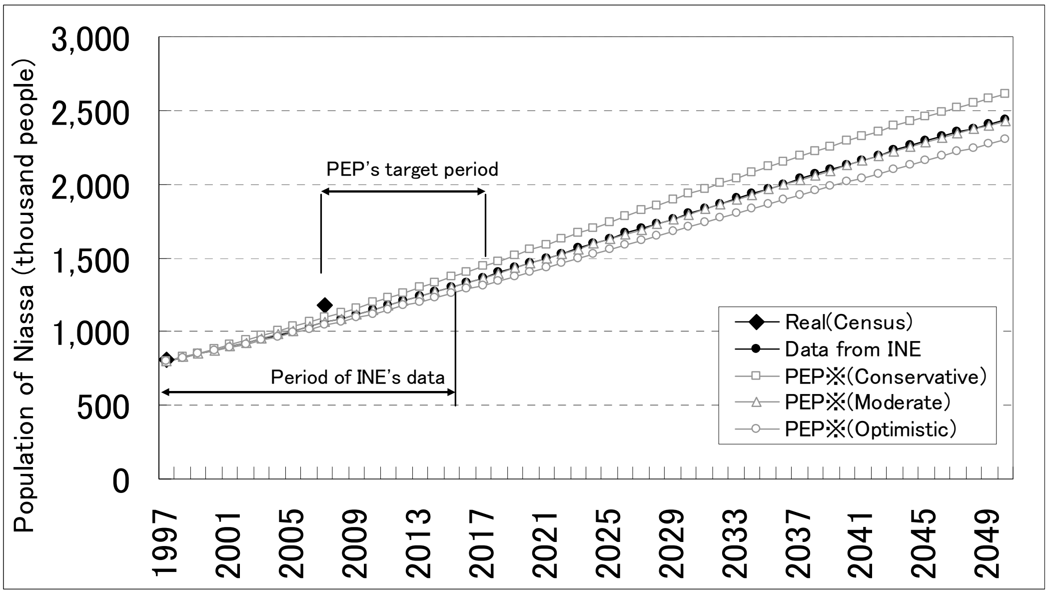
The PEP published the future estimated population from 2007 to 2017, which was estimated based on the census survey in 1997 and consisted of three scenarios (conservative, moderate and optimistic). The population growth rate in the conservative scenario, moderate scenario and optimistic scenario is assumed as 3.0%, 2.7% and 2.5%, respectively.

The figure on the next page shows the future estimated population in Niassa up to 2050. This estimation was applied by the logistic curve (growth curve) based on the estimation period and the future population in each scenario.

According to this estimation, even in the lowest case which is the optimistic scenario, the population is about 2,300,000 and increases about 200% within 40 years. Most serious case is the conservative scenario which is 2,600,000 people in 2050 and about 220% within 40 years.

It should be noted that the preliminary results of 2007 census population in

Niassa have already exceeded the above estimations.



Source: INE, PEP (Plano Estrategico Provincial, Niassa 2017), estimated by Study Team

Figure 3.1.3 Population Estimation

For reference, conditions for estimation of PEP are as below;

- Target year: 2007 - 2017
- Anchor Project of Transportation

a. Road Project

- ➢ Complete paving of the highways in the development triangle Lichinga-Cuamba-Marrupa (N13 and N14).
- ➢ Paving and good conservation of the two roads, N360 (Cuamba to Marrupa) and N361(Lichinga to Metangula)

b. Railway Access

- ➢ Complete rehabilitation of the Lichinga – Cuamba railway within five to 10 years, and provide daily circulation of passenger and cargo trains.

c. Air Transportation

- ➢ Rehabilitation and expansion of Lichinga airport and its transformation into an international airport to accommodate, among other things, the foreseeable increase in tourism
- ➢ Opening of international roads in Metangula and Cobue, both with pertinent services for migration.

Table 3.1.1 Growth Scenarios in PEP

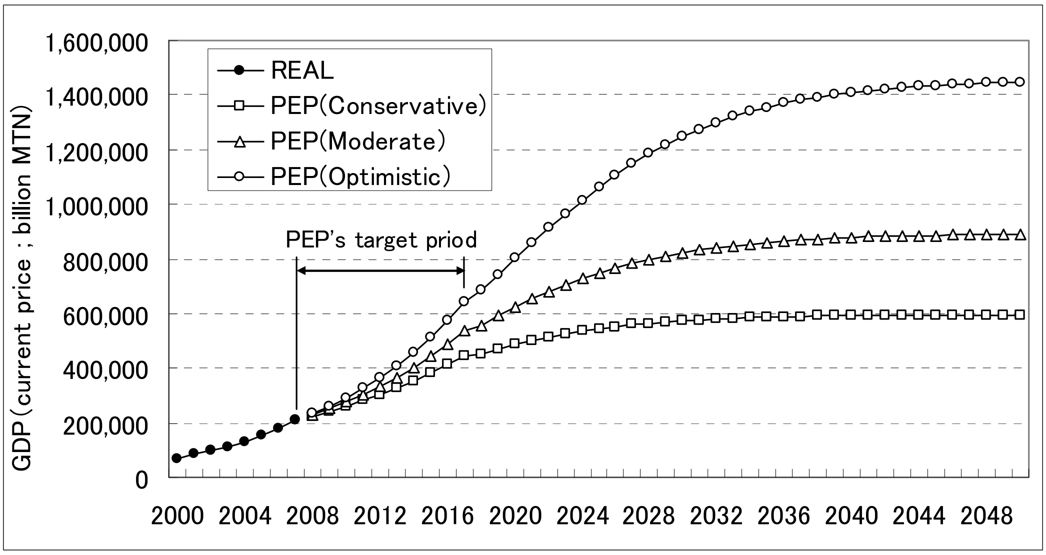
	Conservative	Moderate	Optimistic
GDP Growth	+8%	+10%	+12%
Population	+3%	+2.7%	+2.5%
GDP per Capita	+4.8%	+7.1%	+9.3%
Agricultural Production	+2.1%	+4.5%	+5.0%

Source: PEP

3.1.2 GDP & Poverty Index (Current, Growth Scenario)

PEP analyzed three different scenarios. Growth rate of GDP is estimated as 12% in optimistic scenario, 10% in moderate scenario and 8% in conservative scenario. The analysis period is till 2017.

Future GDP by 2050 is estimated by applying a logistic curve (growth curve) based on the PEP's estimation till 2017. As a result, upon comparing GDP between 2050 and 2007, it is about 3 times in the conservative scenario, about 4.3 times in the moderate scenario, and about 7 times in the optimistic scenario.



Source: INE, PEP, estimated by Study Team

Figure 3.1.4 GDP Estimation

3.1.3 Economical Development Potentials in Niassa Province

(1) Introduction

In case of traffic demand forecasting, it should be taken into consideration that each economical development potential discussed in Chapter 1 should affect the future traffic demand. Therefore, this section discusses the three possible potentials, such as a) Agro-products, b) Forestry and c) Tourism.

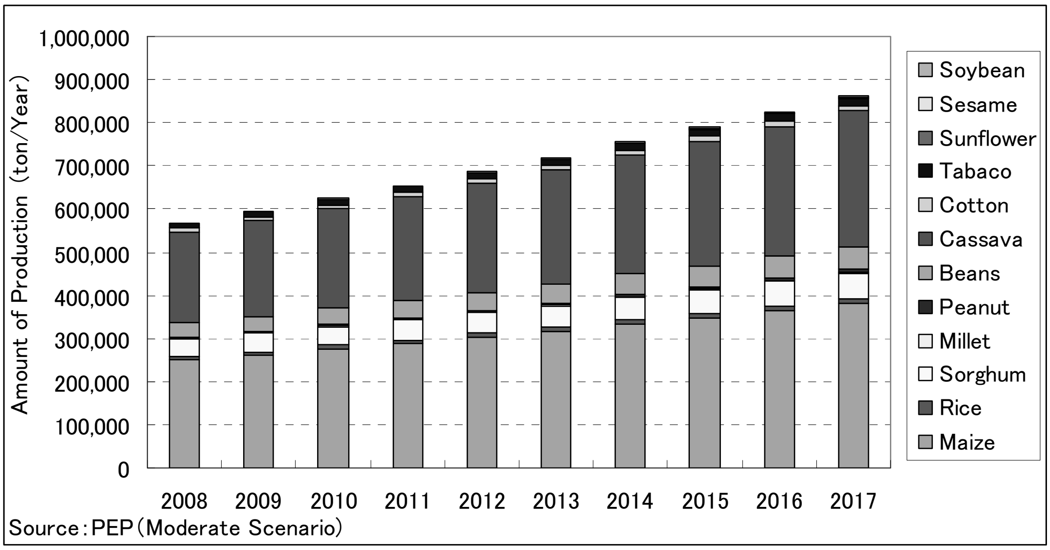
(2) Agro-products (Source: Strategy Plan in Niassa Province)

PEP treated 12 kinds of agro-products and estimated future volume of its production. In moderate scenario, annual increase rate is estimated as 4.5%.

The volume of each agro-product from 2008 to 2017 is shown in the next pages.

Each agro-production has different level in different local/district areas.

For example, millet, potato, cotton, sesame, and sunflower, etc. are produced only in limited areas/districts, while maize, beans, rice, sorghum, peanuts, and cassava, etc. are produced almost all over Niassa.



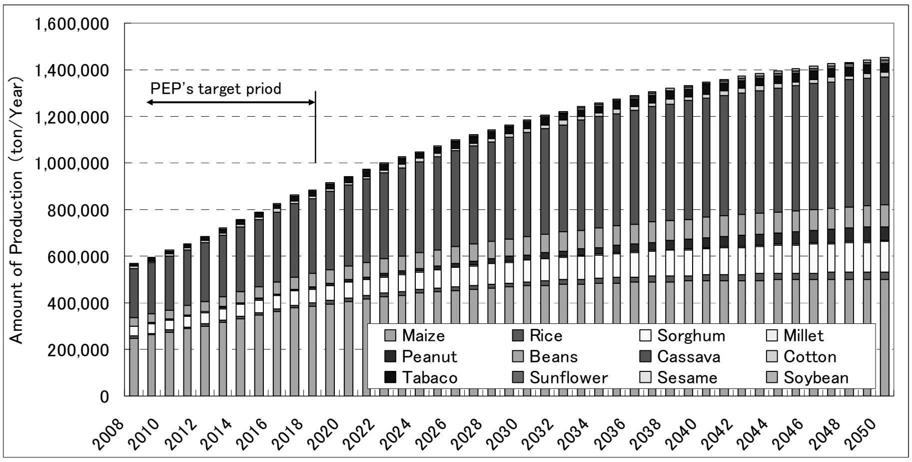
	Maize	Rice	Sorghum	Millet	Peanut	Beans	Cassava	Cotton	Tabaco	Sunflower	Sesame	Soybean
2008	250,000	8,000	40,000	1,200	2,500	34,000	212,000	8,000	12,000	291	150	35
2009	261,250	8,360	41,800	1,254	2,613	35,530	221,540	8,360	12,540	304	157	37
2010	274,882	8,736	43,681	1,310	3,292	37,529	231,509	8,736	13,104	718	164	400
2011	287,958	9,129	45,647	1,369	3,493	39,300	241,927	9,129	13,694	832	171	600
2012	302,540	9,540	47,701	1,431	4,064	41,446	252,814	9,540	14,310	1,247	179	1,200
2013	316,327	9,969	49,847	1,495	4,330	43,870	264,191	9,969	14,954	1,863	187	1,600
2014	332,765	10,418	52,090	1,563	5,256	46,677	276,079	10,418	15,627	2,779	195	2,000
2015	347,739	10,887	54,434	1,633	5,492	48,777	288,503	10,887	16,330	2,904	204	2,090
2016	363,388	11,377	56,884	1,707	5,739	50,972	301,485	11,377	17,065	3,035	213	2,184
2017	379,740	11,889	59,444	1,783	5,998	53,266	315,052	11,889	17,833	3,171	223	2,282

Source: PEP (Moderate Scenario)

Figure 3.1.5 Estimated Agro-products in PEP

In the moderate scenario, the PEP estimated annual increased rate for agro-production volume is 4.5% by 2017 as shown in table above. Based on above data, the Study Team estimated by the method of applying logistic curve (growth curve) which has upper limitation of provincial capacity of production which should be same as capacity of production per capita. And the Study Team assumed the limited products such as sunflower, sesame, and soybean which are only farmed in limited districts to be applied the same as 4.5% annual increase rate after 2017.

In the results described in figure below, agro-production in 2050 is estimated as 1,450,000 tons compared to 500,000 tons in 2008. This represents an increase of about 2.6 times.



Source: PEP (Moderate Scenario)

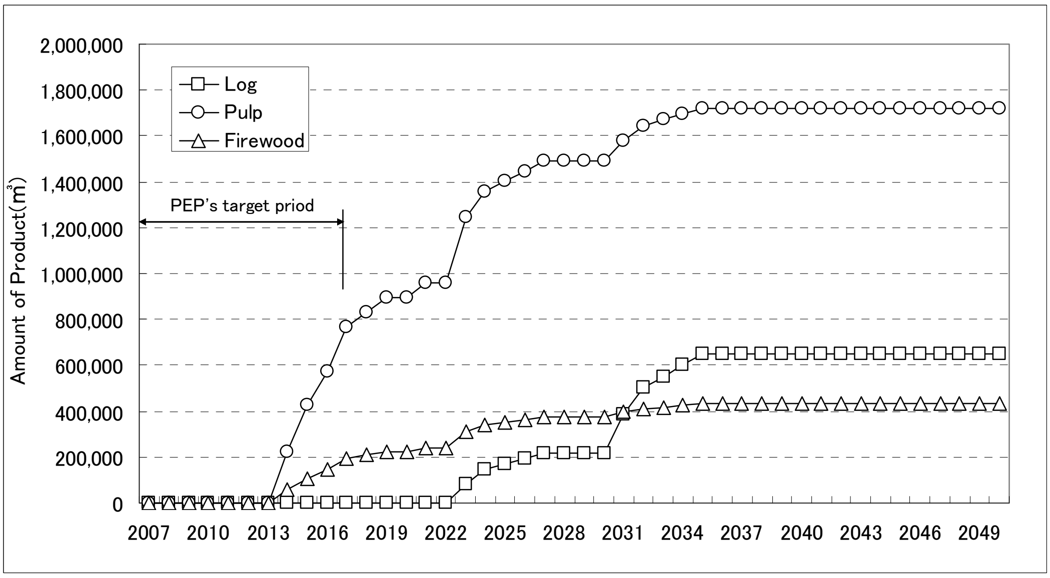
Figure 3.1.6 Estimated Agro-products

(3) Forestry (Source: Strategy Plan in Niassa Province)

In the moderate scenario, PEP assumed that annual tree planting will be planned as 6,000 - 17,000 ha, and forestry products (e.g. log, pulp and charcoal) will be distributed on the market gradually after planting and growing. In 2017, it is planned that 130,000ha of area will be covered by forest.

Assuming that the same level of annual afforestation (17,000ha) will be continued after 2017, afforestation area will cover about 741,000ha (about 6% of province area) in 2050.

Based on the conditions described below, the quantity of production will increase gradually and level from 2035. Annual production will be 1.7 million cubic meters for pulp, 0.6 million cubic meters for log and 0.4 million cubic meters for charcoal.



Source: PEP（Moderate Scenario）

Figure 3.1.7 Forest Estimation

Reference: Condition for estimation in PEP

The forestry products produced by afforestation of 1ha are divided into three products, namely log, pulp and charcoal. Forest of 1ha area is supposed to produce 80 cubic meters. Table below shows share of each production in accordance with the elapsed years after afforestation.

Table 3.1.2 Assumed Share of Forest Production

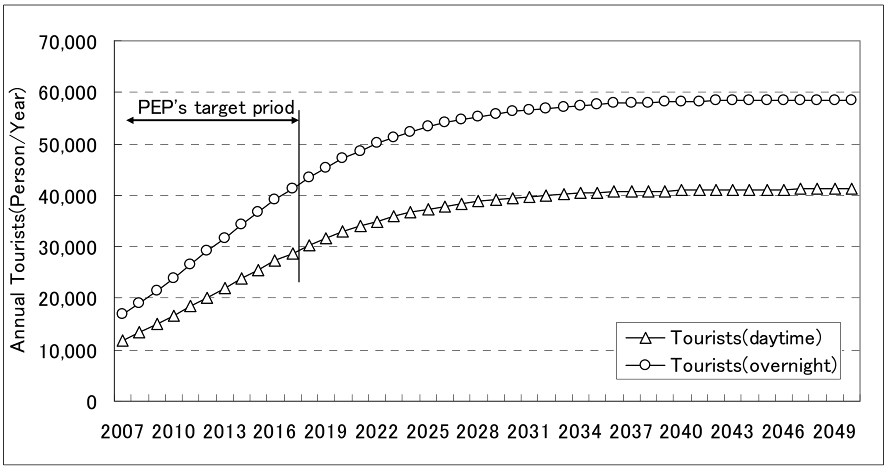
	8years later	16 years later	25 years later
Log	0%	30%	60%
Pulp	80%	56%	32%
Firewood	20%	14%	8%
Total	100%	100%	100%

Source: PEP after 8 years, 16 and 25 years are estimated by description of PEP

(4) Tourism (Source: Strategy Plan in Niassa Province)

PEP analyzed that tourists will increase to 70,000 tourists including one day trips and stays in 2017 which is more than twice the number in 2007 (about 30,000 tourists). However, PEP also estimated that the increase rate will be reduced after 2017.

Therefore, the Study Team applied the logistic curve (growth curve) based on PEP's estimation and estimated future tourists by 2050. It shows that increase of visitors will level out around 2030 at about 100,000 tourists comprising 40,000 visitors for one-day tours and 60,000 visitors for stay tours as shown in the figure below.



Source: PEP (Moderate Scenario), Study Team estimated Long term

Figure 3.1.8 Tourism Estimation

3.1.4 Summary

The Section from 3.1.1 to 3.1.3 discussed the basic macro-economic assumption for traffic demand forecasting. These assumptions are summarized in the table below.

Table 3.1.3 Summary for Macro-Economics Assumptions

Item	Assumptions	Annual increase rate (2050/2007)
Population	Future population up to 2050 has been estimated in each district based on PEP's estimation, and applied logistic curve by the Study Team	About 2.5 – 2.8% (2.2times)
GDP	Future provincial GDP up to 2050 has been estimated based on PEP's estimation, applied logistic curve	Conservative: 8% (3.0times) Moderate: 10% (4.3times) Optimistic: 12% (7.0times)
Agro-products	Future agro-products up to 2050 have been estimated based on PEP's estimation, applied logistic curve and some conditions/ assumptions	About 4.5% (2.6times)
Forest	Future forest products up to 2050 have been estimated based on PEP's estimation, applied logistic curve and some conditions/ assumptions	Annual production after 2035 Pulp: 1.7 mil. m^3 Log: 0.6 mil. m^3 Chacol: 0.4 mil. m^3
Tourism	Future tourists up to 2050 have been estimated based on PEP's estimation, applied logistic curve and some conditions/ assumptions	Annual visitors after 2030, One-day: 40,000 visitors Stay: 60,000 visitors

3.2 Forecasting Methods

3.2.1 Review of Forecasting Methods in Previous Feasibility Study

In order to apply suitable forecasting method, the forecasting method in the previous study should be reviewed. In this context, the Study Team examined the following previous studies which are a) Lichinga – Montepuez (2001), b) Milange – Mucuba (2008) and c) Nampula – Cuamba (2007).

The outline of these studies is summarized in the table below.

Table 3.2.1 Outline of Previous Feasibility Studies

Item	Lichinga ~ Montepuez: N14 BCEOM, 2001	Milange ~ Mucuba: N11 BCEOM, 2008	Nampula ~ Cuamba: N13 JICA, 2007
Forecasting Period	2005～2015	2011～2030	2012～2028
Traffic Survey	2002 Traffic volume survey: 3 locations 7days (18hrs.) + 1day (24hrs.) OD survey: 2 locations (3days)	2007 Traffic volume survey: 4 locations 4days (12hrs.): incl. Sat. Sun. 2nights at 1 location OD survey: 3 locations 4days (12hrs.): incl. Sat. Sun. 2nights at 1 location	2006 Traffic volume survey: 9 locations 4: 3days(24hrs.): Oct&Dec 5: 2days(12hrs.): Oct&Dec OD survey 4 locations 3days(12hrs.): Oct
	Interview survey to traffic related firms at Lichinga	Interview survey to transporter at Lilongwe	Railway/ Bus passenger survey Interview survey for railway company Interview survey to transporters
Road Network	TAZ: 5 combined with districts Link nos.: 6 (straight line) Network assignment: No	TAZ: not treated Link nos.: not treated Network assignment: No	TAZ: 17→25 Link nos.: many with Malawi's link Network assignment: done
	Study link nos. : 5	Study link nos.: 1	Study link nos.: 4
Forecasting Method	- Carefully discussed with Traffic Generation (daily consumption, agro-products) - Passenger traffic was estimated by fix unit generation ratio.	- The concept of trip generation and attraction was not treated. - Traffic volume was estimated based on the fuel consumption estimated by another agency[1]	- Traffic volume was estimated based on the fuel consumption estimated by another agency, and included future provincial population[2]. - Diverted traffic from railway was considered.
Generated Traffic	About 30~50% of each consumption item	Estimated by the saving of time value using elasticity of value	N/A
Diverted Traffic	N/A	- Route diverted from Nacala and Beira Port related traffic	- International route choice from Beira to Nacala Port - Modal shift from railway both passenger/ freight traffic - Route diverted estimated by traffic assignment
Bicycle	N/A	Change to vehicle for long trip bicycle riders	N/A

According to the above results, it is found that there are many differences of forecasting methods among studies. It is true that each study road has different characteristics of traffic pattern, so that it may be possible to apply more suitable method for the objective.

1 An assessment of road traffic growth, 2006, prepared by ANE in-house consultant (not officially opened)
2 Same as above

More details of estimation method in each study are attached in the appendix.

However, African Development Bank (AfDB) pointed out the several issues for traffic demand estimation in the preliminary appraisal mission for Nampula – Cumaba road improvement project. The issues pointed out are summarized as follows;

- Generated traffic must be included in Traffic Demand Forecasting (Economist of AfDB suggested that 30% of estimated traffic will be added as generated traffic)
- For sensitivity analysis, GDP should also consider both the optimistic and pessimistic scenarios.
- For economic analysis, both motorcycles and bicycles should be taken into consideration.

3.2.2 Concepts for Traffic Demand Forecasting Method

(1) General Concepts

Considering the above section, the Study Team has set the general concepts for traffic demand forecasting method described below.

- Forecasting model shall be able to explain the potential/ hidden demands caused by rainy season and bad surface conditions.
  - Passenger traffic: model includes difficulties of moving in rainy and dry seasons.
  - Freight transport: model includes the demands of consumption and supplement in market by each item.
- Route choice shall be considered by each item's origin/ destination
- International freight transport from Malawi shall be considered as diverted traffic.
- Railway transportation shall be treated as below;
  - Nacala - Nmpula – Entre Lagos – Malawi Line: Capacity of railway transportation has already leveled out because of poor rail condition and limited number of locomotives as described in 1.6. In this estimation, railway improvement will not be considered, and capacity of traffic will be stable as it is.
  - Cuamba – Lichinga line: As described in 1.6, Northern line is not operated properly, and wagons can make only one round tripper month. And CDN, which is the operation firm under concession, has difficulties of rehabilitation of railway condition under its concession agreement. Therefore, this line will stay in its current condition.
- Port facility shall be considered to be the same condition as present.
- Border facility at Mandimba will be assumed in both its current status and improved status such as one-stop-border post.

Note that in the middle of October 2009 there was an announcement for new railway construction plan between Motivaze and Blantyre for transporting coal to Nacala Port. It is said that feasibility study will be started soon. At this moment, there is no concrete information for this project. However, there must be much rehabilitation through the SEAR and CDN for allowing coal transportation. Therefore, in this Study, this will not be considered for application to this estimation.

(2) Estimation Periods

For estimation of future traffic demand, the following analysis period is defined:

- Horizon year: 2009
- Construction period: 2011-2013
- Base year: 2014
- Analysis period: 2014 – 2034 (20 years)

(3) Scenarios for Traffic Demand Forecasting

According to general concepts described before and study sections between Cuamba and Lichinga, forecasting scenarios are formulated as below.

Table 3.2.2 Scenarios for Traffic Demand Forecasting

Scenario Case	Road Network			Border	Railway Network			Port
	Lichinga ~ Mandimba	Mandimba ~ Cuamba	Nampula ~ Cuamba	OSBP	Nacala~ Entre Lagos	Cuamba ~ Lichinga	Malawi Doest.	Nacala
Without Case	As it is	As it is	As it is	As it is	As it is	As it is	As it is	As it is
With Case (Scenario -1)	As it is	Improved	Improved	As it is	As it is	As it is	As it is	As it is
With Case (Scenario -2A)	Improved	Improved	Improved	As it is	As it is	As it is	As it is	As it is
With Case (Scenario –2B)	Improved	Improved	Improved	Improved	As it is	As it is	As it is	As it is

Nampula – Cuamba (N13) section is already undergoing implementation of construction, therefore, all of the “with” cases take this section to be improved.

3.3 Traffic Demand Forecast

3.3.1 Methodology of Traffic Demand Forecasting Method

Based on the discussion in 3.2, future traffic volume was estimated by three different types of traffic, such as i) passenger, ii) regional goods and iii) international goods, used by following data and process.

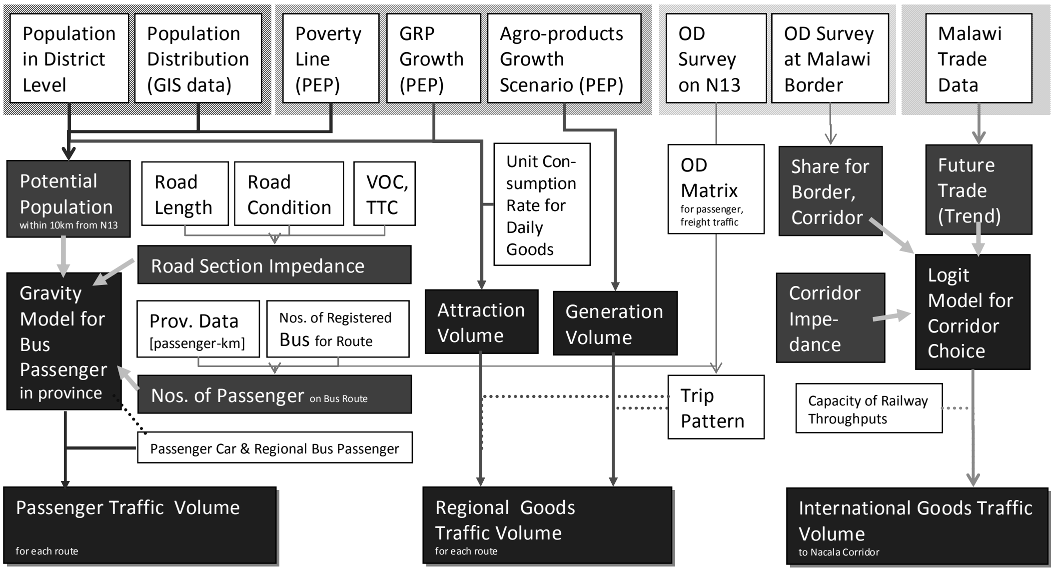


Figure 3.3.1 Process of Traffic Demand Forecast

Each component of traffic estimation is described below;

Passenger traffic volume is estimated by "Gravity Model" with the variable index of potential population and road section impedance, developed by the actual number of passengers for each O-D trip.

Regional traffic volume is considered by divided traffic as attraction and generation for each zone. Trip attraction is estimated by the consumption of daily goods, and trip generation is based on agro-products from Niassa province.

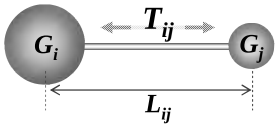
International traffic volume is thought to be generated after the road network is improved. It is estimated by the Malawi trade and railway capacity, and applies the corridor choice model, named lodgit model.

Following sections describe the estimation method and the results for each estimation component.

3.3.2 Passenger Traffic Estimation

(1) Introduction

For describing the "hidden demands" of social and business passenger movement, "gravity model" had been chosen as a suitable method. The basic model equation for gravity model is shown below.



$$T_{ij} = k \frac{G_i^{\alpha} G_j^{\beta}}{L_{ij}^{\gamma}}$$

T_{ij} Nos. of Passengers between "i" to "j"

G_i Potential for moving (e.g. Population)

L_{ij} Impedance between "i" to "j" (e.g. Road Length under condition)

Figure 3.3.2 Gravity Model Equation

(2) Model Development

In order to apply this model into this Study, the Study Team selected following definitions for each data set after acquiring data available in Niassa Province.

T_{ij} : Number of minibus passengers between "i" to "j", calculated by the static data (e.g. provincial data for passenger-km and number of registered buses for each route) and OD survey data. The figure right shows the estimated number of daily passengers for each OD trip.

L_{ij} : Number of population within 10km from district center calculated by GIS, whose income level is above the poverty line (52% in 2007). Future value based on the INE projection and target poverty index in 2017 (37%).

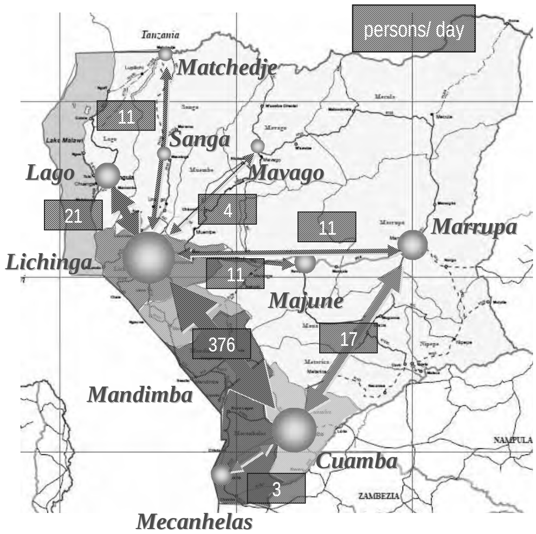


Figure 3.3.3 Estimated Number of Minibus Passengers

G_i : Impedance between "i" to "j", which is calculated by the vehicle operation cost (VOC) and travel time cost (TTC) at each road section with same road condition such as IRI. Note that the Study Road will have decreased impedance when the rehabilitation is completed.

After collecting the above data, coefficients for each explanatory variable were estimated and validated for relevance. The results of model estimation are described in the table below. It is clear that t-value of parameter was estimated as more than two, and coefficient determination is nearly 1.00.

Table 3.3.1 Results of Model Estimation

[Model Equation]

$$T_{ij} = k \frac{G_i^{\alpha} G_j^{\beta}}{L_{ij}^{\gamma}}$$

Explanatory Variables	Estimated Coefficient (t-value)	R^2 (Coefficient Determination) = 0.94, DW (Durbin-Watson) Ratio = 1.41
α: Population-1	2.78 (3.25)	
β : Population-2 / 3	1.02 (4.80) / 0.22 (1.35)	
γ : Impedance	-0.85 (3.19)	
K: Constant	1.58*10^-15 (-3.63)	

Using this developed gravity model, the future traffic volume will be estimated using the future population and road condition when the Study Road will be improved.

(3) Future Number of Passengers and Vehicles

There are two types of scenario for the “with case” discussed in 3.2.2, so three types of estimation including “without case” have been conducted as shown below.

- **Without case**: only “normal traffic” affected by population increase
- **With case (Senario-1)**: “normal traffic” and “generated traffic” are affected by the improvement of only “Cuamba – Mandimba” section. [Generate-1 in figure 3.3.4]
- **With case (Senario-2)**: “normal traffic” and “generated traffic” are affected by the improvement of all Study Road section. [Generate-2 in figure 3.3.4]

The conversion factor from number of minibus passengers to vehicles is taken as 14.3 passengers/vehicle, which is analyzed by the result of OD survey.

The results of estimation are shown in figure below. The normal traffic will be increased more than 20% per year due to hidden traffic demand, and 30% of normal traffic will be generated when the road will be improved.

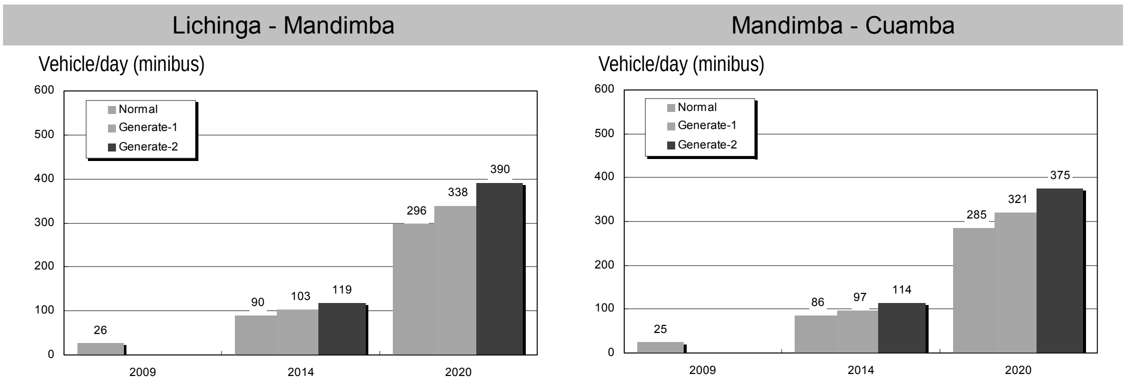


Figure 3.3.4 Minibus Traffic Estimation <Results>

In the case of passenger cars, the trip pattern is analyzed by the OD survey, which is shown as the percentage of OD pair in figure below. More than half of trips communicate between Cuamba and Lichinga. Only a few trips reach Tete or Beira.

Due to the estimation for future trips, the annual increase rate of population and GRP per capita will be applied to the number of passengers of trip generated zone.

The results of passenger vehicles for each section are shown in figure below.

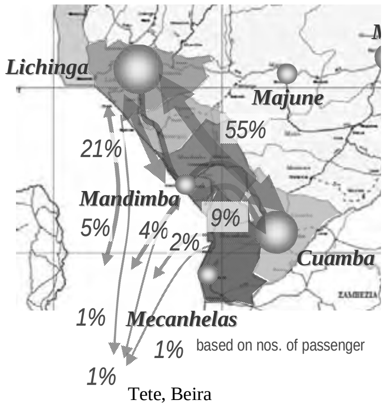


Figure 3.3.5 OD-pair Trip Pattern for Passenger Cars

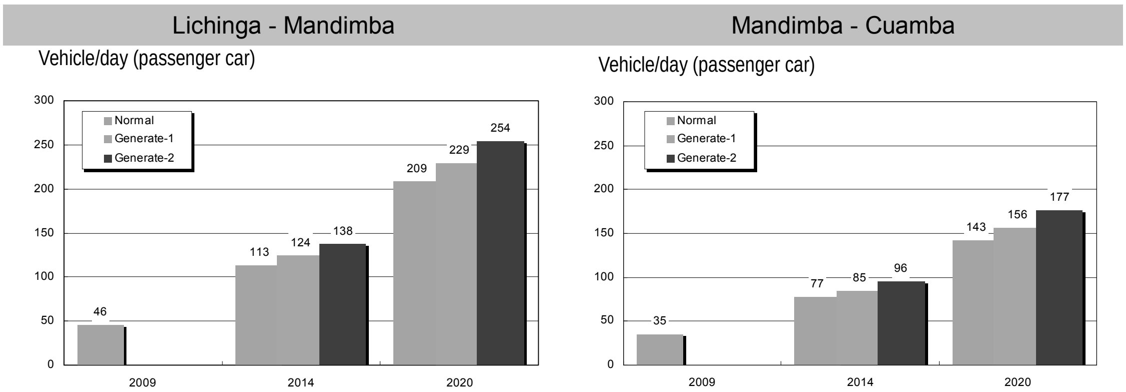


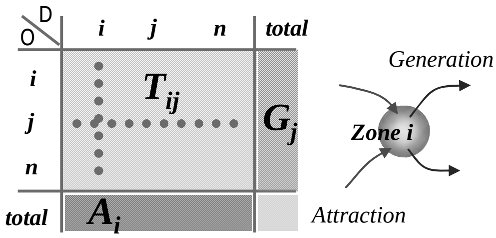
Figure 3.3.6 Passenger Traffic Estimation <Results>

Based on the results, both minibus and passenger car vehicles are cumulated to future traffic volume. Note that some minibus passengers may shift traffic mode to passenger cars as they enter higher income groups. However, it is difficult to account because of the limitation of this type of estimation method.

3.3.3 Regional Goods Traffic Estimation

(1) Introduction

As already discussed in the previous section in 1.5.2, the regional goods movement is characterized when the OD survey is carefully analyzed on separated trip "attraction" and "generation" described on the right.

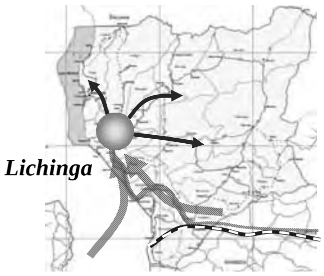


T_{ij} : *Volume of goods which are transported from "i" to "j"*

G_j : *Trip Attraction to "i" from other zone*

A_i : *Trip Generation from "j" to other zone*

It is assumed that the "**trip attraction**" is mainly caused by the traffic of consumer goods for Lichinga, because of the limited road network surrounding this provincial capital. Therefore, once consumer goods reach to Lichinga, these are distributed to northern part of Niaasa Province. The result of trip attraction to Lichinga is calculated as 165.0ton per day. Future attracted traffic will be estimated by the future consumed goods volume.



$\Sigma A_{Lichinga}$ = **165.0** *ton/ day*

Distributed to; Lichinga Municipal, Lichinga District, Ngauma District, Mandimba District, Lago District, Sanga District, Muembe District, Mavago District, Majune District, Mecula District, Marrupa District

Figure 3.3.7 Concept of Trip Attraction

On the other hand, for the "**trip generation**", the Study Team recognized that

Niassa Province has essential potential for agro and forestry products, therefore, future generated traffic will be estimated by the planned agro products in Niassa Province on PEP (Niassa Provincial Strategy). The figure below shows the current potential for trip generation conducted by Niassa Province.

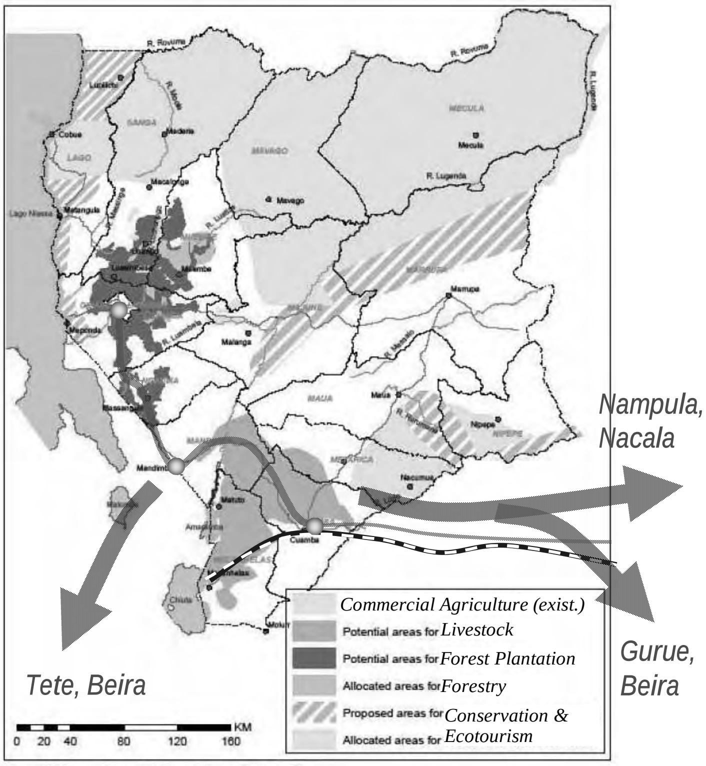
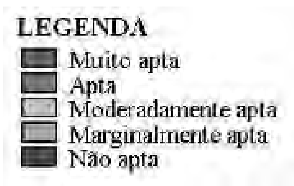
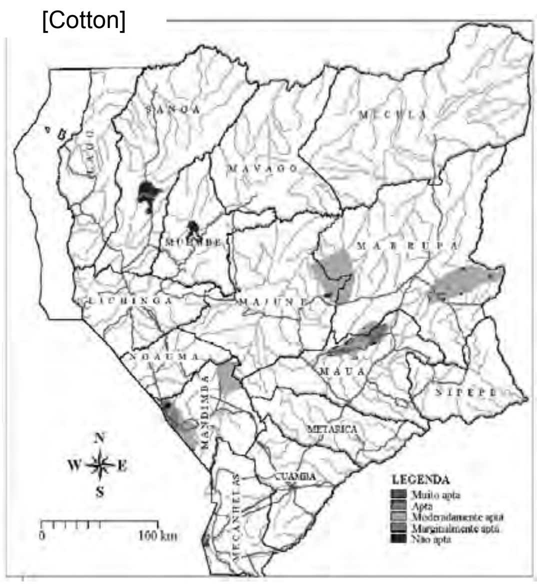


Figure 18: Proposed areas for forestry/livestock/ecotourism

Source: Zoning & Identification of Areas for Investment in the Agrarian Sector and Socio-Environmental Analysis for Niassa Province, Rural Consult. Ltd. and Savocor Indufor, 2007.5





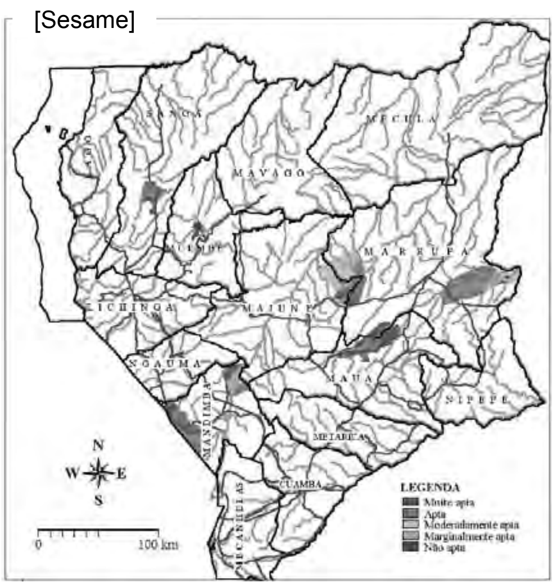


Figure 3.3.8 Current Potential for Trip Generation

(2) Estimation Process and Results for Trip Attraction

The figure below shows the trip pattern analyzed by OD survey attracted to Lighinga, Mandimba and Cumaba. The percentage of share is calculated based on the tonnage of goods transported.

[To Lighinga]

165.0ton/day

- About half of goods are transported from Cuamba, Nampula and Nacala side.
- 23% of goods are from Maputo.
- 20% of goods are from Malawi, Tete and Beira..

[To Mandimba]

18.0ton/day

- Mamdinba relays on the goods from Malawi for more than half of them.
- 27% of goods are distributed from Lichinga.
- Only a few goods are transported from Cuamba side.

[To Cuamba]

9.7ton/day

- Because OD survey was only conducted on the Study Road section, there are no transportation data from east side to Cuamba. Also, there may be existing railway transportation.
- The road transportation on the Study Road accounts for 74% from Tete and Beira.
- 24% of goods comefrom Lichinga.

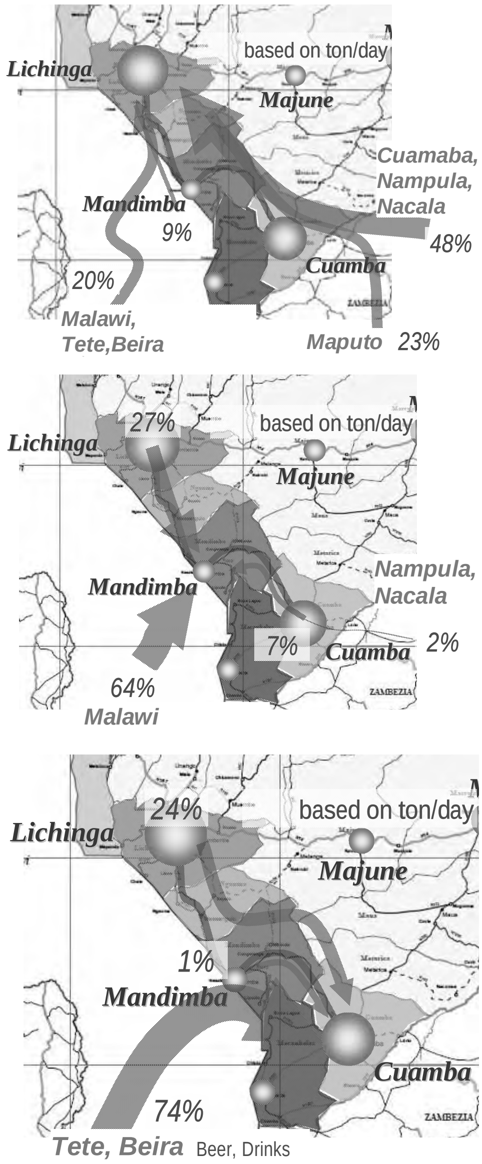


Figure 3.3.9 Current Trip Pattern for Attraction

It is assumed that this trip pattern will be kept to the future traffic pattern.

Regarding the future volume of required goods, the unit method for major consumption goods will be applied, such as "unit consumption rate", future population and increased growth of disposable income level (+10% in annual). The table below shows the applied rate for major consumed goods.

Table 3.3.2 Applied Unit Consumption Rate

Item	Consumption Rate
Consumer Dry Goods	14.4kg/ pp/ year
Oil	3.6kg/ pp/ year
Salt	1.2kg/ pp/ year
Sugar	3.6kg/ pp/ year
Powdered Milk	3.6kg/ pp/ year
Construction Materials	5kg for Cement, 10kg for roof material
Beer/ Soft drink	20bottles/ pp/ year
Fuel	2truck for 30,000L per day
Fertilizer	17 % of cotton, 42% of tobacco product

Source: Feasibility Study on Lichinga - Montepuez (N14) BECEOM, 2001 and Study Team (adjusted to OD results)

Based on the above procedure, the future goods traffic is estimated in the figure below. Regional goods traffic will be increased by 10 - 15% per year.

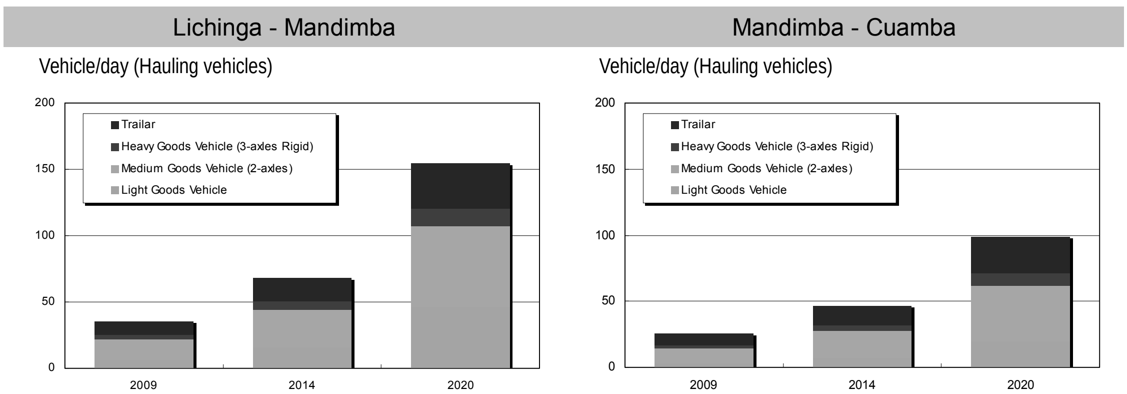


Figure 3.3.10 Regional Goods Traffic Attraction Estimation <Results>

(3) Estimation Process and Results for Trip Generation

As described in 3.1.3 (2) and (3), future agro-products and forestry products are applied to regional generation traffic.

The figure below shows the trip pattern analyzed by OD survey generated from Lighinga, Mandimba and Cumaba for type of goods. Note that this movement is supposed to have many seasonal or monthly variations. Therefore, the ideal modeling of trip generation described below will be applied.

Future generation volume (ton) for agro-products is estimated in figure below. Total volumes of agro-products are estimated by “Agro-products in PEP – Internal Consumption (maize, rice, sorghum, millet, peanuts, beans, cassava, cotton, tobacco, sunflower, sesame, soybeans)”.

Note that forest products are assumed to be generated from the northern side of Niassa as described in Figure 3.3.8. Therefore, all products will be generated from Lichinga.

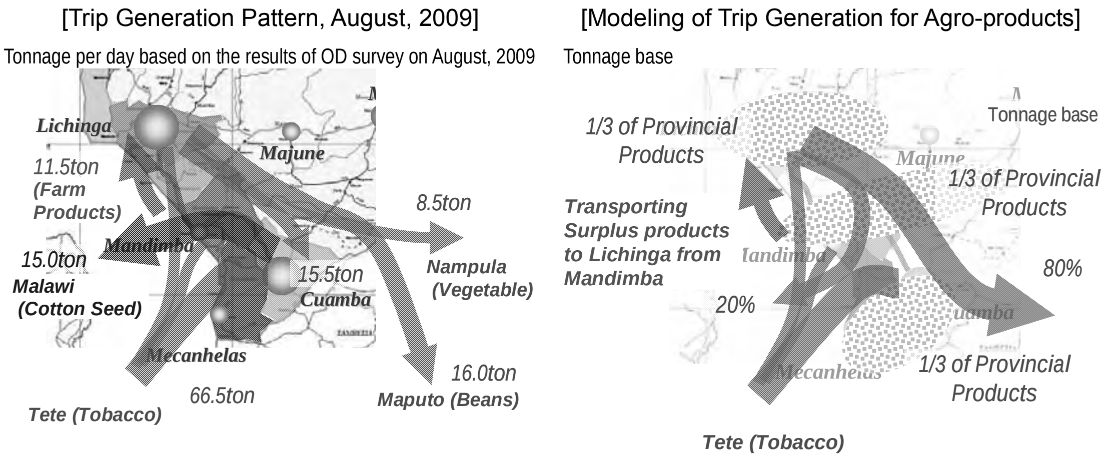


Figure 3.3.11 Trip Pattern for Regional Goods Traffic for Generation

Based on the above procedure, the future goods traffic is estimated in figure below. Regional goods traffic will be increased by 5 - 10% per year.

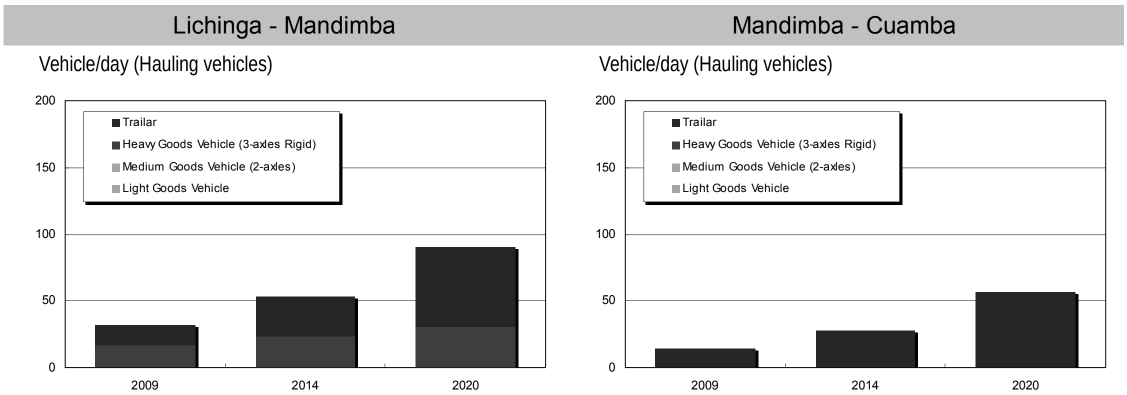


Figure 3.3.12 Regional Goods Traffic Generation Estimation <Results>

3.3.4 International Goods Traffic Estimation

(1) Introduction

For the international goods transportation on Nacala Corridor in future, both Nacala and Beira Corridor networks should be considered with Malawi and Zambia trade. However, the OD survey found that only Malawi trade existed and is possibly applied to future corridor transportation, so this Study took the possible route for Malawi trade in the figure below.

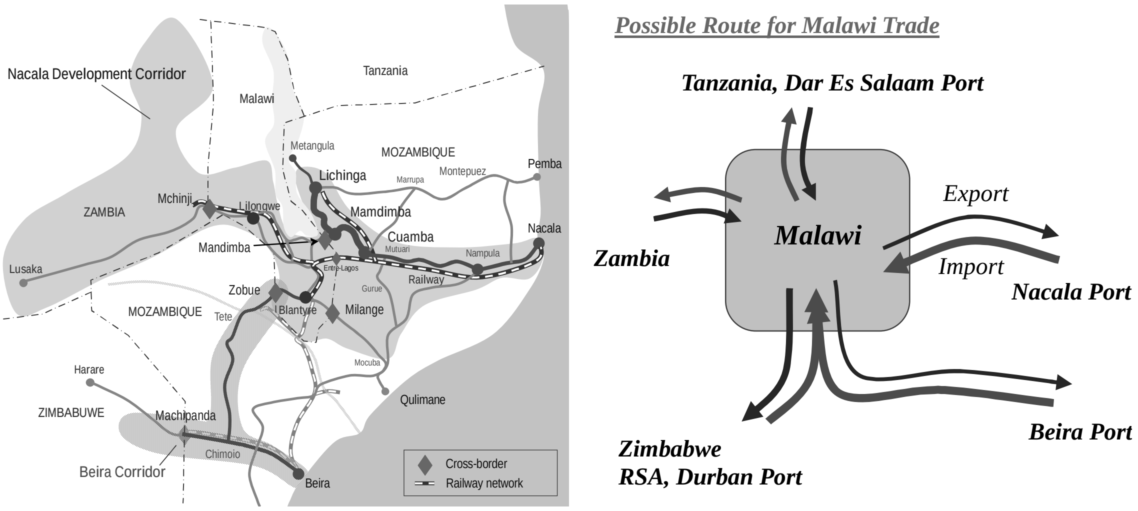


Figure 3.3.13 International Network and Possible Route for Malawi Trade

In order to find more suitable estimation for international transportation in this area, the Study Team took the point of view for Malawi trading data, then assigned to each route.

(2) Estimation Process

The future Malawi trade will be estimated based on the historical trade data. Then, applying the border share at different borders in/out of Malawi and neighboring counties, possible volume of international transportation is estimated for railway on Nacala Corridor (CDN) and road transportation on Nacala and Beira Corridors. The route preference between Beira Corridor and Nacala Corridor is estimated by the “Logit Model” which is developed based on the existing stated preference such as the result of cross-border OD survey. The whole process is shown in the figure below.

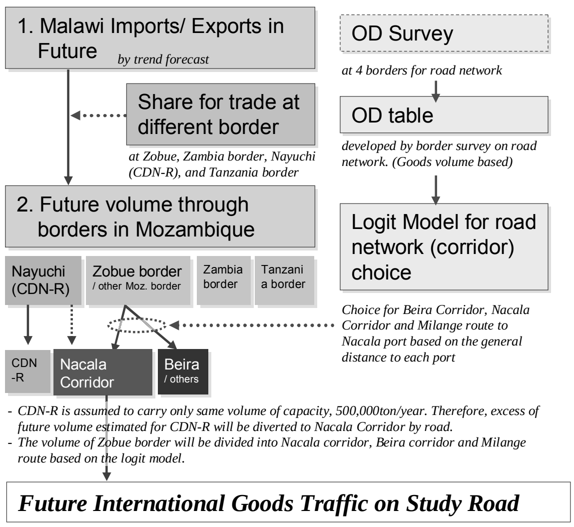


Figure 3.3.14 Estimation Process for International Goods Transportation

(3) Results for each Estimation Step

Future Malawi trade is estimated by the logistic model developed using the last 20 years trade data in monetary value for Malawi (1987-2006). The figure right shows the curve of future estimated trade data. Then, this estimated future monetary value is converted into tonnage value by the actual ratio between monetary value and total tonnage of the top 20 commodities in 2006. It should be noted that there are still large gaps between export and import from Malawi.

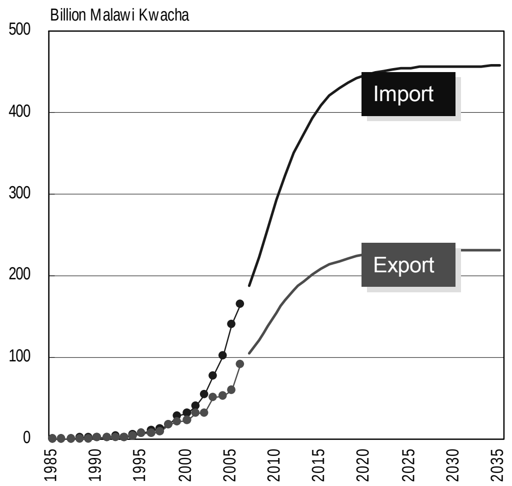


Figure 3.3.15 Estimated Future Malawi Trade

After estimating this trade data, previous research was conducted to find the percentage share of throughput at various borders in Malawi to neighboring countries. For example, taking the case of importing, 63.8% of imports use road transportation through Mozambique and 21.2% are by Nacala railway as indicated in "Entre Lagos". The details are shown in below.

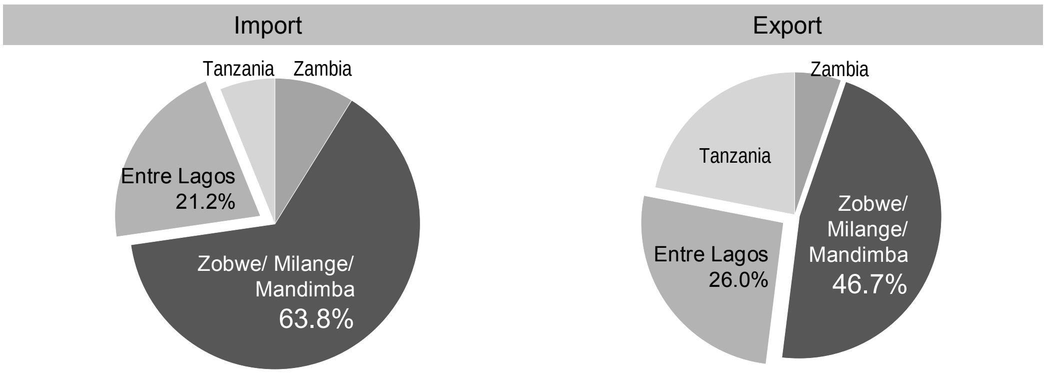


Figure 3.3.16 Percentage Share for Border Throughput

In addition, OD survey conducted at four Malawi borders in August 2009 were analyzed to find the percentage share for road transportation to select the route in tonnage based on different origin and destination. The table below is the result of this analysis.

Table 3.3.3 Percentage Share of Route Choice for Road Transportation (tonnage base)

Import (from)			Export (to)		
Mozambique		9.8%	Mozambique		5.0%
Nacala Port	Mandimba	-	Nacala Port	Mandimba	-
	Milange	-		Milange	18.2%
Beira Port		40.5%	Beira Port		33.3%
South Africa		24.0%	South Africa		18.2%
Zimbabwe		25.7%	Zimbabwe		25.3%

Source: Study Team (Border OD Survey)

Based on the performance of route choice for Nacala Port and Beira Port, the Study Team developed the route choice model such as "logit model" described in the following equation.

$$Pr_i = \frac{e^{V_i}}{\sum_j e^{V_j}}$$

Pr_i: Probability for route choice "i"

$V_{Beira} = \beta_1 L_{Beira} + \beta_2 ASV_{Beira}$

$V_{Milange\text{-}Nacala\,(M\text{-}N)} = \beta_1 L_{M\text{-}N} + \beta_3 ASV_{M\text{-}L}$

$V_{Mandimba\text{-}Nacala\,(Ma\text{-}N)} = \beta_1 L_{Ma\text{-}N}$

where,

V_i: Utility of route choice "i"

L: General distance (Explanatory Variable)

ASV: Alternative Specific Variables

It should be noted that general distance was applied to the length of each route and its surface condition. When the Nacala Corridor will be improved, the general distance will be changed to less distance compared with Beira Corridor.

The results of route choice probability after road improvement on Nacala Corridor are summarized in the table below. It is estimated that about 40% of imports and 77% of exports will use Nacala Corridor, which means that more time-conscious transportation will choose Nacala Corridor, which can be described as the "Diverted Traffic" for route.

Table 3.3.4 Route Choice Probability after Road Improvement on Nacala Corridor

Import (from)		
Nacala Port	Mandimba	39.5%
	Milange	0.1%
Beira Port		60.4%

Export (to)		
Nacala Port	Mandimba	76.7%
	Milange	8.3%
Beira Port		15.0%

Source: Study Team, estimated by Logit Model

Moreover, regarding diverted traffic from railways, after estimating the transportation volume on Nacala railway, overflow of railway capacity will be diverted to Nacala Corridor. Based on the discussion in 3.2.2, there are not enough investment and rehabilitation plans, so the capacity of railway is assumed as "Export: 182,000 tons/year" and "Import: 325,000 tons/year".

The diverted traffic will be generated for international goods transportation when the Study Road will be improved. About 70 or more trailers will start running diverted from the other corridor (Beira Corridor) or Nacala railway (CDN). Note that this will happen only on Cuamba – Mandimba section, not on Mandimba – Lichinga section. The photo right is the typical trailer running at cross-border in Mozambique/Malawi.

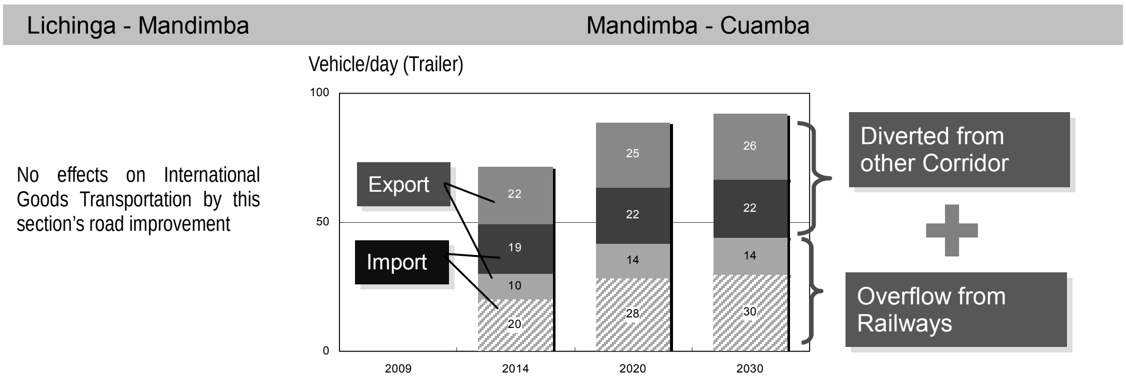
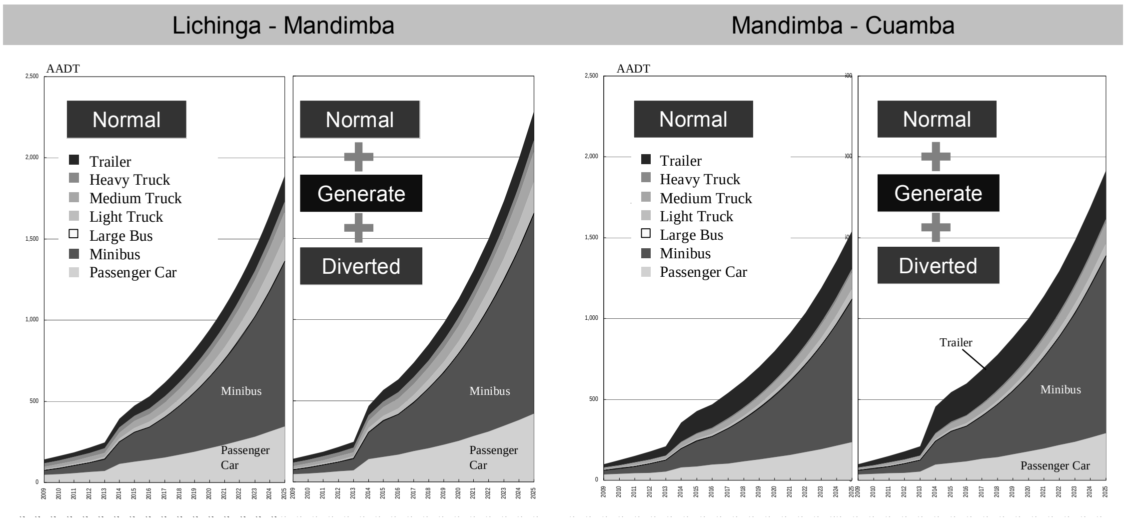


Figure 3.3.17 Diverted Traffic for International Goods Transport <Results>

These estimations are based on the assumptions described in 3.2.2. One of most sensitive factors which will influence traffic demand, especially heavy vehicles, is railway and port investment and rehabilitation. It should be carefully checked whether these plans will be announced. At the end of this Study, an investment plan has been announced for creating new railway line connecting from Moatize in Tete province to Blantyre in Malawi for coal deliveringy from Tete to Nacala Port. The plan announces that it will be constructed by 2015, However, the Study Team has disregarded this because many improvements and rehabilitations are required in both the Malawi (CEAR) and Mozambique (CDN-R) sections in order to bear the heavy wagons for coal delivering, and there are not enough financial resources.

3.4 Results of Traffic Forecast

Accumulating the results of 3.3.1 to 3.3.4, future traffic volume for both sections will be summarized. Future traffic volume in AADT is estimated about 450AADT in 2014, 1,700AADT in 2023 and 6,000AADT in 2033. If comparing only the AADT, the section of Lichinga – Mandimba is more than Mamdimba – Cuamba. It is because social communication will be more active by minibus and passenger car than the connection of provincial capital in Lichinga. The section of Mandimba – Cuamba is characterized by numbers of trailers e diverted from Beira Corridor and railway. It is evidenced that this section will compose part of the international corridor.



Lichinga - Mandimba

year	2009	2014	With case	2023	With case	2033	With case
Passenger Car	46	113	*138*	283	*344*	760	*925*
Minibus	28	136	*165*	738	*897*	2,958	*3,598*
Trailer	26	53	*58*	138	*152*	288	*328*
Others	42	91	*106*	280	*339*	1,278	*1,566*
Total	142	393	*467*	1,439	*1,732*	5,284	*6,417*

Mandimba - Cuamba

year	2009	2014	With case	2023	With case	2033	With case
Passenger Car	35	77	*96*	193	*239*	519	*643*
Minibus	26	117	*145*	641	*795*	2,587	*3,207*
Trailer	23	118	*164*	213	*272*	343	*425*
Others	17	42	*52*	143	*176*	612	*753*
Total	101	355	*457*	1,190	*1,481*	4,061	*5,027*

Figure 3.4.1 Estimated Traffic Volume for Each Section

Compared with the previous feasibility study between Nampula and Cuamba, this estimated traffic volume is almost same level of volume for previous section. The table below shows both results on the same time series.

Table 3.4.1 Comparison of this Study and Previous Study

Nampula-Ribaue

Year	Passenger Car	Mini Bus	Large Bus	Cargo	Total	D/D Total (Normal+Div.+Gen.)
2007	37	80	54	57	228	
2008	40	85	56	60	241	
2009	43	91	59	63	256	
2010	46	9	61	66	182	356
2011	48	104	64	69	285	
2012	51	198	107	443	799	
2013	54	207	111	461	833	
2014	58	218	115	479	870	1,201
2015	61	228	119	499	907	1,259
2016	64	238	122	520	944	
2017	68	249	127	542	986	
2018	72	260	131	565	1,028	
2019	76	272	135	588	1,071	
2020	80	283	139	613	1,115	1,647
2021	85	295	145	640	1,165	
2022	89	308	150	669	1,216	
2023	91	322	155	698	1,266	
2024	100	337	160	729	1,326	
2025	105	351	167	761	1,384	2,117
2026	111	367	173	795	1,446	
2027	117	383	179	830	1,509	
2028	124	401	186	867	1,578	
2029	131	419	193	906	1,649	
2030	138	438	200	946	1,722	
2031	146	458	207	988	1,799	
2032	154	480	215	1,032	1,881	
2033						3,198
2034						
2035						

Ribaue-Malema

Year	Passenger Car	Mini Bus	Large Bus	Cargo	Total	D/D Total (Normal+Div.+Gen.)
2007	51	28	25	47	151	
2008	55	30	26	49	160	
2009	59	33	27	52	171	
2010	63	35	29	54	181	107
2011	67	37	30	56	190	
2012	71	57	80	436	644	
2013	75	60	81	454	670	
2014	79	61	84	472	696	808
2015	84	68	86	491	729	847
2016	89	71	89	512	761	
2017	94	75	91	534	794	
2018	99	80	94	556	829	
2019	105	84	96	580	865	
2020	110	89	98	604	901	1,089
2021	117	94	102	631	944	
2022	123	99	104	659	985	
2023	130	104	107	688	1,029	
2024	137	110	111	718	1,076	
2025	145	116	114	750	1,125	1,384
2026	153	123	117	783	1,176	
2027	162	130	120	818	1,230	
2028	171	137	124	854	1,286	
2029	180	145	128	892	1,345	
2030	190	153	132	931	1,406	
2031	201	161	136	973	1,471	
2032	212	171	140	1,016	1,539	
2033						2,071
2034						
2035						

Malema-Cuamba

Year	Passenger Car	Mini Bus	Large Bus	Cargo	Total	D/D Total (Normal+Div.+Gen.)
2007	46	13	21	41	121	
2008	49	14	22	43	128	
2009	53	15	23	45	136	
2010	57	16	24	47	144	252
2011	60	17	25	49	151	
2012	64	77	91	484	716	
2013	68	81	93	504	746	
2014	72	84	96	525	777	1,083
2015	76	87	97	546	806	1,136
2016	80	90	100	569	839	
2017	85	93	103	593	874	
2018	89	96	106	619	910	
2019	94	100	107	645	946	
2020	100	104	110	672	986	1,478
2021	105	107	113	702	1,027	
2022	111	110	116	733	1,070	
2023	117	114	118	766	1,115	
2024	124	118	122	800	1,164	
2025	131	121	124	836	1,212	1,893
2026	138	125	127	873	1,263	
2027	146	129	131	912	1,318	
2028	154	134	134	953	1,375	
2029	162	138	137	995	1,432	
2030	172	143	141	1,040	1,496	
2031	181	147	145	1,086	1,559	
2032	191	153	148	1,135	1,627	
2033						2,855
2034						
2035						

Cuamba-Mandimba

Year	Passenger Car	Minibus	Large Bus	Cargo	Trailer	Total
2007						
2008						
2009	35	26	0	17	23	101
2010	39	34	0	19	32	124
2011	43	43	1	22	41	150
2012	48	56	1	25	50	178
2013	53	71	1	28	57	209
2014	96	145	1	52	164	457
2015	108	195	1	59	181	543
2016	117	217	1	67	195	598
2017	130	266	2	76	210	684
2018	144	324	2	87	219	777
2019	160	393	2	100	229	883
2020	177	472	2	114	236	1,001
2021	195	565	2	131	245	1,139
2022	216	672	3	150	252	1,294
2023	239	795	3	173	272	1,481
2024	264	934	3	198	286	1,686
2025	292	1,093	4	229	297	1,914
2026	323	1,272	4	264	309	2,171
2027	357	1,473	4	304	321	2,459
2028	394	1,697	5	352	332	2,780
2029	435	1,945	5	408	345	3,137
2030	480	2,219	6	473	359	3,536
2031	529	2,520	6	550	381	3,986
2032	583	2,849	7	640	404	4,483
2033	643	3,207	8	745	425	5,027
2034	708	3,594	9	870	448	5,628
2035	780	4,011	10	1,017	473	6,290

Mandimba-Lichinga

Year	Passenger Car	Minibus	Large Bus	Cargo	Trailer	Total
2007						
2008						
2009	46	28	1	42	26	143
2010	51	36	1	47	29	163
2011	57	46	1	52	31	187
2012	63	58	1	58	34	214
2013	70	74	1	65	37	247
2014	138	165	1	104	58	467
2015	154	221	2	118	70	566
2016	169	247	2	133	80	631
2017	187	302	2	151	92	735
2018	207	368	2	171	99	848
2019	229	445	2	195	108	979
2020	254	535	3	222	114	1,129
2021	281	639	3	254	123	1,301
2022	311	759	3	291	131	1,495
2023	344	897	4	335	152	1,731
2024	381	1,054	4	386	166	1,991
2025	421	1,233	5	446	179	2,283
2026	465	1,433	5	516	192	2,612
2027	513	1,658	6	600	207	2,984
2028	567	1,909	6	699	220	3,401
2029	626	2,187	7	816	235	3,871
2030	690	2,494	7	955	252	4,398
2031	761	2,831	8	1,121	278	4,999
2032	839	3,199	9	1,320	304	5,671
2033	925	3,598	10	1,555	328	6,416
2034	1,019	4,031	11	1,836	356	7,253
2035	1,122	4,497	12	2,173	385	8,189

In the case of appraisal for AfDB, estimation of future non-motorized traffic (NMT) should be also estimated for economic evaluation. Therefore, based on the traffic count data at four locations and OD results for motorcycles, averaged bicycle traffic volume for each section will be estimated by applying the trip demand curve method.

As a result of the OD survey for motorcycles, the trip demand curve based on the travel time is developed.

*[Trip Demand (%)] = 98,439 * [Travel Time (min.)]* $^{-2.8277}$ *(R^2 = 0.991)*

The figure below shows the bicycle demand curve applied to the number of bicycles counted at each section. The total area for each curve means the same traffic volume at survey point. The averaged vehicle-km for each section will be calculated based on this curve in each direction. The results of averaged bicycle volume are 694 bicycles/day in the section of Lichinga – Mandimba and 473 bicycles/day in the section of Mandimba – Cuamba. The annual increase is applied as just 1% because of consideration to mode shift to minibus or other modes due to the income increased.

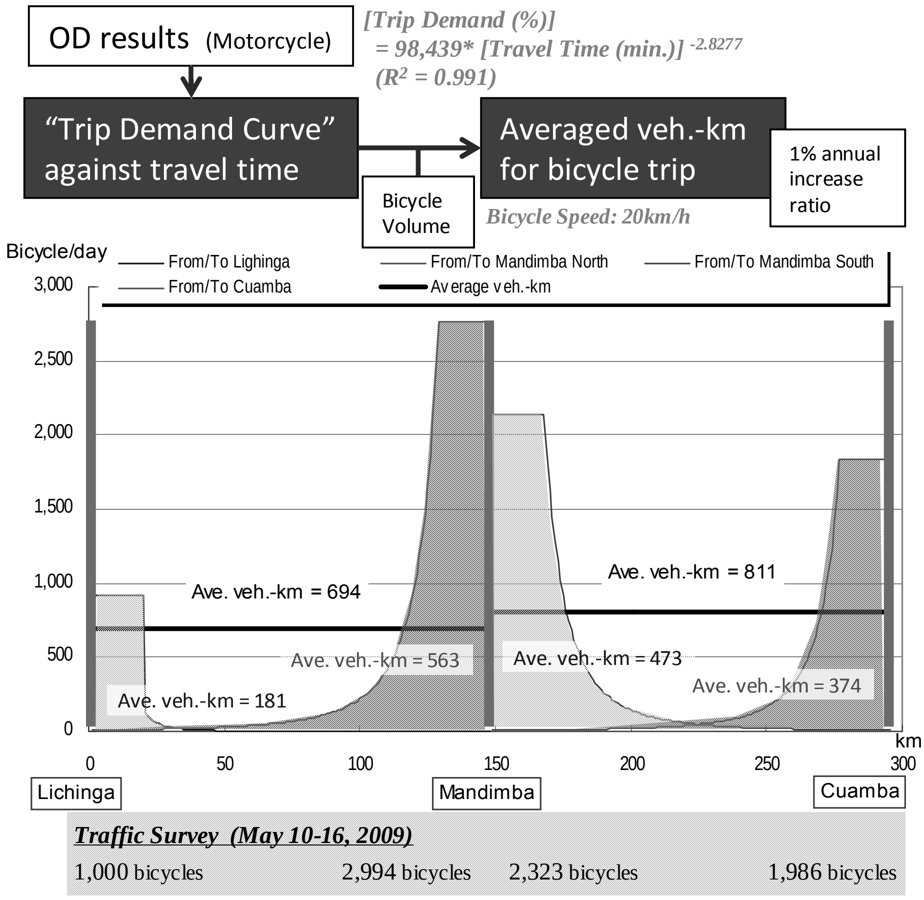


Figure 3.4.2 Estimated Bicycle Traffic Volume for Each Section

Chapter 4 Economic and Financial Analysis (Cuamba-Mandimba Section)

4.1 Introduction

The Study objective is "to determine the most technically feasible and economically viable, environmentally acceptable and socially optimal option of upgrading the existing earth/ gravel roads in the rural areas to paved roads." For the purpose of the economic evaluation, it is important to first define the existing state of the Project road for the base case, and then to define the alternatives to be analyzed, and finally the structure of the analysis.

Economic analysis for the Project consists of comparing the case "without the project" to those "with the different project alternatives." The case "without the project" entails maintaining the existing road and applying routine/periodic maintenance where necessary. The case "with the project" is the implementation of the road improvement interventions discussed in the previous chapters. The analysis determines their impact, and whether or not they are economically feasible, i.e. yielding a positive Net Present Value (NPV) and other indicators. Sensitivity tests are then applied on costs and traffic volume.

4.2 Methodology

In the road improvement under the Road and Bridge Management and Maintenance Project (RBMMP or Roads-3) implemented by the World Bank and other major road construction projects, calculation of economic indicators is mainly applied by the Highway Design and Maintenance Standards Model (HDM-4 model). HDM-4 was developed by the World Bank's Transportation Department to meet the needs of highway authorities, particularly in developing countries, for evaluating policies, standards, and programs of road construction and maintenance. Thus, ANE commented on the Inception Report for the Project on April 2, 2009, that the economic analysis for the Project will be conducted based on the HDM-4 model.

However, it should be noted that some advantages and disadvantages are found comparatively among the typical tools for economic analysis for the road project. In this Study therefore, HDM-4 analysis will be applied and supplemented by other tools for reference or comparison, where necessary.

The quantitative measure used to determine the feasibility of the Study Road to evaluate the Project from an economic perspective is the economic internal rate of return (EIRR) and other indicators. EIRR is the discount rate at which the net present value of an investment is zero.

4.3 Basic Assumptions for Analysis

The economic analysis was made based on the information and data derived from the natural condition in the Project area, existing road condition, improvement plan of the Project road, vehicle characteristics and traffic demand forecast, that are studied in the previous chapters. However, regarding the motorcycle surveyed individually, its forecasted volume is incorporated in the automobile or bus category in HDM-4 computation.

Careful attention should be paid when selecting the discount rate for cost-benefit analysis and investment decision making. The estimated economic benefits that are expected to accrue from improving the road should be assessed against the expected benefits from making alternative investments. From an economic perspective, the opportunity cost of capital is the most appropriate discount rate to rationalize road investment decisions and inform investment choices. For purposes of the economic analysis conducted in this feasibility study, the discount rate applied to the cash flows is 12 percent, as is suggested by ANE. Other major premises of the Project evaluation are summarized below.

- Project life: 20 years after the opening of the project road (2014)
- Pricing date: As of October 2009
- Social discount rate: 12%
- Exchange rate: US$1.00 = 28.00 Meticais (MT)

The economic evaluation period for the Project is assumed as 24 years from 2010 at which the detailed design work will be commenced prior to the construction works for 3 years. Analysis period for the Project is defined considering the durability of the road to be improved, reliability of accuracy of the traffic volume forecasted and other standard analysis conducted by the international institutions.

4.3.1 Conversion Factors (CF) to Economic Price

For the purpose of the economic analysis, all Project construction, maintenance and vehicle operating costs are expressed as economic costs. Economic costs represent the opportunity cost of production in the Project, or of a benefit resulting from the Project, such as savings in vehicle operating expenses. This entails removing transfer payments such as taxes, import and export duties and subsidies from the financial, or accounting costs, thus changing them to their values "on the border", such as CIF or FOB. The economic cost of transporting to the Project site is also included.

In practice, the direct unit costs of every construction and maintenance activity of borrow, fill, sub-base, etc., to be used as input to the HDM-4 model must be broken down by percentages into their basic components, such as labor, materials and equipment. Each percentage is weighted by its economic pricing factor, then added together and multiplied by the quantities to obtain the direct economic cost of the activity. Total economic cost is obtained by adding indirect costs such as contractor's overhead.

It is important to calculate economic prices for the construction and maintenance activities, because the vehicle operating costs which are Project benefits will be expressed in economic terms. As economic costs are usually lower than financial ones, failure to do so will negatively impact the economic feasibility of the Project. The economic pricing factors are determined as follows for labor, materials and others.

Table 4.3.1 Assumptions for Conversion Factor to Economic Cost

Major Items	CF	Remarks
Fuel/ Oil	0.95	5% of the price is assumed as fuel tax for gasoline and diesel.
Unskilled labor	0.41	Extracted from the VOC model of ANE and calculated from the production capacity of agricultural goods against the opportunity wage of unskilled labor.
Imported materials	0.84	According to the rate of weighed average import duty on the imported products
Machine and skilled labor	1.00	Due to the scarcity of these items in Mozambique.
Tax and license	0.00	They are just financially transferred to the government.
House compensation (or land acquisition cost)	1.00	It is assumed that land within the right-of -way has potential to be productive so that resettlement accrues the cost of losing such potentials and the price of house compensation reflects such loss.

Source: JICA Study Team

(1) Construction Materials

The economic pricing for materials was based on the removal of taxes and import duties from the financial prices. The principal material items in civil works on roads are asphalt, gravel, structural steel, culverts and cement. Asphalt is imported, likely from the Republic of South Africa, and cement and gravel are produced locally. Financial cost for cement, structural steel and culverts includes the relevant taxes. As materials are fairly common in the Project area, haulage is considered as included in the costs of the equipment portion.

The factor for material is a weighted average of the material types used in each intervention. Factors to convert to the economic prices for material are tabulated in Table 4.3.2.

(2) Construction Costs

The financial total costs are also broken down into labor, materials and plant weighted by the economic pricing factors to create the corresponding economic costs.

To the total of direct financial costs are added contingencies, supervision service fee, IVA, and a reserve for compensation. However, IVA does not enter into the economic cost, since IVA, being a tax, is a transfer payment. Compensation cost is a wish in economic terms, as it compensates people for the economic value of the returns to the land or other properties that are appropriated for use in the Project. In this Study, the compensation is included in the economic cost for the Project.

The economic prices for surfacing which include asphalt seal and cement stabilized base were estimated by a weighted average of the economic factors for the pavement with bitumen and gravel.

(3) Maintenance Costs

To calculate the maintenance costs used in the HDM-4 analysis, economic costs are used for the comparison of alternatives. As explained above, the direct unit costs of every maintenance activity such as pothole filling, seals etc. to be input to the HDM-4 model must be broken down by percentages into their basic components, such as labor, materials and equipment.

Each percentage is weighted by its economic pricing factor, then added together to obtain the conversion factor of the activity. The results are shown in Table 4.3.2 below.

Table 4.3.2 Conversion Factors for the Works

Component	Construction Materials			Construction Works		Maintenance Works	
	% (A)	CF (B)	A x B	% (A)	A x B	% (A)	A x B
Construction Materials	-	0.86	-	20%	0.17	15%	0.13
Land	20%	1.00	0.20	-	-	-	-
Machine (Rent)	35%	1.00	0.35	30%	0.30	20%	0.20
Fuel/Oil	5%	0.95	0.05	10%	0.10	5%	0.05
Skilled Labor	5%	1.00	0.05	10%	0.10	20%	0.20
Unskilled Labor	15%	0.41	0.06	10%	0.04	30%	0.12
License/Tax	5%	0.00	0.00	5%	0.00	5%	0.00
Imported Materials	-	0.84	-	10%	0.08	-	-
Others	15%	1.00	0.15	5%	0.05	5%	0.05
Total	100%	**-**	**0.86**	100%	**0.84**	100%	**0.75**

Source: JICA Study Team

4.4 Main Economic Analysis Components

4.4.1 Road Scenarios "Without" and "With" Project

For the calculation of economic value of the Study Road, two cases had to be prepared; one "with" and the other "without the road improvements."

"Without project" scenario

The reference situation, "without project" scenario, considers the continuation of the existing situation, whereby the normal traffic continues to use the existing earth road, maintained as such, including routine and periodic maintenance. Accordingly, it is assumed that maintenance would provide average roughness conditions of the International Roughness Index (IRI) during the dry season and the wet season.

For the "without" project case, traffic volumes would be the result of the current phase of the Project, which would provide an outlet for the normal traffic flow of goods and passengers in the Project road section.

"With project" scenario

Mainly due to software input constraints, the "with" project situation assumes that the existing road is surfaced during the construction period and that the routine and periodic maintenance would provide an improved average roughness of IRI during the analysis period of the road facility. Benefits related to generated and diverted traffic apply in this case, in addition to those of the normal traffic.

Following table shows possible cases of “with” and “without” to be compared for the Project evaluation.

Table 4.4.1 Alternative Cases for “With” and “Without”

Cases	Road Section			Border	Railway Section			Port
	Lichinga-Mandimba	Mandimba-Cuamba	Nampula-Cuamba	OSBP	Nacala-Cuamba-Entrelagos	Cuamba-Lichinga	Malawi	Nacala
Without Case	As it is	As it is	As it is	As it is	As it is	As it is	As it is	As it is
With Case (Scenario -1)	As it is	Intervention	Intervention	As it is	As it is	As it is	As it is	As it is
With Case (Scenario -2A)	Intervention	Intervention	Intervention	As it is	As it is	As it is	As it is	As it is
With Case (Scenario –2B)	Intervention	Intervention	Intervention	Intervention	As it is	As it is	As it is	As it is

Source: Study Team

In the “With Case (Scenario –2B)” above, however, the traffic conditions over the short road distance (approximately 6km) against total section length (154km) may affect very limited results for economic calculation. Therefore, this case will be incorporated into the “With Case (Scenario -2A).” Relevant cost to the construction of One Stop Border Posts (OSBP) is incorporated in the Project cost for Cuamba-Mandimba section.

For the analysis, careful attention will be paid to the period when the passability is disrupted by a highly deteriorated road condition (wet season). In this case, vehicles will find alternatives routes or use alternative paths along the existing road that facilitate the passage, resulting in higher transport costs due to change of travel distance, road roughness, and/or driving speeds.

According to the World Bank, on 15 separate occasions over the past 25 years Mozambique has been highly vulnerable to changes in rainfall patterns which have caused severe droughts and severe flooding, both of which have resulted in significant reductions in agricultural production. Additionally, distance to the road or access (or the lack thereof) has further been a disincentive to smallholder agricultural producers by contributing to the high cost of production and placing downward pressure on margins. Similarly, passability or the inability to pass through a section of the road due to a bridge being out, a washed out road during the rainy season, or vegetation encroachment during the dry season limits passage by up to approximately 160 days per year.

4.4.2 Comparison of Pavement Options

Another major concern regarding the economic analysis in this report is to identify the optimum paving method for the Project road through a comparison of the DBST option, Gravel option and Asphalt option. Technical advantages or disadvantages are studied in the previous chapter and in this chapter, comparative analysis from the viewpoint of national economy is conducted.

4.4.3 Economic Benefit

The economic road user costs to be considered in this Study are vehicle operating costs and passenger travel time costs which are the most significant economic costs in the economic appraisal of road improvements. In developing countries with low income levels, passenger travel time costs are a less important component of road user costs than vehicle operating costs.

All existing and future road users will benefit from the road improvements as journey times and vehicle operating costs will reduce. As between 60 to 80% of the traffic on the national roads consists of goods vehicles, transport operators will directly benefit the most. It is expected that these savings, accruing to the several hundred trucks using the road every day, will result in reductions in prices of the goods being transported as savings in fuel and other costs are passed on.

It is also expected that bus operations will become more efficient and that public transport provision will improve for persons living along the Nacala Corridor. This may increase opportunities for the population living in the road corridors to access health and educational facilities more easily. Road traffic accidents may decrease on improved road sections, although this may well be counter-balanced by increased accidents due to the opportunity to travel faster than before.

(1) VOC Saving Benefit

Vehicle operating costs are made up of the following cost components:

- Vehicle acquisition costs (for depreciation costs)
- Tire costs
- Gasoline and diesel costs
- Lubricant costs
- Crew costs
- Maintenance labor costs
- Spare parts (their consumption is analyzed within the model)
- Interest
- Overhead costs (these are sometimes omitted from economic costs on the grounds that their marginal cost is zero)

The price and cost information is supplemented by information on vehicle utilization and life. The consumption of spare parts is calculated internally by a sub-model within the HDM-4 vehicle operating cost module, and it is related directly to the vehicle acquisition cost, utilization and road character and condition. Also, non-motorized traffic is included in the traffic volume forecasted.

Oil cost has changed drastically according to the current world economic downturn. As the pricing date was assumed as October 2009, the Study Team adopted US$0.72, and US$0.62 per liter for the economic prices of gasoline and diesel oil respectively, based on the current taxation system in Mozambique. Table 4.4.2 shows the major inputs to the HDM-4 model related to the VOC estimation.

Table 4.4.2 Major Inputs to the HDM-4 Model

(Unit: US$)

Vehicle Type \ Cost Item	New Car Cost	Fuel Cost per litter	Lubricant Cost / litter	New Tire Cost	Mechanic Cost/hour	Crew Cost per hour	Passenger Time Value	Interest Rate
1. Medium Passenger Car	23,682	0.72	2.710	46	5.88	0.94	1.24	12%
2. Light Goods Vehicle	20,087	0.72	2.710	63	5.88	2.21	0.00	12%
3. Minibus and Light Bus	14,700	0.72	2.710	63	5.88	3.44	1.24	12%
4. Medium/Large Bus	66,382	0.62	2.710	120	5.88	3.94	1.24	12%
5. Medium Goods Vehicle	61,208	0.62	2.710	123	5.88	3.97	0.00	12%
6. Heavy Goods Vehicle	105,995	0.62	2.710	233	5.88	4.81	0.00	12%
7. Very Heavy Goods Vehicle	126,449	0.62	2.710	233	5.88	4.81	0.00	12%
8. Non-motorized (Bicycle)	85	0.00	0	10	0.00	0.30	0.00	12%

Source: Road User Cost (ANE, 2006), Detailed Design for Nampula-Cuamba Road Development (partly updated)

(2) Time Saving Benefit

The key elements are the difference in the treatment of work and non-work time and the distinction has to be based on information on passenger trip purpose. Information on passenger trip purpose has to be collected in roadside surveys where vehicles are stopped and drivers and passengers are interviewed.

In the past in Mozambique, such surveys have only been undertaken as part of the Study Teams' origin-destination surveys, and where such surveys have not been considered to be necessary no passenger trip purpose information has been collected. Whereas origin-destination information is only required where there are potential traffic diversion aspects to be considered, passenger trip purpose and vehicle occupancy information is always required. This has not been widely recognized and as a result there is a considerable shortage of passenger trip purpose information in Mozambique and many other developing countries.

The time saving benefit was calculated based on the time value of passengers, drivers and mechanics, which are input to the HDM-4 model. The time value per hour was estimated based on an average wage level statistics by the Ministry of Labor (DNPET 2008). Such time saving benefit accrued from the normal traffic, generated traffic, diverted traffic and non-motorized traffic was calculated by the HDM-4 model.

(3) Benefit from Diverted Traffic

Two types of traffic diversion will be estimated. One is the diverted traffic from railway, since there is a railway line along the Nacala Corridor; the other is from other roads, which is caused by the transport route change from the existing to the newly paved road mainly because of decreased travel time.

The diverted traffic from the railway with regard to passengers is estimated in the following steps.

- The Study Team conducted interview surveys with passengers regarding the railway service.
- Travel time and cost of the railway and bus services along the Project road are studied. Based on the travel cost per hour examination, the Study Team estimates the number of passengers diverting from railway to road.

- This number is converted to number of vehicles per day.

Based on a supplemental survey of trucking companies conducted by the Study Team, freight tariff and transport time are examined together with traffic volume of road and railway. Such diverted traffic from railway is incorporated as the normal traffic in HDM-4 computation.

Another diversion to be examined and estimated by the Study Team is the increase in traffic volume caused by “travel or transport route change”. The travel route change happens when new road opens and existing route takes long time to travel compared to the newly paved road because of its longer road length.

According to the Study, Beira Port is a major port for transporting cargoes to/from the sea for the northern area of Lilongwe of Malawi at the moment. After the Nacala Corridor is improved and transport time reduced, the Study Team considered that Nacala Port would become the major port for the area, and transport route would change to the Nacala Corridor, because transport time becomes shorter compared to the exiting route from Beira.

(4) Benefit from Generated Traffic

a. Agriculture and Agricultural Industries

The traffic projections of agricultural commodities assumed that production will increase at the same level as the population growth. This is because the capital/ labor ratio would remain the same (one man/ one hoe). New techniques could be made available such as the use of bicycles to increase productivity. However, if there is not better access to markets, there will be no incentive to implement these techniques for increasing production. In the “with” project case, on the contrary, it is extremely likely that the Project will provide incentives for additional agricultural output by increasing access to markets.

As Mozambique is largely an agriculture-based economy, the major indirect beneficiary of the road improvements will be farmers who will benefit with lower prices of inputs and better access to markets in northern and southern Mozambique and neighboring countries. Niassa, which suffers from very poor access to external markets, will benefit particularly from improvement to the N13 corridor.

b. Mineral Extraction Industry

There is potential for mineral extraction (including oil) in northern Mozambique. An improved national road network will contribute to the development of this industry through facilitating the delivery of inputs and outputs.

c. Tourism Industry

There is an existing tourism industry in Niassa based on its excellent natural reserves and exotic lake. Accessibility is so poor to this area that most tourists fly by airplane; but the improved national road access should provide the opportunity for cheaper road travel for tourists to access this area and enlarge the potential market. Cheaper inputs will also benefit these industries. In particular, the improvement of N13 to Niassa may provide the opportunity to stimulate tourism opportunities on Lake Malawi.

d. Forest Industry

The province of Niassa has forest reserves in Cuamba, Mandimba, Metarica, Nipepe and Marrupa Districts with a predominance of valuable species. These forests are presently not exploited for lack of transport. Forestry represents only 2% of provincial GDP. Forestry has the potential to grow rapidly once the existing road is upgraded. The exploitation of these lots should start as soon as the road becomes passable by railway or heavy trucks up to the port of Nacala. Traditionally, timber is hauled by trucks from the areas of exploitation to the sawmills. There are currently no sawmills in the area of influence, so the wood should be taken to Nacala for export as logs or raw timber.

e. Other Industries

Other products included in the basic consumption category are processed foods such as cooking oil, salt, sugar, powdered milk, beer, soft drinks, dry goods and construction materials that are brought in from outside the area of influence. The industrial sector barely exists in Niassa except for a small industrial park in Lichinga with small units for milling cereals, producing wooden furniture, pottery, and soap etc. that are supplied to the urban population and areas close to Lichinga. It is not expected that the construction of the proposed road will substantially develop the sector, as the goods can be brought in more cheaply with the road, thus negatively impacting local production.

4.4.4 Economic Costs

The cost to improve, maintain and operate the road was developed on a U.S. dollar per kilometer basis. Investment and maintenance cost data were obtained for alternative road improvements for both paved and unpaved sections. The road improvements are multiyear investments that were allocated over a time period of three years, and the road maintenance costs include routine and periodic maintenance costs over the year life of the Project for each type of road works performed. Source data for determining road improvement, maintenance and operating costs were obtained from the cost estimation conducted by the Team.

(1) Investment Cost

Detailed Project cost is calculated from the cost estimation in the previous chapter. The conversion of financial cost to economic cost is carried out by applying the different conversion factors to respective cost items. It is briefly explained that financial or market price contains several price disturbances such as tax or subsidies which distort the function of the price qualifying the real value of items. In order to measure the real loss of the value, i.e. economic cost, such distortion should be subtracted from the financial price of costs. Conversion factors calculated as above are applied in the HDM-4 computation.

The calculation of economic and financial costs for the different project alternatives is presented in Table 4.4.3. These include upgrading of the road from earth to seal and construction of bridges. The inclusion of these costs in the

Project alternatives in detail is presented in the previous chapter.

Table 4.4.3 Investment Cost for Pavement Comparison (Financial Cost)

Alternatives	Length	Construction Cost		Disbursement (Thous.US$)				Reinvestment Cost	Residual Value
	(km)	US$	US$/km	2010	2011	2012	2013	US$	%
DBTS Option	154	120,642,217	783,391	7,239	43,431	43,431	26,541	13,525,110	73%
Asphalt Option	154	197,375,501	1,281,659	11,843	71,055	71,055	43,423	73,317,281	73%
Gravel Option	154	54,186,886	351,863	3,251	19,507	19,507	11,921	-	-

Note: Tax (IVA) is excluded in the cost.
Source: Study Team

- Re-investment Cost

Re-investment cost was appropriated in 2029, when useful life (considered as 15 years) of the asphalt pavement and seals would expire in the case of the DBST and asphalt pavement option. The re-investment cost is summarized in Table 4.4.3.

- Residual value

The invested resources to the Project have economic value to the economy until the useful life expires. In this Project, useful life of the asphalt pavement and seals is assumed as 15 years. Analysis period of the Project is assumed as 20 years after its operation has started until 2033. Then the value of the re-investment remains for 11 years, or 73 % of the re-investment cost in 2029, when the analysis period ends. As a result, the residual value equivalent percentage of the economic investment cost will be estimated at the last year of the analysis as a negative cost.

(2) Operation & Maintenance Cost

The operation and maintenance cost was converted into economic cost the same as the investment cost. Table 3.4.4 shows the annual cost for the DBST, Asphalt, Gravel and Earth (without project case) roads, respectively in terms of economic cost. Regarding the gravel option, the maintenance and operation cost was assumed as an average of the DBST and earth costs.

In HDM-4 calculation, the operation and maintenance cost is indicated in the "Special cost" of Road Agency Cost, both the routine and periodic maintenance cost combined on the annual basis.

Table 4.4.4 Annual and Periodic Operation and Maintenance Cost

(DBST/ Asphalt/ Gravel/ Earth Option: Financial/Economic Cost)

Financial/Economic	Financial Cost				Economic Cost			
Type of Maintenance	DBST	Asphalt	Gravel	Earth	DBST	Asphalt	Gravel	Earth
Distance in km	154.0	154.0	154.0	154.0	154.0	154.0	154.0	154.0
Annual Routine Maintenance/km	$1,344	$1,344	$1,765	$2,186	$1,007	$1,007	$1,323	$1,638
Annual Routine Maintenance	$207,028	$207,028	$271,865	$336,703	$155,136	$155,136	$203,722	$252,308
Periodic Maintenance/km	$6,844	$6,844	$7,088	$7,333	$5,128	$5,128	$5,312	$5,495
Periodic Maintenance	$1,053,961	$1,053,961	$1,091,602	$1,129,243	$789,785	$789,785	$817,992	$846,199
Interval of Periodic (Years)	5	10	4	4	5	10	4	4

Source: "RSS" and Study Team

4.5 Result of Analysis

4.5.1 Economic Ratio for Alternatives

Output data worked out as a result of HDM-4 analysis for the Project are tabulated in Table 4.5.1.

Table 4.5.1 Result of Economic Analysis for Pavement Option

Design Option for comparison	Economic Ratio		
Pavement Type	NPV (US$ Mil.)	B/C	EIRR
DBST	63.9	1.7	19.2%
Asphalt	-1.1	1.0	11.9%
Gravel	-43.8	-0.2	-30.0%

Table 4.5.2 Result of Economic Analysis for Scenarios

Scenario		Design Option	Economic Ratio		
		Pavement Type	NPV (US$ Mil.)	B/C	EIRR
Scenario 1	Lichinga-Mandimba not improved	DBST	63.2	1.7	19.3%
Scenario 2	Lichinga-Mandimba improved	DBST	65.6	1.8	19.5%

Note: In case the traffic volume of non-motorized traffic (bicycles) is not counted in Scenario 2, EIRR is reduced to 17.5%.
Source: Study Team

From the results shown in Table 4.5.1 above, the gravel option exhibited lower values in the B/C, Net Present Value and EIRR. Rather, the gravel option is not suitable for such higher volume of AADT forecasted. DBST option with Lichinga-Mandimba intervention showed satisfactory values among all.

The EIRR hurdle rate used to determine if a road project is economically feasible is 12 percent in general, over the estimated twenty-year period after intervention. The decision rule applied in conducting the economic analysis was to recommend to ANE the road project alternative that equaled or exceeded the 12 percent hurdle rate. The Study Team considered no other factors that influence their investment decision, based on local conditions and information developed during this Study, as an alternative to strict adherence to the EIRR, NPV and B/C.

In Table 4.5.2 above, the project cost for Scenario 1 and 2 is revised after more detailed calculation for the sub-base of the pavement. The project of DBST option with Lichinga-Mandimba intervention scores best with a normal level as the upgrade-to-paved intervention and its economic viability is acceptable, with an EIRR of over 12% in the selected alternative. The generated traffic seemed to contribute much more than the diverted traffic to the EIRR. Based on this result, the Project is evaluated as one of the prioritized projects to be implemented in the nation. Of particular importance is this primary road and bringing it to an all-weather passable condition.

4.5.2 Other Benefits for the Regional Road Network of the Comprehensive Approach

In developed countries including Japan, the comprehensive method for economic analysis is applied focusing on the network benefit/loss including the targeted project section. Economic figures are derived from the difference of overall travel distance shortened by approximately 106km in the international corridor, travel time and VOC, in case the whole network in the Study area including Beira Corridor is considered. The result of calculation for the network improves the B/C value of the Project intervention eventually.

Table 4.5.3 Comprehensive Economic Effects on the Road Network

Target for Economic Benefit/Loss	NPV @12% (Mil. US$)		
	Benefit	Cost	B/C
Project Road (DBST with Lichinga-Mandimba intervention)	146.0	80.4	1.8
Additional benefits in the network	65.2	-	-
Comprehensive benefit/loss	211.2	80.4	2.6

Source: Study Team

4.5.3 Sensitivity Analysis of Economic Analysis Result

In order to confirm the above favorite result against future uncertainties, sensitivity analysis is conducted for the best alternative case DBST option with Lichinga-Mandimba intervention that scores the highest EIRR. This is firstly done by changing the value of benefit and cost by -20% and +20% respectively and both combined as the worst case. When the EIRR is less than the discount rate of 12%, the project is thought to hold a risky aspect.

These are critical factors to watch, though there is more or less same sensitivity to drop in traffic levels and/or increase in investment costs. These situations are most unlikely as traffic growth rate on the network has been an average of 7.9% per annum in Niassa Province between 1995 and 2004. In the analysis, investment costs are based on the detailed engineering design for Nampula-Cuamba Road Improvement, the current unit rates of recently let contracts and the estimated cost of the evaluated lowest bids. And above those, a physical contingency provision of 10.0% has been taken into account, assuming such increase in capital costs unlikely.

As shown in Table 4.5.4, the feasibility of the project is secured even in the worst case.

Table 4.5.4 Result of Sensitivity Analysis (EIRR)

Case	Assumptions	EIRR
Base	Upgrade to paved road with DBST with Lichinga-Mandinba Intervention	19.5%
1	Decrease in traffic volume of -20%	16.6%
2	Increase in investment costs of +20%	16.9%
3	Both combined of above as the worst case	14.3%

Source: Study Team

Further, effects of oil price changes against the construction cost, which is one of the matters of most concern, were also examined. As a result, the oil price raise by 50% affects 5% increase in the total construction cost. The magnitude was the same in case of the oil price drop. The changes are covered sufficiently within the sensitivity analysis range above.

Table 4.5.5 Elasticity of Oil Price Change to Construction Cost

Price	Increase	Decrease
Oil Price	50%	50%
Construction Cost	105%	95%

4.5.4 Switch Values for Investment Cost and Traffic

In addition to the sensitivity tests above, “switch values” for the cost and benefit which would result in an EIRR of 12 percent threshold opportunity cost of capital for Mozambique have been identified as part of the economic viability analysis.

Switch values on the cost and benefit were calculated for the DBST option with Lichinga-Mandimba intervention as the base case. It also shows satisfactory values as shown below.

Table 4.5.6 Switch Values for DBST with Lichinga-Mandimba Intervention

	Base Case	**Case that yields NPV=0**		
NPV @12% (Mil. S$)	**Value**	**Value**	**Factor**	**Change**
Cost	80.4	146.0	1.82	81.6%
Benefit	146.0	80.4	0.45	-44.9%

In the table above, more than 80% increase in construction costs indicated that the Project economic viability would be threatened, while on the other hand, if the user cost savings drop by 45%, the Project viability will be affected. These situations are most unlikely as discussed in the sensitivity analysis.

4.5.5 Comparison with Other Historical Economic Analysis used by RED for the Project

In the Road Sector Strategy (RSS) prepared in December 2005, N13 Cuamba - Lichinga was categorized as a national roads project under funding. Subsequently, the Millennium Challenge Corporation (MCC) conducted the field survey in the northern area to prepare the Mozambique Road Sector Program Development (Interim Report) on 23 October 2006. The Study is a part of larger program proposed by the Government of Mozambique (GoM), in coordination with the Millennium Challenge Account – Mozambique (MCA-MZ), to MCC. The program’s objectives are to promote economic growth and reduce the poverty level in Mozambique’s four northern provinces: Cabo Delgado, Niassa, Nampula, and Zambezia.

Calculated rates of return were well below the MCC economic feasibility threshold rate of 8.76% and the two road sections were accordingly not recommended for inclusion in MCC's list of roads for detailed feasibility study and potential implementation.

Above calculation was executed using another alternative model "Roads Economic Decision Model (RED)," that is a simplified model developed by the World Bank for use in the economic appraisal of lower traffic volume road projects. Under the same assumptions calculated by RED for the limited period of 20 years including construction period and operation period (17 years instead of 20 years in this Study), the revised IRR for DBST option with Lichinga-Mandimba intervention is sufficiently higher than the economic feasibility threshold rate.

Table 4.5.7 Comparison with Historical RED Analysis

Assumption	Period	JICA	MCC
Evaluation tool	-	HDM-4	RED
Unit construction cost (Economic)	-	US$0.64mil/km	US$0.31mil/km
Traffic forecast	-	Normal, Diverted, Generated	Normal
International Roughness Index (IRI)	-	12	14
Conversion Factor (CF)	-	0.84	1.0
Discount Rate	-	12.0%	8.76%
EIRR	24 years	19.5%	-
	20 years	17.5%	7.6%

4.5.6. New Railway Line from Moatize Mines to Nacala Port

It is recently reported that Mozambique's government has announced that it has secured $500m (£313m) to build a new railway line. The new line will link the coal-rich northern Moatize mines to Nacala Port by 2015.

Subject to limited information, the forecasted traffic volume of the diversion from the railway in this Study might be affected by this plan to some extent. However, the competing volume for diversion to the Project Road will be likely assumed within the range of sensitivity analysis conducted above (-20% of total volume) or even may not reach the switching value estimated.

4.6 Financial Analysis for the Project

In the "Programa Integrado do Sector de Estradas (PRISE 2009-2011)," a sector-wide approach is established for the road sector that incorporates a coherent Mozambican owned and led roads program in a comprehensive and coordinated manner. Under PRISE 2009-2011, sector planning, finance, implementation, monitoring and evaluation are fully integrated.

The program was developed to be in line with the priorities and objectives of the Government of Mozambique Road Sector Policy, PARPA, Medium Term Expenditure Framework (MTEF), and Road Sector Strategy (RSS). PRISE will enable the GoM to guide the road sector and monitor its performance to ensure that it supports the government's main objectives of poverty reduction and balanced economic development. It will also facilitate managing sector expenditures and intersect oral balance by bringing all activities on-budget.

Under PRISE, all funding for the road sector supports a single sector policy and expenditure programme under government leadership while adopting common approaches across the sector, eventually progressing towards full reliance on GoM procedures to disburse and account for all funds.

The sector-wide approach under PRISE will foster stronger country ownership and leadership of the road sector. It will also facilitate coordinated and open policy dialogue for the entire sector, involving the key GoM agents (MOPH, ANE, Road Fund, and various stakeholders) and the sector’s financial partners, observing the government policy of decentralization.

Because PRISE entails a comprehensive planning framework that brings all sector activities under one umbrella, it will lead to a more rational resource allocation, both inter-sectional (the national budget and expenditure frameworks) and within the road sector, based on applications of GoM articulated priorities ranked by Multi Criteria Analysis (MCA.) The results of the integrated planning approach are elaborated in the Road Sector Strategy, the five-year plan, and the rolling three-year PRISE Implementation Plan. Annual contract programs are then established between the Government and the implementing agencies (ANE and the Road Fund).

Among international donors, it appears now that the implementation of captioned project for Cuamba-Mandimba in particular will be included under Enhanced Private Sector Assistance (EPSA) funding, probably beginning in 2011 and extending over three years.

EPSA for Africa was launched by the government of Japan in 2005 as a comprehensive initiative to support African private sector development. It sets forth that Japan International Cooperation Agency (JICA) will provide ODA loans, in cooperation with African Development Bank (AfDB) which is a regional development bank, totaling up to USD$1 billion over the period of five years. On the ground of "the Guidelines for Implementation" to promote co-financing with the AfDB, providing financial assistance for African member countries with medium and long-term loans, equity participation, guarantee, and technical assistance, JICA has cooperative ties which include co-financing social and economic infrastructure development projects in Africa.

The Nacala Road Corridor project to be implemented under EPSA program, comprises 1,033km of road works and two one-stop border posts between Mozambique and Malawi and the other between Malawi and Zambia. Phase one comprises 361 km or 35% of the road works in Mozambique and Malawi. Phase II comprises 360 km or 34.9% of the road works in Zambia, while Phase III comprises 312 km or 30.1% of the road works for the section Cuamba-Mandimba in Mozambique and Malawi and two one-stop border posts between Mozambique and Malawi and Malawi and Zambia. All the phases include design review, pre-contract services and supervision of the civil works, road safety, HIV/AIDS prevention and awareness, compensation and resettlement and audit.

The following figure and tables are the relevant budget allocation by the government and ANE for the road sector and particular projects to be implemented.

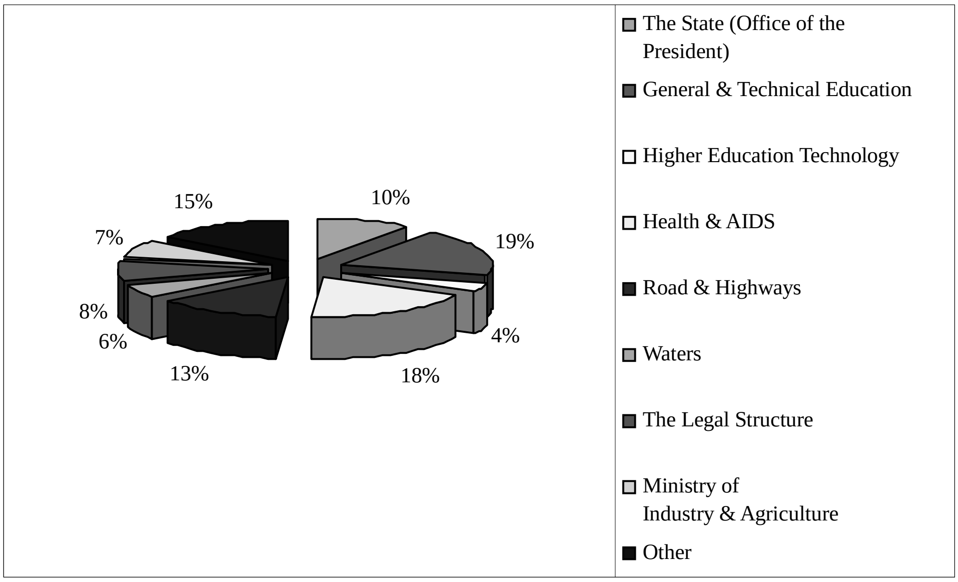


Figure 4.6.1 Government Budget Allocation (2005-2010)
Source: Ministry of Transport and Communications (MTC)

Table 4.6.1 Budget Allocation for Road and Bridge Management Plan (PRISE 2009 - 2011)

(mil. USD)

Designation	2009	2010	2011
Administrative and Support Expense	**21.1**	**21.8**	**22.4**
Technical Capacity and Sector Study	**6.2**	**5.2**	**6.6**
Technical Assistance	2.3	3	2.7
Consulting Service and Study	2.9	1.2	2.9
Logistics	0.6	0.6	0.6
Private Sector Support	0.4	0.4	0.4
Road and Bridge Maintenance	112.4	142.7	155.7
Urban Road Maintenance	7.5	8.1	8.7
District Road Maintenance	5	5.7	6.3
Maintenance Plan	8.3	8.5	8.8
Emergency Works	8.6	9.2	9.9
Maintenance of Unpaved Roads	39.4	43.4	47.7
Maintenance of Paved Roads	43.6	67.9	74.3
Routine Maintenance of Paved Roads	16.3	16.8	17.3
Periodic Maintenance of Paved Roads	26.1	50	56
Engineering Service: Preparation of New Projects	1.2	1.1	1
Construction and Rehabilitation of Bridges	72.3	46.3	46
Construction of Bridges	53.5	26	24.7
Rehabilitation of Bridges	18.8	19.7	20.7
Preparation of Bridge Projects		0.6	0.6
Rehabilitation and Upgrading of Roads	147.9	185	205.4
Rehabilitation and Upgrading of Regional Roads	24.6	38	54
Rehabilitation and Upgrading of National Roads	121.7	144	148.3
Preparation of Road Projects	1.6	3	3.1
Road Safety	4.1	7	7.4
Road Infrastructure Safety	1.6	2.5	2.6
Cargo Control	2.5	4.5	4.8
Grand Total	**364**	**408.1**	**443.5**

Source: ANE

Table 4.6.2 PRISE 2009 - 2011: Projects for Upgrading and Rehabilitation

Code	Name of Section	Km	Province	Intervention	Est. Value (m USD)	Period		Finance Resource		
						From	To	FS	DD	Const.
	Projects Financed									
52104	N7 Vanduzi - Changara	154	Tete	Rehab.	$46.00	2007	2009	GoM/ADB	GoM/ADB	GoM/ADB
52117	N1 Namacurra - Nampevo (Lote 1)	152	Zambezia	Upgrade	$21.20	2005	2009	EU	EU	EU
52117	N1 Nampevo - Alto Molocue (Lote 2)	117	Zambezia	Upgrade	$7.10	2005	2009	EU	EU	EU
522012	N14 Lote B Marrupa - Ruaca	87	Niassa	Upgrade	$40.70	2009	2011	Asdi	Asdi	Asdi
522013	N14 Lote C Lichinga - Litunde	67	Niassa	Upgrade	$31.40	2009	2011	ADB/JICA	ADB/JICA	ADB/JICA
522011	N14 Lote A Montepuez - Ruaca	136	C Delgado	Upgrade	$63.60	2010	2011	ADB/JICA	ADB/JICA	ADB/JICA
52101	N1 Maputo (Jardim - Benfica)	7	Maputo	Rehab.	$22.90	2009	2011	IDA	IDA	IDA
52102	N1 Xai - Xai - Chissibuca	96	Gaza	Rehab.	$52.00	2009	2011	IDA	IDA	IDA
52103	N1 Massinga - Nhachengue	59	Inhambane	Rehab.	$39.70	2009	2011	IDA	IDA	GOP
52205	N11 Mocuba - Milange	171	Zambezia	Upgrade	$91.10	2009	2012	EU	EU	EU
51106	R601 Estima- Magoe	130	Tete	Upgrade	$40.00	2008	2011		GoM	GoM
52204	N103 Gurue - Magige	35	Zambezia	Upgrade	$12.00	2009	2010	IDB	IDB	IDB
51105	R445 Macarretane - Massingir	106	Gaza	Rehab.	$20.00	2009	2011	OPEC	OPEC	OPEC
52105	N1 Rio Ligonha - Nampula	102	Nampula	Rehab.	$38.00	2010	2012	MCC	MCC	MCC
52106	N1 Namalo - Namapa (Rio Lurio	148	Nampula	Rehab.	$50.00	2010	2012	MCC	MCC	MCC
52108	N1 Rio Lurio - Matoro	74	C Delgado	Rehab.	$24.00	2010	2012	MCC	MCC	MCC
52109	N1 Chimuara - Nicoadala	167	Zambezia	Rehab.	$60.00	2010	2012	MCC	MCC	MCC
52203	N13 Nampula - Cuamba	341	Niassa/Nampula	Upgrade	$2,311.80	2010	2012	JICA	JICA	ADB/JICA
	Sub-total	2.149			$891.50					
	Projects Committed									
52202	N13 Cuamba - Mandimba	160	Niassa	Upgrade	$96.00	2011	2014	JICA		
52202	N13 Mandimba - Lichinga	149	Niassa	Upgrade	$89.00	2012	2015	JICA		
	Sub-total	309			$185.00					
	Prioritized Projects to be Financed									
TBA	N103 R657 Magige - Cuamba	85	Zambezia	Upgrade	$51.00	2012	2014			
52208	R1251. N381 Negomane - Mueda	187	C Delgado	Upgrade	$112.00	2011	2013	GoM	GoM	
TBA	N104. R683. R680: Nampula - Nameti - Moma	181	Nampula	Upgrade	$72.00	2011	2013	KCI	EXIM	EXIM
TBA	N200. R403. Maputo - Catembe - Ponta do Ouro	182	Maputo	Upgrade	$200.00	2010	2012	PPP	PPP	PPP
52110	N6 Beira - Inchope	128	Manica	Rehab.	$21.70	2011	2014	EU	EU	
52110	N6 Inchope - Machipanda	153	Manica	Rehab.	$26.00	2013	2016	EU	EU	
	Sub-total	916			$482.70					
	Additional Projects to be Financed									
TBA	N1: Pambara - Rio Save	122	Inhambane	Rehab.	$61.00	2011	2012	IDA	IDA	
TBA	N322: Cambulatsitsi - Mutara - Chire	252	Tete	Upgrade	$150.90	2014	2017	ADB	ADB	
52107	N380: Macomia - Oasse	102	C Delgado	Rehab.	$40.80	2010	2012	GoM	GoM	
TBA	N260: Espungabera - Sussundenga - Chimoio	235	Manica	Rehab.	$23.50	2011	2013			
TBA	N324: R Ligonha - Boila	128	Nampula	Rehab.	$12.80	2013	2014			
TBA	N360: Cuamba - Marrupa	236	Niassa	Rehab.	$23.60	2013	2015			
TBA	N221: Macarretane - Chicualacuala	321	Gaza	Rehab.	$32.10	2012	2015			
TBA	N222: Pafuri - Mapinhanhe	476	Gaza/I'bane	Rehab.	$47.60	2012	2016			
TBA	R689: Monapo - Liupo - Angoche	150	Nampula	Rehab.	$15.00	2013	2015			
TBA	R650. R658. Milange- Molubo - Magige	164	Zambezia	Rehab.	$16.40	2012	2013			
TBA	N282. Dondo - Inhaminga	188	Sofala	Upgrade	$75.20	2013	2016			
TBA	N320. Quelimane - Chinde	93	Zambezia	Rehab.	$18.60	2013	2015			
	Sub-total	2,467			$517.50					
	TOTAL	6.841			$2,968.20					

Source: ANE

In the program above cited, total unpaved road maintenance is budgeted at $130.5 million over three years, an average of about $4 million per province. Unpaved road maintenance is fully funded, all of it through the Road Fund collected from fuel levy exclusively. The unpaved roads maintenance budget is divided into the routine, periodic and passability maintenance; however, provincial engineers are to follow the unpaved roads maintenance strategy which prioritizes passability over riding quality. Following is the latest unpaved road maintenance work contracted for outsourcing in Niassa Province.

Table 4.6.3 Maintenance of Unpaved roads in Niassa Province

Route No.	Section	Distance (Km)	Fund	Period	Amount (Thous.Mt)
R1207	Lumbu-Chala	43	Road Fund	Jan 09-Dec 10	1,924/2,039
R1212	Mandinba-Amaramiza	45	Road Fund	Jan 09-Dec 10	4,272
N13	Cuamba-Missisi	75	Road Fund	Jan 09-Dec 10	9,319
N13	Missisi-Ngauma	75	Road Fund	Jan 09-Dec 10	4,089
R730	Congerende-Mitange	10	Road Fund	Jan 09-Dec 10	2,743

Source: ANE signboards

4.7 Conclusions and Recommendations

(1) Economic Viability of the Project

According to HDM-4 calculation conducted as above, the DBST option with Lichinga-Mandimba intervention is the most feasible among several alternatives.

The Project scores an average level as an upgrade-to-paved intervention and its economic viability is acceptable, with an EIRR of over 12% for the optimum intervention among alternatives. Based on this result, the Project is evaluated as one of the prioritized projects to be implemented in the nation. The particular importance of this primary road and of bringing it to all-weather passable condition is well established.

The Study Team concludes that the road upgrading Project is economically feasible in terms of national economy of Mozambique.

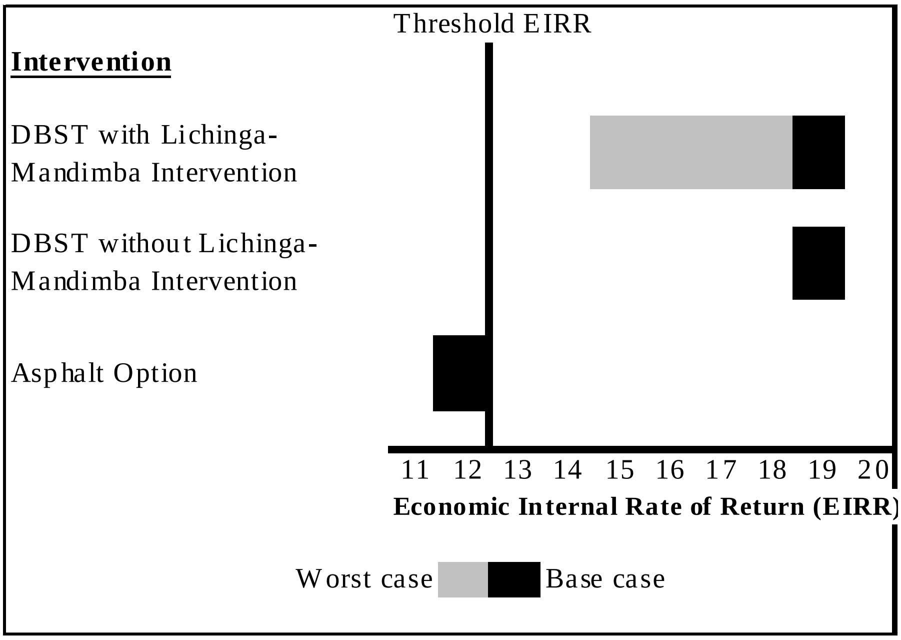


Figure 4.7.1 Summary of EIRR
Source: Study Team

(2) Financial source for the implementation of the Project

In PRISE 2009-2011, the Project cost for implementation is estimated as US$96 million for Cuamba-Mandimba and US$89million for Mandimba-Lichinga. However, this Study proposes that additional project cost will be required.

Therefore, further discussions with the donors who committed the funding for implementation, will be expected for the subsequent detailed design works and construction works based on the cost estimation in this Study.

(3) Post-Construction Management and Maintenance

ANE, through provincial delegation, ensures the management and maintenance of all classified roads including the road sections proposed under this report. The Road Fund (FE) is responsible for financing these activities. The improvement of the maintenance performance is critical for post construction sustainability.

Since maintenance will largely be implemented by the provincial delegation of ANE, the establishment of functional offices will be crucial for the sustainability of the investments. Therefore, it is important to support ANE's re-organization and capacity strengthening especially at provincial level. The funding and implementation of technical assistance, on-the-job training, infrastructure and logistical support activities will be effective measures to ensure sustainability.

Attachments to this Chapter

1. HDM Input for the Existing Road Condition (Cuamba-Mandimba)
2. HDM Input for Vehicle Characteristics
3. HDM Output for Economic Indicators of Alternatives

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Road Sections - Section per Page

Study Name: **CUAMBA-MANDIMBA**
Run Date: **30-10-2009**

CM / Cuamba-Mandimba

Definition

Section name:	Cuamba-Mandimba	Climate zone:	Cuamba	Shoulder width:	0.00 m
Section ID:	CM	Road class:	Primary or Trunk	Number of lanes:	2
Link name:	LT1	Surface class:	Unsealed	Motorised AADT:	101
Link ID:	LT1	Pavement type:	Gravel	NM AADT:	811
Speed flow type:	Two Lane Standard	Length:	154.00 m	AADT year:	2009
Traffic flow pattern:	Inter-urban	Cway width:	6.00 m	Flow direction:	Two-way

Geometry

Rise + fall:	10 m/km	Speed limit:	40 km/h
Avg horiz curvature:	22 deg/km	Altitude:	600 m

Pavement

Surface material:	Lateritic gravel	Compaction method:	Mechanical
Subgrade material:	Clays (inorganic) of medium plasticity (CI)	Last gravel year:	2008

Condition

Condition year:	2008	Gravel thickness:	300 mm	IRI:	12.00 m/km

Speed related

Num rises + falls:	5 no./km	XNMT:	1.00	XMT:	1.00
Superelevation:	3.00 %	XFRI:	1.00	Speed limit enforcement:	1.10
Sigma adral:	0.10 m/s2				

Surface Material Gradation

Max particle size:	21.90 mm	% passing 2.00mm sieve:	51.10 %	% passing 0.075mm sieve:	25.50 %
Plasticity index:	10.10 %	% passing 0.425mm sieve:	77.00 %		

Subgrade Material Gradation

Max particle size:	8.00 mm	% passing 2.00mm sieve:	83.50 %	% passing 0.075mm sieve:	59.00 %
Plasticity index:	18.80 %	% passing 0.425mm sieve:	77.00 %		

Shoulders and NMT Lanes

Num shoulders:	2	Num NMT lanes:	0	NMT lane surface type :	Bituminous
Separate NMT lanes:	No				

Roughness Model Calibration

Derivation:	Computed/derived	Surface minimum:	2.77 m/km	Subgrade minimum:	2.17 m/km
Surface maximum:	21.67 m/km	Subgrade maximum:	18.46 m/km		

Material Loss Calibration

Surface loss factor:	1.00	Subgrade loss factor:	1.00	Subgrade traffic induced:	1.00
Surface traffic induced:	1.00				

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Vehicle Fleet - Economic

Study Name: **CUAMBA-MANDIMBA**
Run Date: **30-10-2009**
Currency: **To be completed**

Motorised Vehicle Types:

Name	Base Type	New Vehicle	Replace Tyre	Fuel (per litre)	Lubr. Oil (per litre)	Maint Labour (per hr)	Crew Wages (per hr)	Annual Overhead	Annual Interest (%)	Passenger Work Time (per hr)	Passenger Non-Work (per hr)	Cargo Holding (per hr)
Medium Bus	Medium Bus	66,382	120	0.62	2.71	5.88	3.94	0	12.00	1.24	0.00	0.00
Medium Truck	Medium Truck	61,208	123	0.62	2.71	5.88	3.97	0	12.00	0.00	0.00	0.10
Car	Medium Car	23,682	46	0.72	2.71	5.88	0.94	0	12.00	1.24	0.00	0.00
Small Bus	Mini Bus	14,700	63	0.72	2.71	5.88	3.44	0	12.00	1.24	0.00	0.00
Articulated Truck	Articulated Truck	126,449	233	0.62	2.71	5.88	4.81	0	12.00	0.00	0.00	0.10
Heavy truck	Heavy Truck	105,995	233	0.62	2.71	5.88	4.81	0	12.00	0.00	0.00	0.10
Small Truck	Light Truck	20,087	63	0.62	2.71	5.88	2.21	0	12.00	0.00	0.00	0.10

Non-Motorised Vehicle Types:

Name	Base Type	Purchase Cost	Crew Wages (per hr)	Passenger Time (per hr)	Cargo Holding (per hr)	Energy Used (per MJ)	Annual Interest (%)
Jitensha	Bicycle	61	0.30	0.00	0.00	0.00	12.00

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HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Indicators Summary

Study Name: **CUAMBA-MANDIMBA**
Run Date: **30-10-2009**
Currency: **US Dollar (millions)**
Discount Rate: **12.00%.**

Alternative	Present Value of Total Agency Costs (RAC)	Present Value of Agency Capital Costs (CAP)	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B+E-C)	NPV/Cost Ratio (NPV/RAC)	NPV/Cost Ratio (NPV/CAP)	Internal Rate of Return (IRR)
Without Project	4.044	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
With Project : DBST(revised)	84.440	82.775	80.396	145.948	0.000	65.552	0.776	0.792	19.5 (1)
With Project: Asphalt	142.040	140.796	137.996	136.866	0.000	-1.130	-0.008	-0.008	11.9 (1)
With Project: Gravel	37.607	37.607	33.563	-10.277	0.000	-43.840	-1.166	-1.166	-30.0 (1)
With Project: DBST w/o L-M	84.440	82.775	80.396	143.633	0.000	63.237	0.749	0.764	19.3 (1)
With Project: DBST	86.091	84.427	82.047	145.949	0.000	63.902	0.742	0.757	19.2 (1)

Figure in brackets is number of IRR solutions in range -90 to +900

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