CHAPTER 9

FUTURE TRAFFIC DEMAND

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9.1 GENERAL METHODOLOGY

The primary tool used for forecasting traffic in this study was the JICA STRADA software. This is a traffic and transit assignment model, with a large number of supporting modules for matrix development and manipulation, network editing and reporting.

The basic approach adopted was to develop origin-destination tables from traffic data gained in the surveys, and simulate the highway network using JICA STRADA. A validated base year (2000) model was created in order to test the effects of changes to both the scale and pattern of trips in the future, and proposals to improve the highway network to accommodate these. Future year models the Study Teamre developed for the years 2020 and 2010.

There are four main data sources used for developing traffic forecasts as below:

- Highway network data – derived from observations and formal surveys,
- Traffic data – derived from the traffic surveys,
- Car Ownership Data – from local and national sources, and
- GRDP Estimates – from national and international sources.

In addition, population and employment data as described in Chapter 8 were also used in the development of traffic forecasts as shown in the schematic flow chart in Figure 9.2.1.

9.2 NETWORK MODEL

The highway network model was constructed using the Network Editor module of JICA STRADA. The base year was taken as the year 2000. The base year model contains 185 nodes and 272 links and is shown as Figure 9.2.2. There are 48 traffic zones of which 32 are internal to the City of Maputo, 8 cover Machava and Matola, and 8 are external to the study area. Catembe is counted as an external zone. Internal zones are shown as Figure 9.2.3. Matola was included so that additional road connections betthe Study Teamen Maputo and Matola could be evaluated in the future. The network in Matola is removed for evaluation purposes.

Each link was described in terms of its maximum speed and capacity and assigned a speed-flow curve to simulate the effect of increasing traffic on speed on each link. Speeds and capacities were determined from field surveys of conditions on the network.

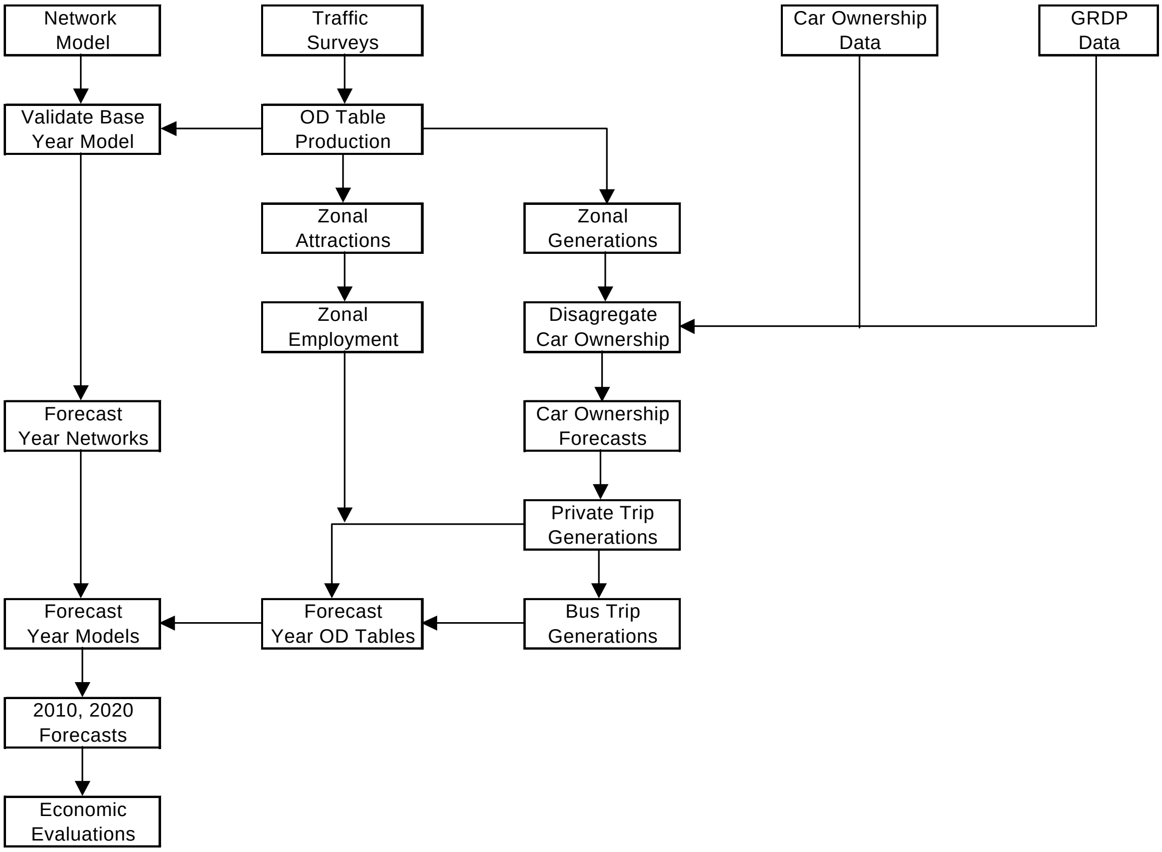


Figure 9.2.1 Traffic Forecasting Overview

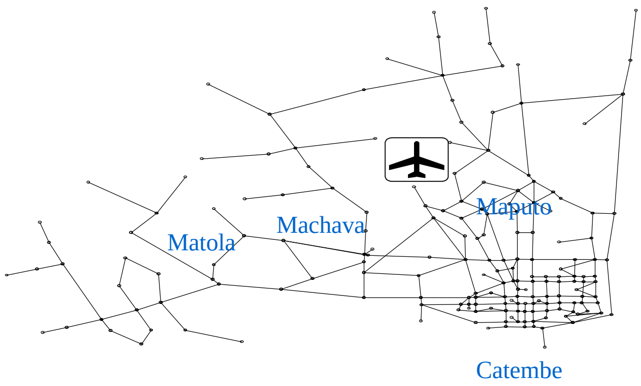
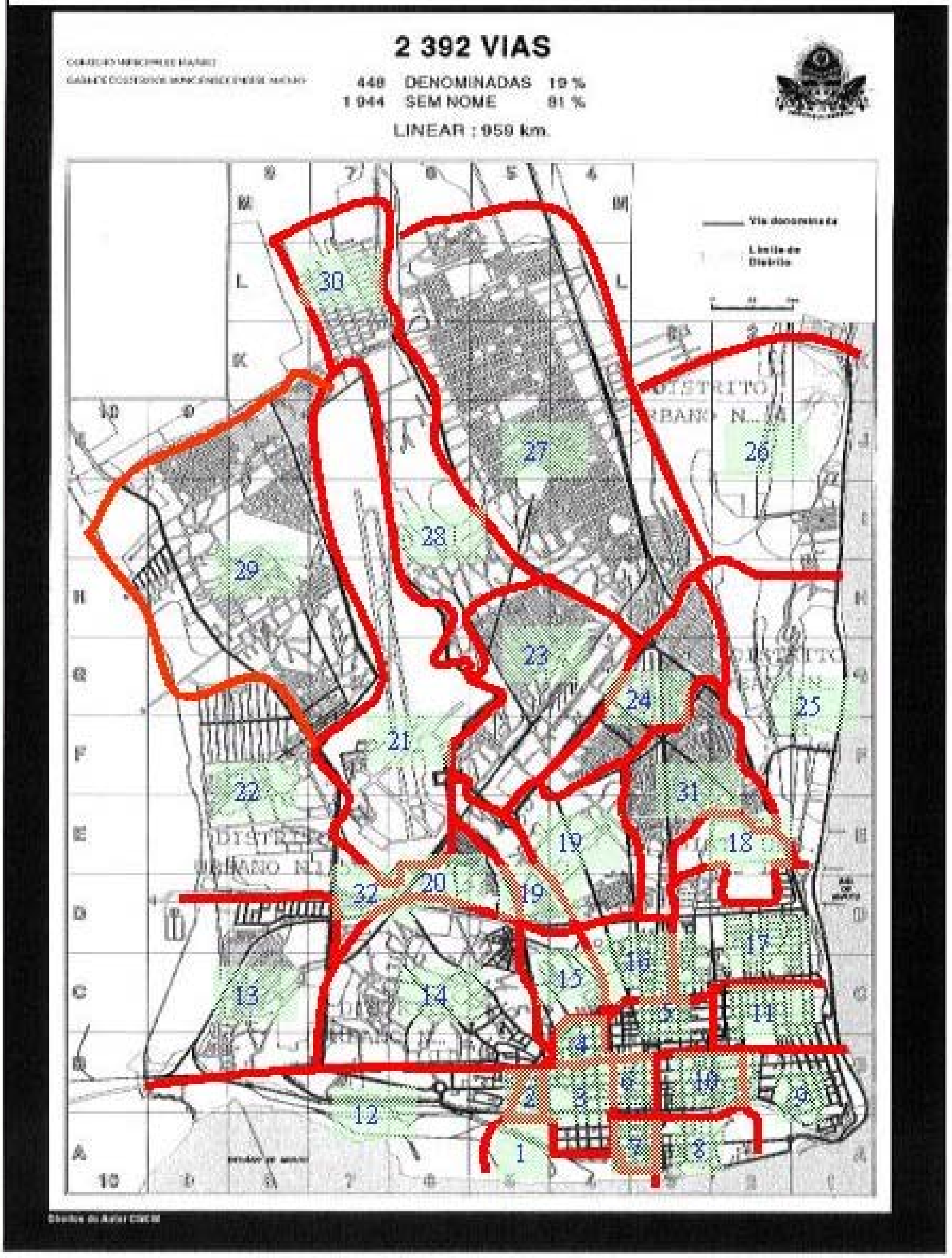


Figure 9.2.2 Base Year Network

Figure 9.2.3 Traffic Zones



9.3 ORIGIN DESTINATION TABLES

The Origin-Destination (OD) surveys were coded into the 48 traffic zones of the model and then expanded using the factors listed in Table7.1.5. Totals for each of the 2,304 cells input to an O-D tables, separately for cars and goods vehicles. Intra-zonal trips for external zones were then removed, as these should not have been recorded at the survey locations. A separate matrix of bus trips was prepared using the results of the bus occupancy surveys.

9.4 CAR OWNERSHIP

Car ownership growth in Maputo is shown in Figures 9.4.1 and 9.4.2. The total number of cars in Maputo grew by 65% in the period 1990 to 1998. However, the population of Maputo grew at the same time, so that the rate of car ownership, per head of population increased by 56% in the same period.

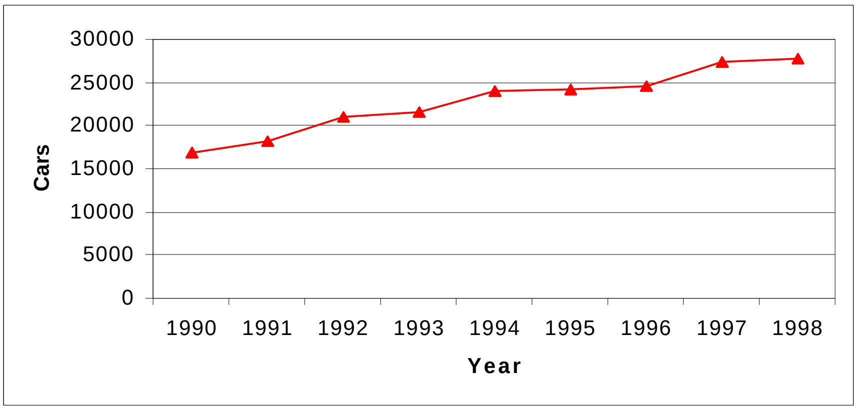


Figure 9.4.1 Cars Owned in Maputo, 1990 to 1998

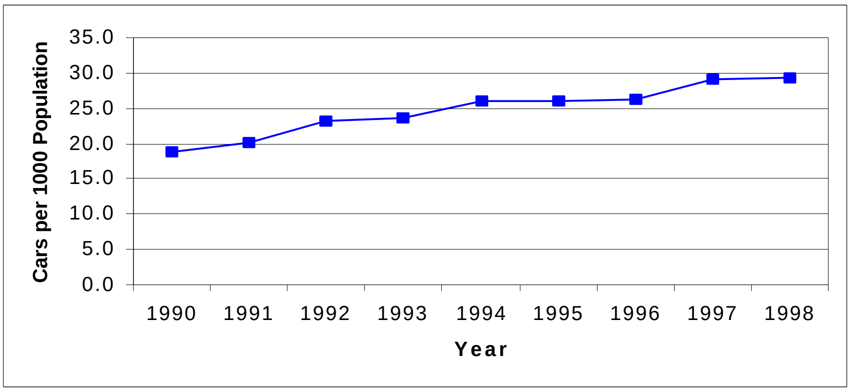


Figure 9.4.2 Car Ownership per 1000 Population in Maputo, 1990 to 1998

9.5 CAR OWNERSHIP FORECASTING METHODOLOGY

It is widely observed that individual car ownership is strongly linked to personal or household income. At city or national level it is reasonable to take Gross Domestic Product (GDP) or Gross Regional Domestic Product (GRDP) as an indicator of average incomes in a country or region. In order to estimate the effect that increasing GRDP in Maputo will have on car ownership the Study Team have taken data from a number of developing and developed countries. These data are shown in Table 9.5.1

Table 9.5.1 GRDP and Car Ownership, Selected Cities and Countries

Area	GRDP/Capita (US$)	Cars owned per 1000 people
Angola	660	18
Zambia	410	17
Tanzania	220	0.8
Mozambique	235	1.8
Zimbabwe	780	29
Botswana	3,310	15
Congo	130	17
Jakarta	1,090	72
Bangkok	2,741	85
Bayern (Germany)	21,955	540
South Africa	3,180	100
Mecklenburg (Germany)	8,718	470
Moscow	2,317	205

A polynomial equation was fitted to this data. The best fit was found to be:

(1) $C = -2 \times G^2/1000000 + 0.0598 \times G - 19.041$

Where C = Car owned per 1000 population
G = GRDP per capita

However, this equation is too highly geared to the squared component giving unfeasibly low car ownership results at medium and high GRDP inputs. As a result the curve shown in Figure 9.5.1 was developed. The best curve has the equation :

(2) $C = -1 \times G^2/1000000 + 0.0474 \times G - 15.619$

Where C = Car owned per 1000 population
G = GRDP per capita

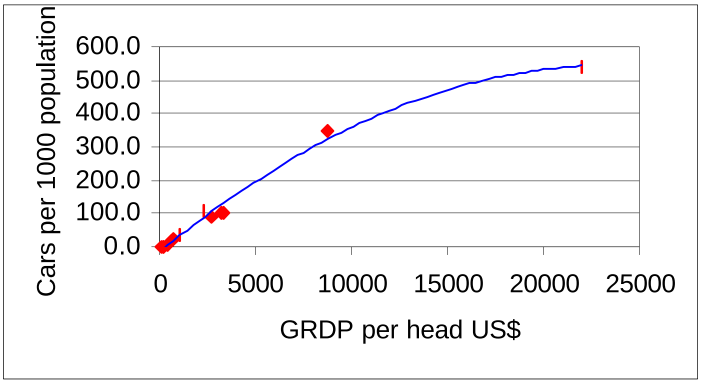


Figure 9.5.1 Synthesised GRDP vs Car Ownership Curve

GRDP in Maputo was estimated in 1998 by the World Bank to be $980 per head. Application of the above formula gives a synthetic car ownership of 27.2 cars per 1000 population. This is only slightly below (7%) the observed value. Equation (2) was adopted for forecasting car ownership in Maputo.

9.6 DISSAGGREGATE CAR OWNERSHIP FORECASTING

Population data for each sub-district in Maputo was used as the basis for disaggregate car ownership forecasting. These data were allocated to traffic zones, as shown in Table 9.6.1

Table 9.6.1 Population of Maputo, by Traffic Zone, 1998

Zone	Zone No.	Population
Caminhos da Ferro Mocambique/Porto	1	0
Assembleia da Republica	2	3159
Museo da Revolucion	3	12635
Alto Mae "A"	4	11126
TPM	5	23658
Museo Nacional de Arte	6	7403
Mercado Centrale	7	4942
Centrale "C"	8	4942
Polona Cimento "A"	9	10787
Centrale "B"	10	7403
Polona Cimento "B" / HCM	11	12791
CFM	12	17651
Luis Cabral	13	47888
Xipamanine	14	101080
Mafalala	15	21189
Malhangalene	16	17138
Sommerschield/Coop	17	14219
Universidade	18	3555
Maxaquene A, B, Urbanizacao	19	66180
Aeroporto "A"	20	17132
Airport Mavalane	21	0
Inghagoia	22	50411
Mavalane "B"	23	70449
Maxaquene "D"	24	20518
Costa do Sol Sud	25	38346
Costa do Sol Nord	26	19338
Mahotas, Ferroviario	27	99793
Hulene	28	38644
George Dimitrov, 25 de Junho	29	100809
Magoanine	30	11900
Polana Canico "B"	31	64318
Aeroporto B, Unidade 7	32	26887
Total		946,292

For each zone car ownership was estimated and the number of consequent trip generations calculated on the basis of a fixed trip rate per car for all zones of 3.8 car trips per day per vehicle. These synthetic trips were calibrated against trip generations from the OD Table so that the aggregate car ownership in Maputo that resulted matches the data in Figures 9.4.1 and 9.4.2. The data used in this process are shown in Table 9.6.2

Table 9.6.2 Estimated Disaggregate Car Ownership

Zone No.	Population	Estimated Cars Owned	Synthesised Car Trip Generations with fixed trip rate	Car Trips Generations Observed from Surveys	Estimated Car Ownership Rate per 1000 population
1	0	0	0	0	29.3
2	3159	181	686	695	57.2
3	12635	734	2788	2750	58.1
4	11126	914	3472	3414	82.1
5	23658	243	923	932	10.3
6	7403	825	3135	3128	111.4
7	4942	1160	4406	4403	234.6
8	4942	957	3635	3657	193.5
9	10787	2119	8054	8036	196.5
10	7403	1324	5032	5014	178.9
11	12791	1876	7127	7110	146.6
12	17651	1242	4721	4669	70.4
13	47888	2106	8005	8004	44.0
14	101080	1452	5519	5581	14.4
15	21189	808	3070	3138	38.1
16	17138	1005	3820	3898	58.7
17	14219	2293	8715	8715	161.3
18	3555	31	119	293	8.8
19	66180	970	3687	3727	14.7
20	17132	1758	6682	6664	102.6
21	0	0	0	1993	29.3
22	50411	133	506	475	2.6
23	70449	868	3297	3294	12.3
24	20518	376	1429	1400	18.3
25	38346	1057	4017	4094	27.6
26	19338	397	1508	1579	20.5
27	99793	161	612	699	1.6
28	38644	374	1421	1401	9.7
29	100809	739	2808	2768	7.3
30	11900	454	1724	1723	38.1
31	64318	566	2150	2045	8.8
32	26887	39	150	181	1.5
Total	946292	27162	103217	105480	28.7

The disaggregate car ownership estimates were then used to estimate GRDP/capita in each traffic zone. The formula used to convert car ownership to GRDP is as follows:

(3) $G = 0.03 \times C^2 + 20.5 \times C + 317.7$

Where C = Car owned per 1000 population

G = GRDP per capita

Disaggregate GRDP/head estimates are shown as Table 9.6.3.

Table 9.6.3 GRDP per Head Estimates by Traffic Zone, 1998

Zone No.	GRDP per head, $US per year, 1998
1	942
2	1577
3	1598
4	2181
5	531
6	2933
7	6595
8	5285
9	5375
10	4838
11	3897
12	1893
13	1271
14	618
15	1138
16	1612
17	4318
18	500
19	624
20	2703
21	942
22	372
23	574
24	702
25	903
26	750
27	351
28	519
29	469
30	1138
31	500
32	348
Average	978

The base year (2000) model was developed with 3 transport modes (car, goods and bus). Average vehicle occupancy for each type were found from the surveys and set as:

Table 9.6.4 Base Year Average Vehicle Occupancy

Car :	2.1
Goods :	3.6
Bus :	19.7

In order to estimate bus trip generations passenger flows were aggregated across the survey locations listed in Table 9.6.5. This allows for an aggregate modal share of trip making across the city to be determined.

Table 9.6.5 Car and Bus Shares, Selected Locations

Survey Point	Car Passengers	Bus Passengers	% share By car
Matola road	20572	94499	17.9
Machava Road	15773	72011	18.0
Av 24 de Julho	25799	106595	19.5
Av de Trabalho	5846	40941	12.5
Av De Angola	18481	41775	30.7
Av Accordos do Lusaka	29795	131669	18.5
Av Vladimir Lenine	24807	37400	39.9
Av Julius Nyerere	26164	24745	51.4
Av de Mozambique	4794	54747	8.1
Av Marien Ngoubai	14118	31558	30.9
Av 24 de Julho	23201	17270	57.3
Av 25 de Septembro	28476	23028	55.3
Av Vladimir Lenine	17178	63166	21.4
Total	255004	739405	25.6

From Table 9.6.5 the ratio of bus passengers to car passengers is 2.9. This target was adopted in preparing disaggregate forecasts of bus trip generations. The general method adopted therefore assumed that :

$$\mathrm{B}_i = f(\mathrm{PNC}_i)$$

Where B_i = bus trip generations in zone i
PNC_i = population not owning a car in zone i

Such that :

$$\sum B_i = 2.9 \times \sum C_i$$

Where C_i = car trip generations in zone i

Table 9.6.6 lists the resultant bus trip generation estimates.

Table 9.6.6 Daily Bus Generations, 2000, (16 hours), Based on Population

Traffic Zone	Bus Trips
1	0
2	942
3	3765
4	3230
5	7407
6	2081
7	1197
8	1261
9	2742
10	1923
11	3453
12	5190
13	14482
14	31514
15	6447
16	5103
17	3772
18	1115
19	20627
20	4863
21	0
22	15904
23	22010
24	6371
25	11795
26	5991
27	31515
28	12105
29	31654
30	3621
31	20166
32	8492
Total	290737

Total mechanized trip generation is estimated to be 0.42 trip per person per day (16 hours). This is very low and partly accounted for the reliance on walking as a mode of transport, and partly the use of goods vehicles for passenger movement. If passengers in goods vehicles are also included (excluding drivers) then the mechanized trip rate rises to 0.46 trips per head per day.

9.7 GRDP FORECASTS

Forecasting economic growth is not something that can be done with a great degree of certainty, especially in southern Africa. To a large extent, developing countries are simply not in control of their economies – the greater forces tend to international politics and multi-national capital. Since the end of the Civil War Mozambique has enjoyed economic growth, albeit from a very low base. The Study Team believe that in the short term the conditions exist for such growth to continue but feel that growth predictions over the longer term should be purposely conservative in order to hedge against potential political instability, wider international economic problems, inflation and devaluation of the currency. Furthermore the Study Team prefer to offer scenarios for economic growth without applying judgments at the outset.

For this study the Study Team have adopted three economic growth scenarios : low, medium and high as set out in Table 9.7.1

Table 9.7.1 Economic Growth Scenarios, Maputo, GRDP per head

Period	Growth per year		
	Low	Medium	High
1998 to 2010	3%	4%	5%
2010 to 2020	2%	3%	5%

The effect of these three scenarios on GRDP for Maputo is shown in Figure 9.7.1

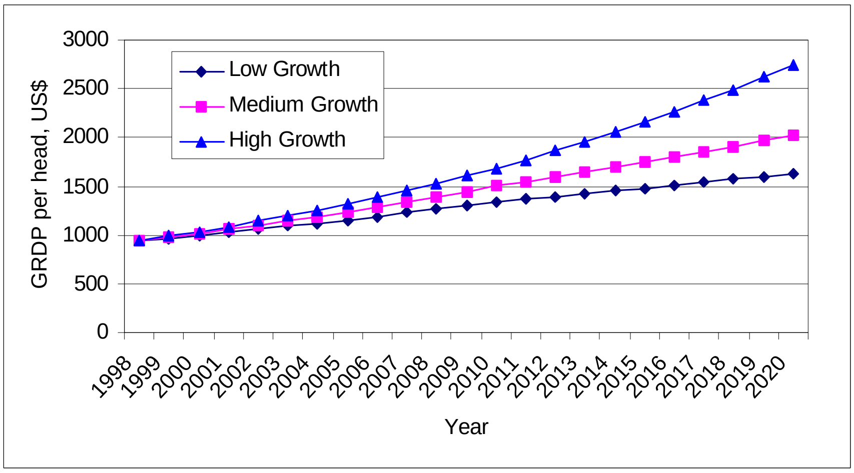


Figure 9.7.1 Forecasts of GRDP per head, Maputo

The High scenario forecasts suggests that in 20 years time the population of Maputo will enjoy the same real income levels as that of Bangkok. This is highly implausible. For this reason alone, the Study Team believe that forecasting should concentrate on the Low and Medium scenarios.

9.8 CAR OWNERSHIP FORECASTS FOR MAPUTO

Estimates of the numbers of cars that will be owned in Maputo in the future have been made on the basis of the above methodology relating car ownership to GRDP. Estimates were first made for the city as a whole, for the three economic growth scenarios, and for two forecast years : 2010 and 2020. Figure 9.8.1 shows the forecast of cars per 1000 population under the three scenarios.

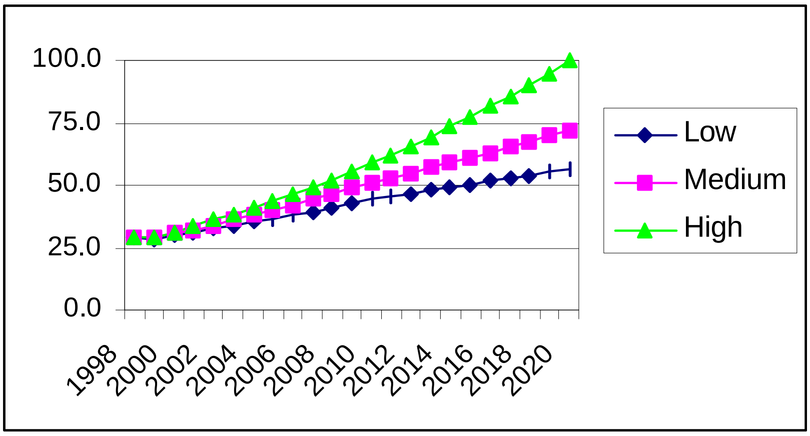


Figure 9.8.1 Forecast Car Ownership per 1,000 Population, Maputo City

The Low forecast indicates that the car ownership rate will double over the next 20 years. Under the Medium forecast the rate of ownership would increase by 2.5 times. Under the Medium forecast the rate of ownership in 2020 in Maputo would be similar to that of Jakarta in 1998. The Study Team feel that this is possible, but is necessarily predicated on the continuous and sustained economic growth assumed above.

The above rates of car ownership were converted to cars owned using the population forecasts for Maputo city set out in Chapter 8. The resultant forecasts are displayed in Figure 9.8.2. Largely because of the very high expected growth in population the forecasts of cars that will be owned in the city are very high. Even under the Low forecast it is estimated that the number of vehicles will grow by more than three times by 2020. Under the High forecast the growth could be as much as six times. The scale of these forecasts underline the need for the provision of infrastructure to address the demands for movement that will occur.

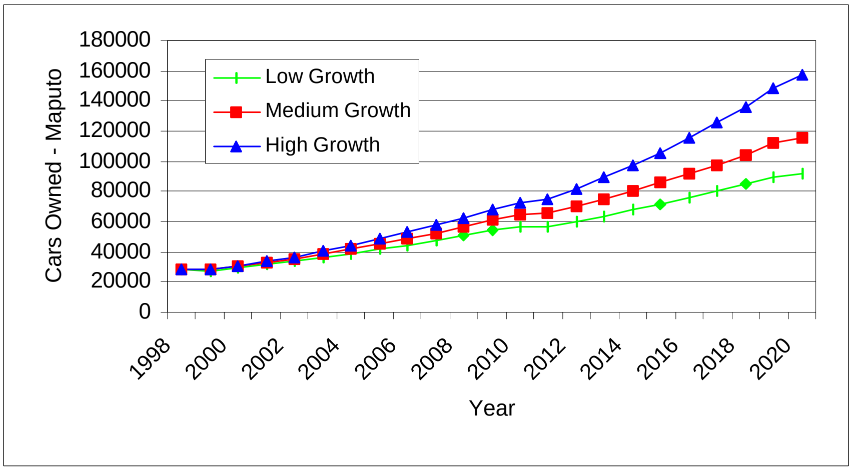


Figure 9.8.2 Car Ownership Forecast, Maputo

9.9 DISAGGREGATE CAR AND BUS FORECASTS

Car ownership and car trips have been estimated at the zonal level, by considering disaggregate GRDP. The trip rate per vehicle is likely to decline slightly as car ownership rises, because when households obtain more than one car individual vehicles will make less trips. The Study Team have assumed that the trip rate per car will decline from 3.8 trips to 3.5 in 2010, and 3.3 in 2020. Using the scenarios in Table 9.6.5 each traffic zone's GRDP is factored equally, and car ownership derived using the same formula (2) as provided in Section

4.5. Table 9.9.1 lists car ownership and trip generations by internal zone for the year 2010, and forecasts for 2020 are set out in Table 9.9.2.

Bus passenger forecasts for the future years were calculated using the same method as for the base year. Thus bus trip generations are forecast to lower under the high growth scenarios, than the corresponding medium growth scenarios. However, bus trips are forecast to increase significantly as well due to the increase in population. Bus trip forecasts are set out in Table 9.9.3.

Table 9.9.1 Car Ownership and Trip Generations by Zone, 2010, Based on Population

Traffic Zone	Cars Owned			Car Trip Generations (16 hour day)		
	Low	Medium	High	Low	Medium	High
1	0	0	0	0	0	0
2	341	385	433	1194	1349	1515
3	1384	1562	1754	4844	5468	6141
4	1563	1744	1937	5470	6106	6779
5	556	676	808	1947	2366	2827
6	1366	1507	1652	4780	5273	5782
7	1254	1296	1313	4388	4537	4595
8	1128	1199	1258	3950	4197	4402
9	3890	4127	4319	13615	14443	15117
10	2000	2142	2268	6999	7496	7940
11	3199	3479	3752	11197	12176	13133
12	1603	1798	2007	5609	6294	7025
13	2810	3200	3623	9834	11200	12681
14	2301	2743	3230	8053	9602	11305
15	1137	1301	1480	3981	4555	5180
16	1680	1896	2128	5879	6635	7448
17	4473	4832	5171	15655	16912	18099
18	96	117	141	335	411	495
19	1431	1704	2005	5008	5965	7017
20	1964	2174	2393	6874	7610	8375
21	0	0	0	0	0	0
22	521	692	881	1822	2420	3082
23	2279	2740	3248	7976	9590	11367
24	552	650	758	1932	2276	2654
25	1414	1638	1881	4951	5731	6585
26	2379	2788	3236	8326	9757	11328
27	1287	1759	2280	4504	6155	7981
28	636	776	930	2227	2715	3254
29	2820	3500	4249	9870	12249	14873
30	8841	10116	11504	30942	35405	40263
31	1095	1343	1617	3833	4701	5659
32	155	212	276	541	743	966
Total	56153	64097	72533	196536	224339	253867

Under the low growth total car traffic would almost double by 2010, and be 2.5 times more under the high growth scenario.

Table 9.9.2 Car Ownership and Trip Generations by Zone, 2020, Based on Population

Traffic Zone	Cars Owned			Car Trip Generations (16 hour day)		
	Low	Medium	High	Low	Medium	High
1	0	0	0	0	0	0
2	419	516	677	1383	1702	2235
3	1698	2088	2739	5604	6891	9038
4	1881	2262	2855	6207	7466	9421
5	800	1088	1611	2641	3592	5317
6	1610	1886	2256	5313	6223	7444
7	1311	1377	1446	4328	4544	4771
8	1789	2148	2731	5903	7087	9013
9	4270	4480	4752	14090	14783	15682
10	2234	2415	2355	7373	7970	7772
11	3675	4149	4555	12128	13691	15031
12	1946	2366	3042	6422	7806	10040
13	4578	5716	7673	15106	18862	25320
14	3947	5250	7602	13024	17324	25088
15	1582	1990	2700	5220	6568	8911
16	2283	2806	3677	7534	9260	12133
17	5513	6805	8801	18194	22456	29042
18	134	185	276	443	609	911
19	2010	2670	3861	6632	8810	12742
20	2851	3367	4097	9408	11111	13521
21	0	0	0	0	0	0
22	1237	1835	2929	4084	6054	9667
23	4365	5865	8579	14406	19353	28312
24	821	1075	1533	2708	3549	5058
25	2122	2716	3768	7002	8963	12436
26	3980	5181	7329	13135	17096	24186
27	3627	5502	8943	11968	18156	29511
28	1692	2310	3432	5583	7622	11326
29	7468	10389	15712	24646	34284	51850
30	19236	24201	32835	63480	79864	108356
31	1776	2441	3649	5862	8055	12043
32	277	422	687	914	1391	2268
Total	91134	115497	157104	300741	381141	518442

Under the low growth total car traffic would almost treble by 2020, and be five times more under the high growth scenario. The greatest growth in car trips is forecast to be in Zone 30 (Magoanine), largely because of the huge forecast rise in population. The effect of an additional 30,000 to 40,000 cars per day from this single area on the road network of Maputo has played an important part in the development of the Masterplan.

Table 9.9.3 Forecast Bus Passenger Trip Generations by Zone, Based on Population

Traffic Zone	2010			2020		
	Low	Medium	High	Low	Medium	High
1	0	0	0	0	0	0
2	1227	1213	1198	1202	1172	1121
3	4902	4845	4784	4802	4679	4473
4	3902	3845	3784	3802	3681	3494
5	9029	8991	8949	9331	9240	9075
6	2494	2449	2403	2417	2329	2212
7	1169	1156	1150	1151	1130	1108
8	1209	1186	1168	1000	886	702
9	4115	4040	3980	3995	3929	3843
10	2293	2248	2208	2219	2162	2181
11	4429	4340	4254	4278	4128	4000
12	4681	4619	4553	4572	4439	4225
13	13061	12937	12804	16804	16444	15825
14	28880	28740	28586	36615	36203	35458
15	6062	6010	5953	6617	6488	6263
16	5890	5822	5748	6395	6230	5954
17	5645	5532	5425	5316	4908	4276
18	1735	1728	1720	1723	1707	1678
19	17672	17586	17491	18375	18166	17789
20	3902	3836	3766	4634	4471	4240
21	0	0	0	0	0	0
22	18213	18159	18100	27191	27003	26656
23	32271	32125	31965	45118	44644	43785
24	5677	5646	5612	6351	6271	6126
25	10181	10110	10033	11792	11604	11271
26	22212	22083	21941	28190	27810	27131
27	53209	53060	52895	90332	89739	88650
28	10775	10731	10682	20468	20273	19918
29	57753	57538	57301	106388	105464	103780
30	47119	46715	46276	80460	78889	76158
31	19835	19756	19670	22782	22572	22190
32	6562	6544	6524	7030	6984	6900
Total	406104	403591	400923	581350	573644	560483

Figure 9.9.1 shows the Forecast change in overall modal share by car. Currently car trips account for one quarter of mechanized trips (excluding goods), and this is forecast to rise to between 30% to 40% by 2020.

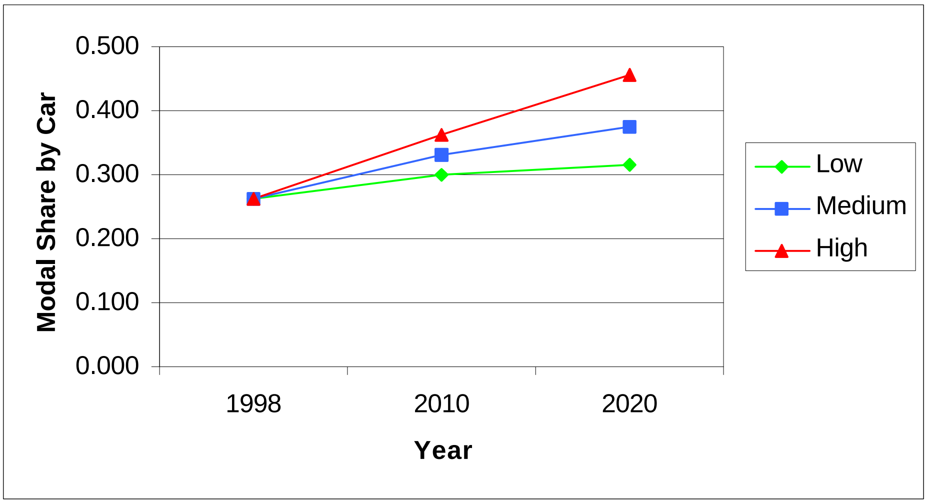


Figure 9.9.1 Forecast Change in Modal Share of All Trips by Car, Maputo, 1998 to 2020

Figure 9.9.2 shows total car and bus trip forecasts graphically. In considering the highway network required to absorb this demand it is very important to take account of the large rise in demand for bus travel ,and hence the numbers of vehicles expected on the network.. For the future the Study Team have assumed the same bus occupancy as observed in the surveys. Should bus occupancy rise, through an increase in the average size of vehicle, the overall effect in pcu (passenger car unit) terms is likely to be small.

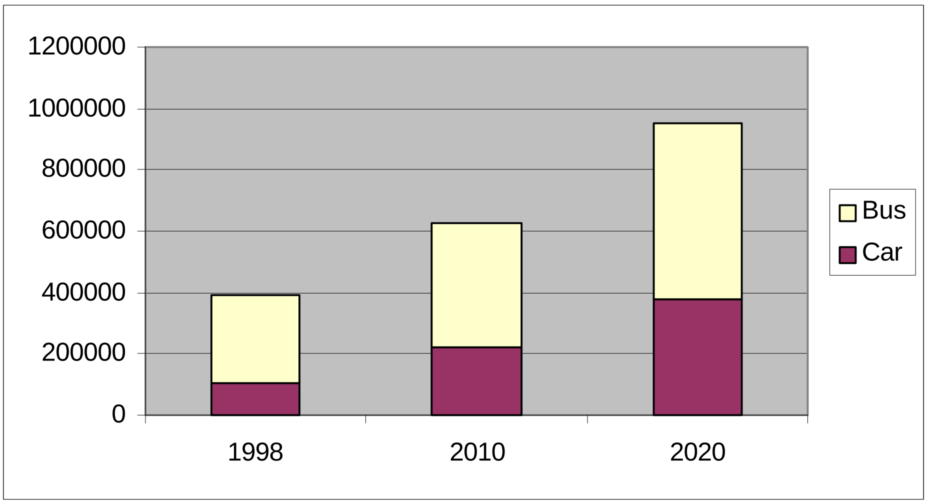


Figure 9.9.2 Total Daily Forecast Bus and Car Trip Generations, Maputo

9.10 GOODS VEHICLES

The goods vehicle matrix for the base year was taken directly from the OD surveys using the expansion factors given in Table 7.1.5. In the base year (2000) matrix there are 22,294 vehicles. Goods vehicle generations by zone are listed in Table 9.10.1. Zone 12 (Port) was found to have the highest generation.

Table 9.10.1 Daily Goods Vehicle Generations by Traffic Zone, Maputo, 2000

Zone	Vehicle Generations
1	20
2	0
3	208
4	1335
5	86
6	628
7	833
8	510
9	561
10	128
11	890
12	1378
13	895
14	978
15	654
16	885
17	217
18	110
19	482
20	877
21	602
22	130
23	666
24	252
25	395
26	470
27	268
28	562
29	760
30	347
31	1139
32	162

9.11 BASE YEAR MODEL VALIDATION

The following pcu values are used in the traffic model :

Car : 1.00
Bus : 1.50
Goods vehicle 2.02

The traffic model was calibrated by altering capacities and speeds and validated against the observed traffic volumes. Figure 9.11.1 shows the general form of the volume (V) to speed (Q) formula used in the model.

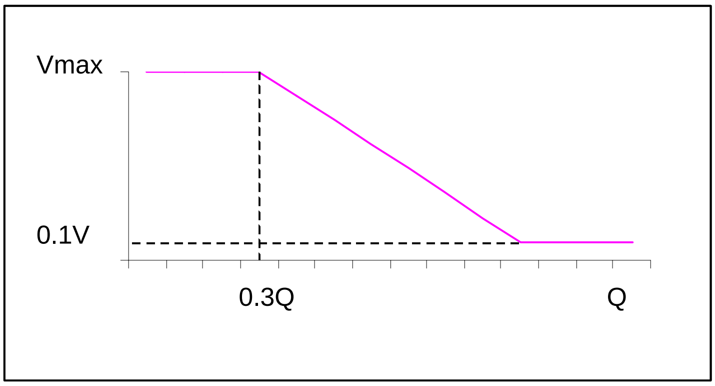


Figure 9.11.1 QV Formula Used in Maputo Traffic Model

The comparison of synthesized and observed traffic volumes is set out in Table 9.11.1

Table 9.11.1 Observed and Modelled Traffic Volumes, (16 hour pcu's)

Survey Point	Road	Observed PCU's	Synthesised PCU's
1.1	Matola road	17703	18300
1.2	Machava Road	15204	15200
1.3	Rua 5.579	3018	2800
1.4	Marracuene Road	10017	10000
1.5	Marracuene Road	3800	3700
1.6	Rua 4.755	1805	1800
1.7	Av da Marginal	1227	900
1.8	Catembe Ferry	339	300
2.1	Av De Mozambique	21661	17300
2.2	Machava Road	15220	17000
2.3	Largo de Deta	8187	7200

Survey Point	Road	Observed PCU's	Synthesised PCU's
2.4	Av Accordos do Lusaka	10790	7900
2.5	Rua 4.029	1112	4700
2.6	Av Julius Nyerere	21483	23700
2.7	Rua 4.680	586	4600
3.1	Av 24 de Julho	19118	24200
3.2	Av de Trabalho	9048	8900
3.3	Av De Angola	16186	13400
3.4	Av Accordos do Lusaka	27688	20200
3.5	Av Milaga Mabote	1435	4100
3.6	Av Manhangalena	3637	4400
3.7	Av Vladimir Lenine	17658	20000
3.8	Av Julius Nyerere	18206	15800
3.9	Av da Marginal	7213	5800
4.1	Av Julius Nyerere	20995	19500
4.2	Av de Mozambique	13342	13700
4.3	Av Marien Ngoubai	13863	11700
4.4	Eduardo Mondlane	27096	21500
4.5	Av 24 de Julho	21816	20100
4.6	Rua da Radio	3784	6000
4.7	Av 25 de Septembro	16613	13500
4.8	Av Vladimir Lenine	18221	10600
4.9	Av FPLM	14705	14700
4.11	Maria Mutola	9288	11900
4.12	Av Kenneth Kaunda	15185	16900

Screenline/Cordon flows are compared in Table 9.11.2.

Table 9.11.2 Observed and Synthesised Cordon Traffic Volumes, 16 Hour, 2000

Cordon/Screenline	Observed PCU''	Assigned PCU's	Difference	% Difference
External	53115	53000	115	0.2
Outer	79039	82400	-3362	-4.3
Central	120189	116800	3389	2.8

All cordon and screenline flows are within 5% of the observed.

Network statistics are shown in Table 9.11.3

Table 9.11.3 Network statistics, Base Year (2000) Traffic Model

Statistic	Value
PCU – kilometres	1,514,357
PCU – hours	49,428
Average Speeds (kph)	30.6
Average Volume to Capacity Ratio	0.59
Average Trip Length (km) - Car	6.3
Average Trip Length (km) – Goods	8.4
Average Trip Length (km) - Bus	11.1

The synthesized traffic volumes, relative to capacity are shown in Figure 9.11.2. Overall, the network is not congested, although the average speed is lower than it ought because of the poor quality of many of the roads. The areas of limited congestion are confined to Av da Machava, between Av de Angola and Av Accordos do Lusaka, because of capacity limitations at the signaled junctions, along Av de Mozambique because capacity is affected by roadside activities and chapas, and at Praca dos Combatentes. In the city center there is congestion on a few links, particularly Av Guerra Populare.

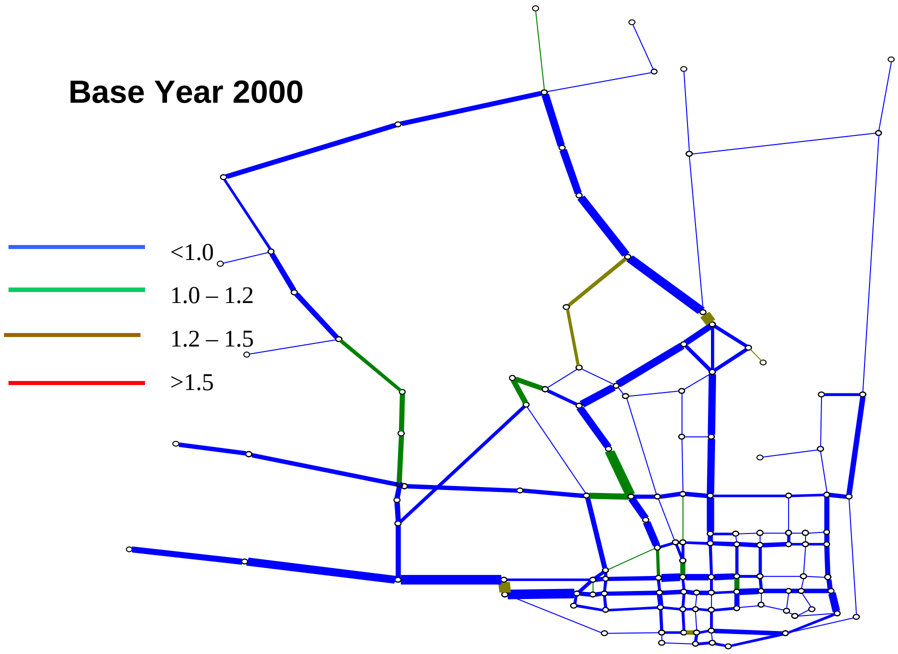


Figure 9.11.2 Base Year Volume to Capacity Ratios

9.12 FUTURE YEAR BASE NETWORKS

In order to test options for road development programmes, 'Do-Minimum' networks were established for the forecast years of 2010, and 2020. The 2010 Do-Minimum network includes the following additions and amendments to the base network

- Improvement of Rua da Machava to Dual-2 lane standard between Av Vladimir Lenine and the City boundary at Machava, with high capacity at grade junctions at Av de Angola and Av Accordos do Lusaka, and an all movement junction at Av de Mozambique, with grade separation maintained.

- The completion of the improvement to EN4 from the city boundary to Av de Trabalho (in the base year network the capacity of these links was reduced to reflect the fact that traffic was surveyed during the construction period)

- The full rehabilitation to Dual-2 standard of Av Organacao dos Nacioas Unidas, which was flood damaged in February 2000.

The same network was also adopted for the 2020 Do-Minimum case

9.13 FUTURE YEAR MATRICES

Car trip generations were taken from the disaggregate forecasts listed in Tables 9.9.1 and 9.9.2. For zones with no population (1 and 21) the average growth factor for =trips was applied to the base year row total, and the same factors applied to external trip generations.

Car trip attractions were factored from the base year column totals using zonal employment change, but controlled to the matrix total established by the trip generations.

This process was applied to both 2010 and 2020 matrices.

The goods vehicle matrix was subjected to a simple factoring based on total employment growth between 2000 and 2010. Because many goods vehicles are used for transporting passengers currently, the Study Team feel that the growth in car ownership could replace some goods vehicle use. In order to provide conservative estimates of traffic the goods vehicle matrix for 2020 was held at 2010 values.

Bus passengers were growth according the disaggregate totals set out in Table 9.9.8. Because most buses are able to adopt flexible routes, future year buses were assigned to network as a vehicle mode. This allows the model to forecast the demand for buses on least cost routes, and demand figures thus produced were then used for planning public transport facilities.

9.14 DO-MINIMUM TRAFFIC FORECASTS

Figures 9.14.1 to 9.14.3 show forecast volume to capacity ratios

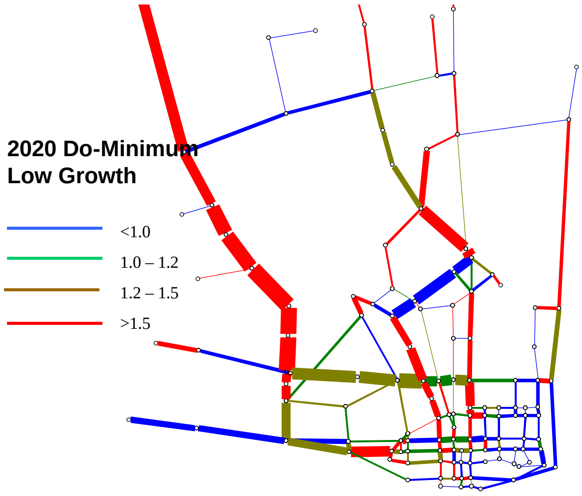


Figure 9.14.1 Do-Minimum (2020) (Low Growth)

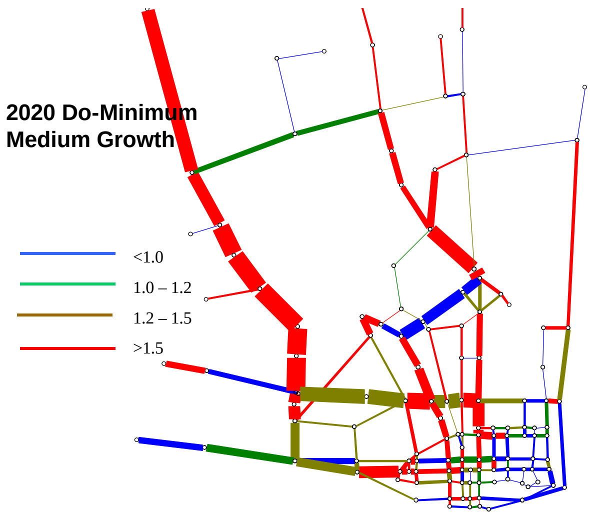


Figure 9.14.2 Do-Minimum (2020) (Medium Growth)

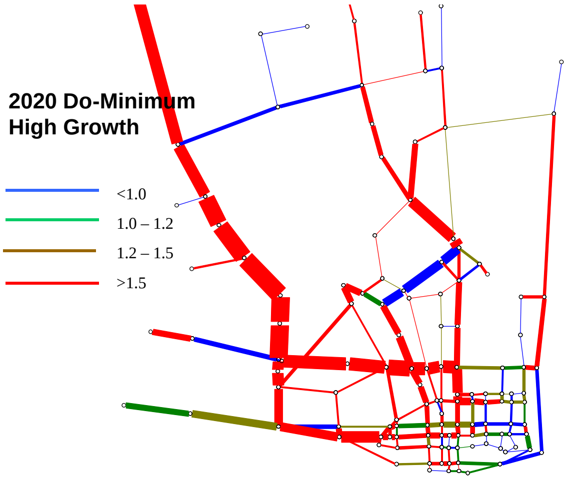


Figure9.14.3 Do-Minimum (2020) (High Growth)

Table 9.14.1 Network Statistics for Do-Minimum Networks, 2020

	Low Growth	Medium Growth	High Growth
Pcu-km	3,880,256	4,543,801	5,665,689
Pcu-hours	262,683	337,439	485,956
Volume to Capacity Ratio	1.29	1.51	1.89
Average Speed (kph)	14.8	13.5	11.7

Figures 9.14.1 to 9.14.3 and Table 9.14.1 reveal that under all of the economic growth scenarios, by the year 2020 Maputo will become severely congested unless counter-measures are taken. The forecast average speeds on the network represent a massive deterioration in the level of service, to an extent that the economic development of city would be adversely affected.

The primary problem faced by the city will be the huge increase in demand for the north-south movement due to the massive population increase in Magoanine and areas on the north side of the city. The key roads which are likely to suffer from heavy and persistent congestion would be :

Low Growth

Av. de Mozambique
Av Vladimir Lenine
Av Julius Nyerere, north of Praca dos Combatentes

Av Accordos do Lusaka
Av 24 de Julho
Av Guerra Populare

<u>Medium Growth</u>

As above plus

Rua da Machava, junctions with Av de Angola, Av Acccordos de Lusaka,
Av Vladimir Lenine
Av Julius Nyerere, south of Praca dos Juventudes
Av Mao Tse Tung
Av 25 de Septembro
Av de Angola

<u>High Growth</u>

As above plus

Rua da Machava, whole length

From the above it is clear the urgent priorities in the future will be :

- Additional north-south capacity along the Av de Mozambique corridor
- Relief to traffic on Av Vladimir Lenine, through the re-instatement of Av Julius Nyerere or new north-south capacity on the east side of the city
- Development of the Av Accordos do Lusaka corridor and increase to a consistent capacity in the city center (Av Guerra Populare)
- Strengthening of the east-west capacity

CHAPTER 10

INITIAL ENVIRONMENT EXAMINATION AND RECOMMENDATION OF MITIGATION MEASURES

CHAPTER 10 : INITIAL ENVIRONMENTAL EXAMINATION AND RECOMMENDATION OF MITIGATION MEASURES

10.1 GENERAL

As concerns the future road network (the master plan for the road development), it is required to examine whether striking environmental impacts arise from implementation of the project or not and to evaluate the results. If necessary, measures that mitigate environmental impacts should be taken against the project.

10.2 ENVIRONMENTAL EVALUATION

10.2.1 Social Environment

(1) Resettlement

There are a lot of shops, residential buildings settled along roads and streets. It is anticipated that there would be a resettlement will be required due to widening of the existing roads. The number of houses to be resettled for the master plan and prioritized projects shall be carefully studied to estimate the compensation values to be given, to carry out the official resettlement program, and to find alternative land for resettlement if necessary.

(2) Economic Activities

There will be both positive and negative impacts on economic activities by the implementation of the improvement projects during the construction and operation stages.

It is considered that construction of roads and the widening of the routes in the secondary and tertiary sector areas would give benefits and conveniences to the commercial and industrial activities in the areas. Therefore, several positive impacts on the economic activities are expected by widening construction.

However, possibility of changes to economic structures and land use values including commercial activities and job opportunities will be considered by construction of road and widening section. These changes would have both positive and negative impacts depending on the circumstances and situations in the areas. Therefore, construction of road and widening section shall be planed and designed to mitigate possible negative impacts in accordance with future developments and land use plans.

(3) Road and Traffic

In recent years, the pavement of roads, especially located in a lowland area of the city has being damaged by heavy rain. The traveling of vehicle has become difficult day after day especially in rain season. On these devastated roads, the vehicle speed is forced to be slow, and such low speed traffic aggravates the air pollution emitted from vehicle exhausts. Therefore, the traffic condition and the air pollution shall be improved by the improvement project.

(4) Public Facilities

Public facilities, such as commercial facilities (markets), medical facilities, educational facilities, and cultural institutions, are mostly located in the center areas of Maputo city. These public facilities are taken a special care of consideration on congestion, accidents and others in this study.

(5) Split of Community

The communities have been formed not only by administrative, but also cultural boundaries, such as racial, linguistic, and religious differences. In case of improving the existing roads, these indigenous communities should not be affected.

Regarding school (primary school) zone, a few of school zones will be cutted by trunk road network.

(6) Cultural property

There are 18 items of cultural property mentioned in previous section under state protection in Maputo city. Some of them are not far from the improvement roads, therefore the construction of roads should be carefully designed to avoid negative impact on these cultural properties.

(7) Solid Waste

During the construction stage of the projects, generation of solid waste such as construction and demolition waste, debris and logs will be predicted. And during the operation stage, the total amount of road waste from vehicles will increase due to the increase of traffic volume.

Therefore, proper solid waste management will be required during the construction and operation stage respectively.

10.2.2 Natural Environment

(1) Topography and Geology

There will be no large scale excavation for the construction of roads and widening. Therefore, no impact will be expected during and after the improvement.

(2) Soil Erosion

As there will be no large scale changes of lands for the construction of roads and widening. No impact will be expected during and after the improvement. However, there are intensive rainfalls in the rain season, it is necessary to take a notice on soil erosion at final design and construction stages.

(3) Ground Water

As same as in the previous topic, there will be no large-scale excavation for the construction of roads and widening. Therefore, no impact on the ground water is expected. On the other hand, the quality of ground water will be improved because of the development of a drainage ditch of roads.

(4) Flora and Fauna

Mangroves, open green space and street trees exist in the project area. However, no impact on mangroves and open green space will be expected. Regarding street trees, some impact will be expected due to the road construction and widening.

(5) Meteorology

No large scale excavation, no land reclamation and no large construction such as water reservoirs and high-rise buildings is planned for the improvement project. Therefore, no impacts can be predicted on the meteorological situation.

10.2.3 Environmental Pollution

(1) Air Pollution

It can be evaluated that air quality in the study area is not a critical situation at present, according to field survey results.

As a matter of course, the increase of total numbers of vehicles in the study area, namely, the increase of total quantity of exhaust gas will be concerned in the future, however, raising speed of vehicles will be anticipated by implementation of the master plan of road network. In result, the total quantity of exhaust gas from vehicles will be controlled.

To evaluate improvement of emission quantity of each pollutant load, the difference of the quantified load between the case of "2020 Do Minimum" and the case of "2020 Do Plan1 (master plan of road network)"on trunk road network in Maputo city have been calculated by use of parameters of roads length (km), traffic volume (t-vehicle), heavy vehicle traffic volume (h-vehicle) and velocity (km/h). Table 10.2.1 is the calculation result.

Table 10.2.1 Air Pollutants Total Improvement Quantity on Trunk Road Network

	average Speed (km/hr)	Pollutant (ton/year)		
		NO_x	CO	CO_2
2020 Do Minimum	17.1	639	3,307	1,621
2020 Do Plan1	26.9	629	2,116	1,193

As a result of the calculation above, apparently, environmental loads of NO_x, CO and CO_2 caused by vehicle traffic will decrease by the implementation of the projects.

(2) Water Pollution

There will be no large scale excavation for construction of the improvement projects. Therefore, no impact on water is expected in the area. However, during the construction stage, the surplus soil, construction debris and so on shall be controlled to avoid contamination of the Maputo bay.

(3) Noise and Vibration

It can be evaluated that noise and vibration level for houses of roadside in the study area is not a critical situation at present, according to field survey results.

However, the increase of total numbers of vehicles in the study area, namely, the increase of noise level will be concerned in the future. Therefore, some of mitigation measures should be considered.

10.3 RECOMMENDATION OF MITIGATION MEASURES

10.3.1 Social Environment

(1) Resettlement

In Mozambique national government owns the whole land and the individual or collective people have the right to use the land given by the government. There is a compensation system for involuntary resettlement, however, there is neither any precise regulation nor law on resettlement. Therefore, there should be necessity to establish a rule on compensation for resettlement by the government. In addition, the compensation is generally agreed upon in the talks between residents and local government, thus it is important to make a resettlement plan in which opinions of residents are admitted.

(2) Economic Activities

Special policy to promote new economic activities along roads shall be considered to mitigate negative impacts on existing economic activities by the projects in accordance with the situations of areas.

(3) Public Facilities

Traffic accidents are considered to be a problem to the Public Facilities. Therefore, traffic safe facilities that mitigate traffic accidents such as pedestrian crossing, guard fence and traffic signs and so on are expected to be constructed. In addition, traffic safe education of people (pedestrian and driver) is considered to be a useful and principal measure to decrease traffic accidents.

(4) Split of Community

A few of school (primary school) zones will be cutted by trunk road network. Mitigation measures to the split of primary school zones are considered as follows:

- To establish pedestrian crossing
- To limit car speed

(5) Cultural property

As some of the state protected cultural properties are near by improvement roads, special care should be given during the construction period. It is important to make a work plan that include a specific contracting clauses to define responsibilities of constructing companies and workers who will actually to the construction work.

(6) Solid Waste

In order to mitigate impacts on solid waste of the projects, proper solid waste management by official management (in addition, by constructing companies during the construction period) will be required during the construction and operation stage respectively.

10.3.2 Natural Environment

(1) Soil Erosion

As there are intensive rainfalls in the rain season, it is necessary to take notice on soil erosion. At final design and construction stages to mitigate soil erosion, several countermeasures such as planting, slope protection and construction of drainage ditch will be necessary in accordance with the soil situations.

(2) Flora and Fauna

Street trees that are in conflict with road development can be replaced with new trees. Therefore, at design stage the space for trees should be considered.

10.3.3 Environmental Pollution

1) Air Pollution

(1) During Construction Period

To prevent the fugitive dust emission and its dispersion, it is proposed to provide a water sprinkling system at the construction site, particularly for residential areas. In addition, dust covers may be required over the beds of trucks that will be used for transportation of materials.

(2) During Operation Phase

- Establishment of a national standard regarding air quality, emission of vehicle exhausts gas quantity and quality.
- Introduction of an obligatory car inspection system.
- Build up a public traffic system, and convert car use to public traffic use.
- Improvement of road structures:

The concentration of automotive emissions decreases by diffusion as the distance from the road increases. Therefore, it is important to maintain distance between roads and dwellings by the establishment of buffer zones and greenbelts.

- Improvement of traffic flow:

Improvement of speed and control of starting and stopping is expected to reduce the concentration of exhaust gas from vehicles.

2) Noise and Vibration

(1) During Construction Period

- Use low noise producing equipment
- Control daily operation hours

(2) During Operation Phase

- Introduction of obligatory systems for equipping muffler devices with adequate quality controlled by a technical standard and a muted horn with a national standard on every vehicle will be principal measures for mitigating road noise.
- Facilities to mitigate future noise level issue such as a planted area, green belt and so on are expected to be constructed along the roads.

CHAPTER 11

FORMULATION OF

ROAD DEVELOPMENT MASTER PLAN

CHAPTER 11 : FORMURATION OF ROAD DEVELOPMENT MASTER PLAN

11.1 INTRODUCTION

As described in Chapter 8, urbanization of Maputo City will continue at fairly high speed. The future population of Maputo City is expected to grow up to about 2 times as large as present, while future employment will also grow up to about 2 times as large as present.

However, this urbanization will not follow the trend of the past that is characterized by a strong concentration of business functions in the city center and disorderly expansion of residential area in the suburbs.

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The city center has already developed highly and there are not enough spaces to be developed except for the vertical dimension such as construction of high buildings.

Alternative places of urban development have to be sought out and future developments have to be concentrated not only in potential development areas, but also in and around the existing residential areas.

As far as the foreseeable future is concerned, the role of economic activities and social function of Maputo City in the nation would not be weakened but rather it would be emphasized.

For this reason, the Road Development Plan as well as the urban development plan should enhance the urban activities in order to avert economic inefficiency brought about by urban biases.

Table 11.1.1 Prospects of Urban Development of Maputo

	Present	2010	2020
Population (‘000)	1,090	1,366	1,960
Employment (‘000)	301	423	608
Total Daily Trip (‘000)	500	750	1,100

11.2 ROAD DEVELOPMENT CONCEPT

Based on the future traffic demand forecast on the basis of the land-use development plan, the following road development concepts have been evaluated:

- **Classified Road Development to improve Basic Human Needs and Environment**
- **Road Development to solve Existing Road Problems**
- **Road Development to enhance Future Traffic Efficiency**
- **Road Development to promote Metropolitan Development**

11.2.1 Classified Road Development to improve Basic Human Needs and Environment

The Road Network System should be developed in a hierarchic manner based on the Road Classification proposed by the Study Team together with its functions as shown in Table 11.2.1. The proposed road classification is mainly concerned with following two types of roads.

- **Primary Trunk Road and Trunk Road --------- Trunk Roads**
- **Collector Road and Local Area Road ----------- Community Roads**

As for the traffic functions concerned, Trunk Roads should provide high / medium speed and serve heavy traffic with full or partial access control from roadside area. Community Roads should provide low/medium speed and serve less traffic with no access control

In order to create a better environment in the existing Community Zones as well as to create good access to public community facilities in the community zones, Trunk Roads should be located outside the community zones or school zones and Community Roads should also be located within the community zones.

In case of the Maputo City, most of existing Trunk Roads are routed outside of the community zones and primary school zones except some Trunk Roads in urbanized area where either pedestrian safety crossing measures or rearrangement of school zones are required. Community Roads are well located to give access to public facilities in the community zones.

In case of new construction of Trunk Roads, location of Trunk Roads should be outside of the community zones and the recommended location for new Trunk Roads are shown in Figure 11.2.1.

Table 11.2.1 Proposed Functions of Classified Roads

Road Class	Expectable Function						Target		
	Traffic Function			Community Service Function					
	Speed	Traffic	Access control	Access to Public Facility	Bus/ Emerg. vehicle	Access to Community zone	Location	Traffic capacity	Speed
Primary Trunk Rd.	High/ Medi.	Heavy	Full control	Partial access	Full service	No school zone cut/ penetration	Outside school zone	High	High/ medi. 60-80
Trunk Rd.	High/ medi.	Heavy	Partial control	Direct access	Full service	No school zone cut/ penetration	Outside school zone	High	High/ medi. 60-80
Collector Rd.	Medi.	Medi.	No control	Direct access	Full service	Direct access	Inside school zone	Medi.	Medi. 30-5-
Local area Rd.	Low	Small	No control	Indirect access	Partial service	Direct access	Inside school zone	Small	Low 20-40

11.2.2 Road Development to solve Existing Road Problems

Identification of the existing road problems of the Maputo City has been conducted in previous chapter. The major problems identified are:

- **Deterioration of Road Pavement in urbanized area**
- **Heavy Deterioration of Community Roads in sub-urbanized area**
- **Traffic Congestion**
- **Poor Drainage System**
- **Poor Road Maintenance**

The Road Development Plan should contain the following appropriate measures required in order to solve the existing road problems.

1) Deterioration of Road Pavement in urbanized area

All Trunk Roads and most of Collector Roads in the urbanized area of Districts 1, 2 and 3of Maputo City have been subjected to the emergency pavement repair in the past year. But due to poor engineering and skill of work done, amounts of potholes and pavement undulations can be seen even again on the Trunk Roads.

In order to improve this deterioration, the following pavement rehabilitation should be incorporated into the Road Development Plan. (See Figure 11.2.2)

Existing Problems	Required Measures
Heavy Deteriorated Collector Roads	Pavement reconstruction with drainage improvement
Pavement Deterioration on Trunk Roads	Pavement reconstruction or over-lay with drainage improvement
Pavement Deterioration on almost all Local Area Roads	All pavement reconstruction of Local Area Roads in District 1 and some Collector Roads in District 2 and 3.

2) Heavy Deterioration of Community Roads in sub-urbanized area

Some Collector Roads and Local Area Roads are paved but others are either earth or gravel roads in the sub-urbanized area of the Maputo City. The existing pavement conditions of all Community Roads in the sub-urbanized area are heavily deteriorated to an extent where normal routine maintenance is no more cost effective.

Therefore, pavement reconstruction of all Collector Roads in District 4 and 5 should be incorporated into the Road Development Plan. Selection of the appropriate Collector Roads in each of the community zones was based on the evaluation of main access roads, which have sufficient road reserve and the location of public facilities in each community zones. (See Figure 11.2.2)

3) Traffic Congestion

Existing traffic congestions can be seen on main intersections of two Trunk Roads at peak hour only. (See Figure 11.2.3) Based on the estimation of the future traffic demand estimation, future traffic congestion on main intersections can be expected. Therefore, the following intersection improvements would be incorporated into the Road Development Plan.

- **Intersections of existing two dual carriage roads** should be improved as either **grade separations** or **well designed signal intersections**.
- In the case of **new construction of dual carriageway road or widening to be dual carriageway** being necessary, based on the future traffic estimation, all main intersections on these roads should be well designed having enough traffic capacity especially on **Av. Marien Ngoubai, Av. Acordos de Lusaka and Av. Angola.**

- Main intersections in the central area **are not heavily congested except a few junctions and widening of intersections may not be possible due to existence of large-scale buildings along side of roads. Therefore.** Traffic Management Controll Measures are necessary.

4) Poor Drainage System/ Road Maintenance

There are only two roadside drainage systems functioning in the Maputo City: the piped drainage system along side of most of city center roads; and an open drainage system of the Basin A on some Trunk Roads and Collector Roads in District 2 and 3.Other roads are completely missing roadside drainage systems.

In addition, the piped drainage system is not recommended due to the necessity frequent maintenance to remove filling sand. In case of Av. Julius Nyerere, heavy erosion has been caused not only by heavy rain but also by either the poor capacity of drainage pipe itself or a reduction in decreasing of drainage capacity due to poor maintenance of sand cleaning.

Therefore, Open Drainage System is recommendable to be incorporated into the Road Development Plan due to considerations of the ease of routine maintenance.

11.2.3 Road Development to enhance Future Traffic Efficiency

The low density of Trunk Road Network with its low traffic capacity and lack of road sections at critical parts, will lead to saturated urban traffic flow in the near future.

Based on the future traffic assignment on the Road Network of "Do Minimum" case which consists of the existing road network plus a widening of Mashava Road from 2 to 4 lane carriageways committed by the Central Government, expected heavy traffic congestion on the following North-South Corridors and on the roads in the city center should be solved by either widening of existing carriageways or new construction of Bypasses for alternatives.

Av. Mocambique:
- **Widening to Dual Carriageway, or**
- **Construction of New Bypass**

Av. Julius Nyerere:
- **Widening to Dual Carriageway on northern section and**
- **Reconstruction of Dual Carriageway on Missing Link or**
- **New construction of Bypass on Missing Link**

Av. Acordos de Lusaka: - Increasing traffic capacity by widening dual carriageway on entire section and by improvement of intersections through construction of grade separation or well designed signal junction

Av.Vladimir Lenine: - Increasing of traffic capacity by construction of proper bus stops and improvement of intersections due to difficulty of large amount of land acquisition and compensation for widening of existing road to dual carriageway.

Av. F.P.L.M: - Extension and widening of Av.F.P.L.M or
- Strengthening of Av. Julius Nyerere, Av. Vladimir Lenine and Av. Acordos de Lusaka

Av. Marien Ngouabi: - Extension and Widening of Av.Marien Ngouabi

The selection of counter measures was evaluated on the basis of availability of land, difficulty of resettlement and economic efficiency. (See Figure 11.2.4) Traffic Congestion in the city center will be solved by the above, in co-ordination with a Traffic Management Plan.

11.2.4 Road Development to promote Metropolitan Development

In the Structure Plan of the Metropolitan Maputo, the future Trunk Road Network is already prepared as shown in Figure 11.2.5. This Trunk Road Network links with important urban facilities efficiently and also future potential development areas as well.

In order to promote the concept of the Structure Plan, following New Construction and widening of existing Trunk Roads should be considered. (See Figure 11.2.4)

- **Extension of Outer Ring Road (extension of Rue 5.750) to Matola**
- **Widening of Middle Ring Road (Machava Road)**
- **Widening of Av. Mocambique or construction of New Bypass**
- **Widening of Av. Julius Nyerere or construction of New Bypass**
- **Extension and Widening of Av. F.P.L.M**

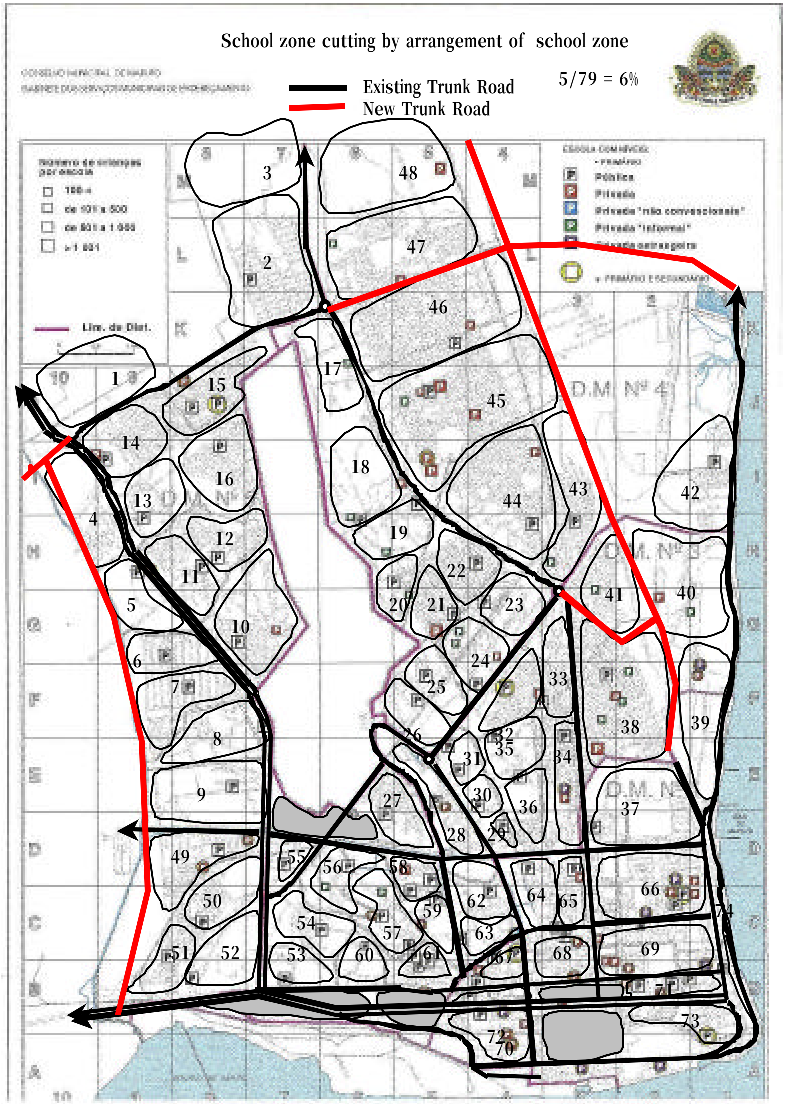


Figure 11.2.1 Recommendable Location of Trunk Roads

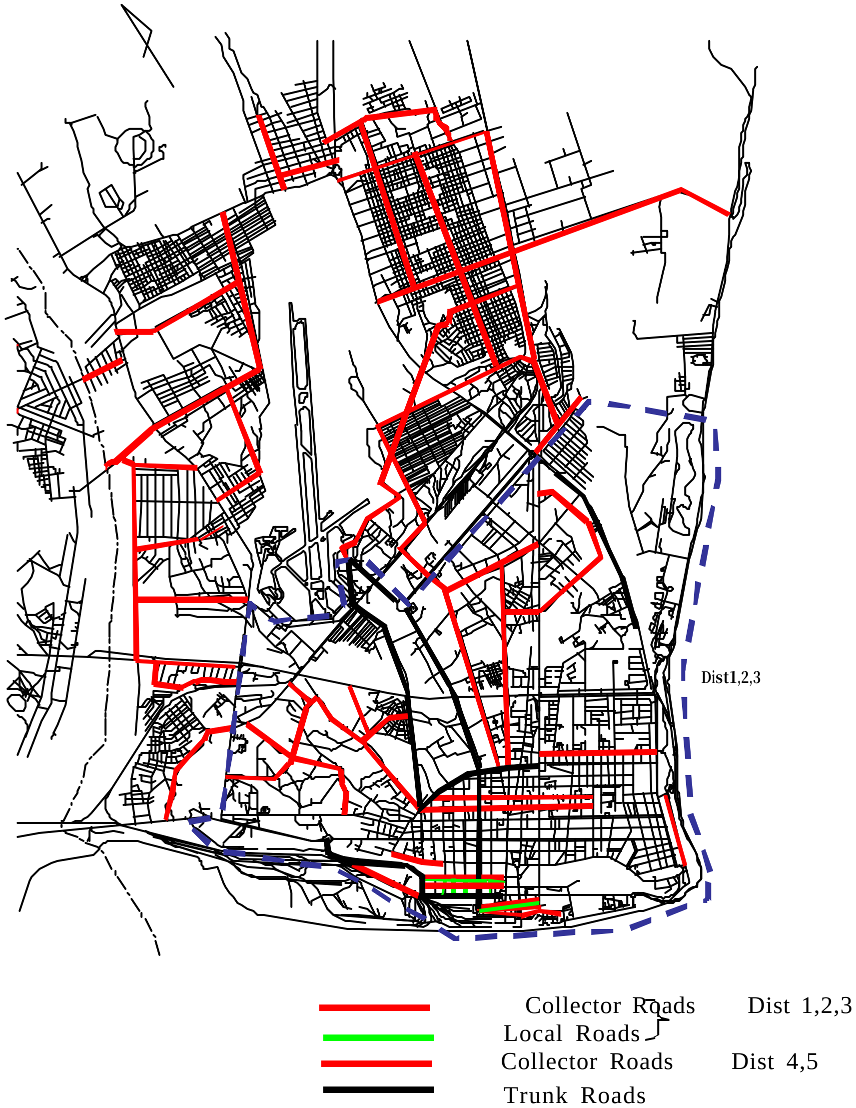


Figure 11.2.2 Road Pavement to Be Improved

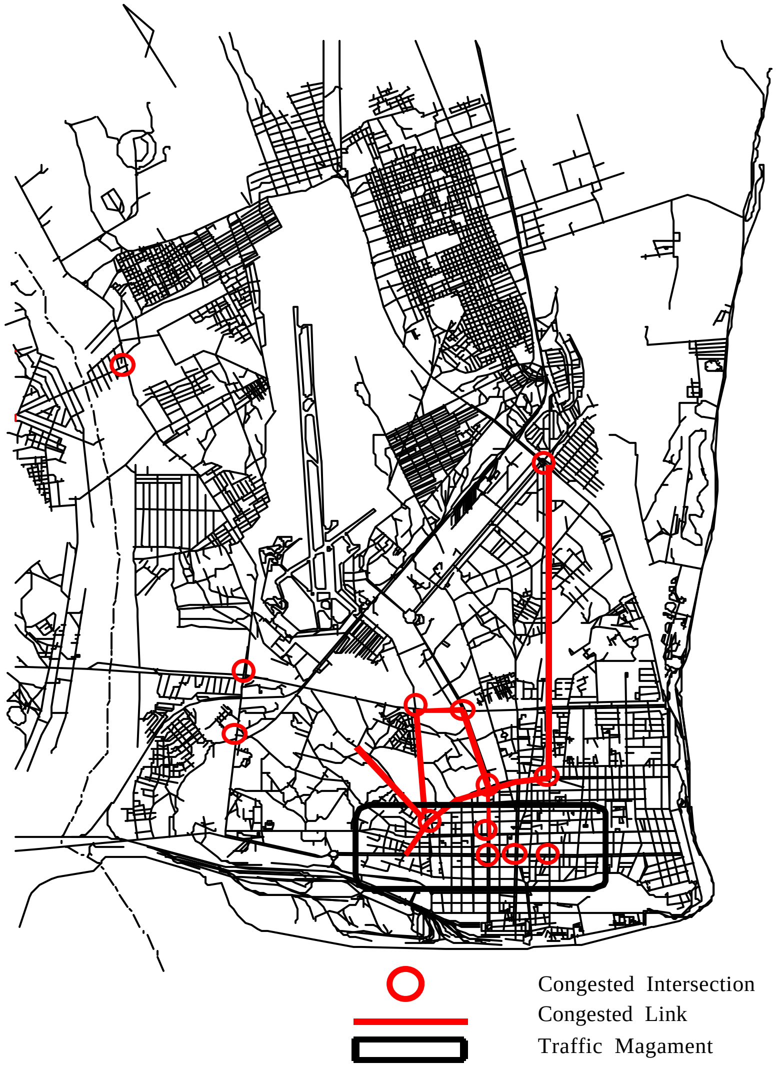


Figure 11.2.3 Existing Bottle-Necks to Be Improved

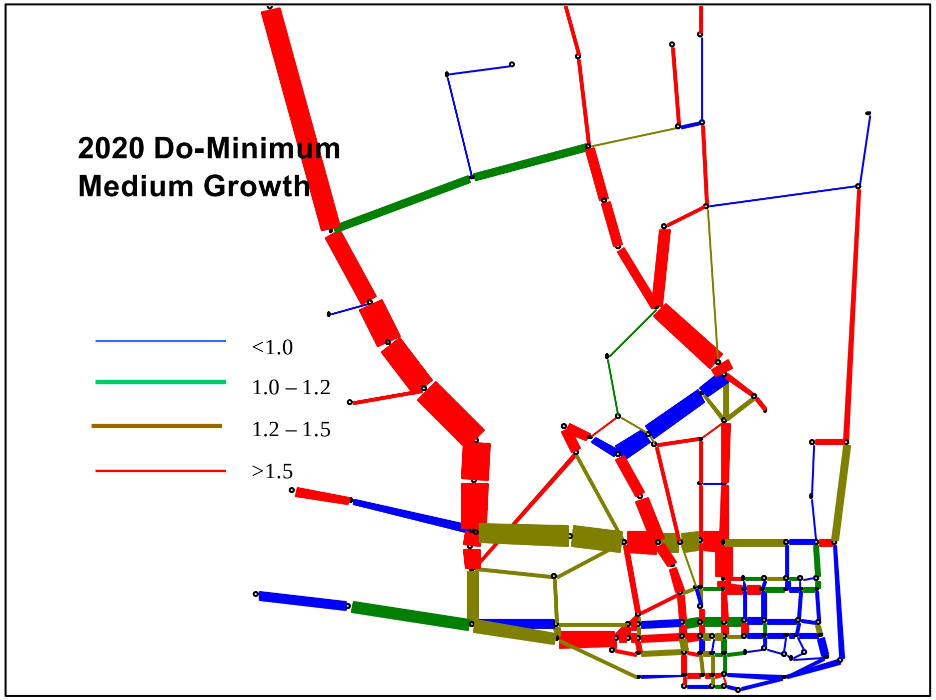


Figure 11.2.4 2020 Do-Minimum Medium Growth

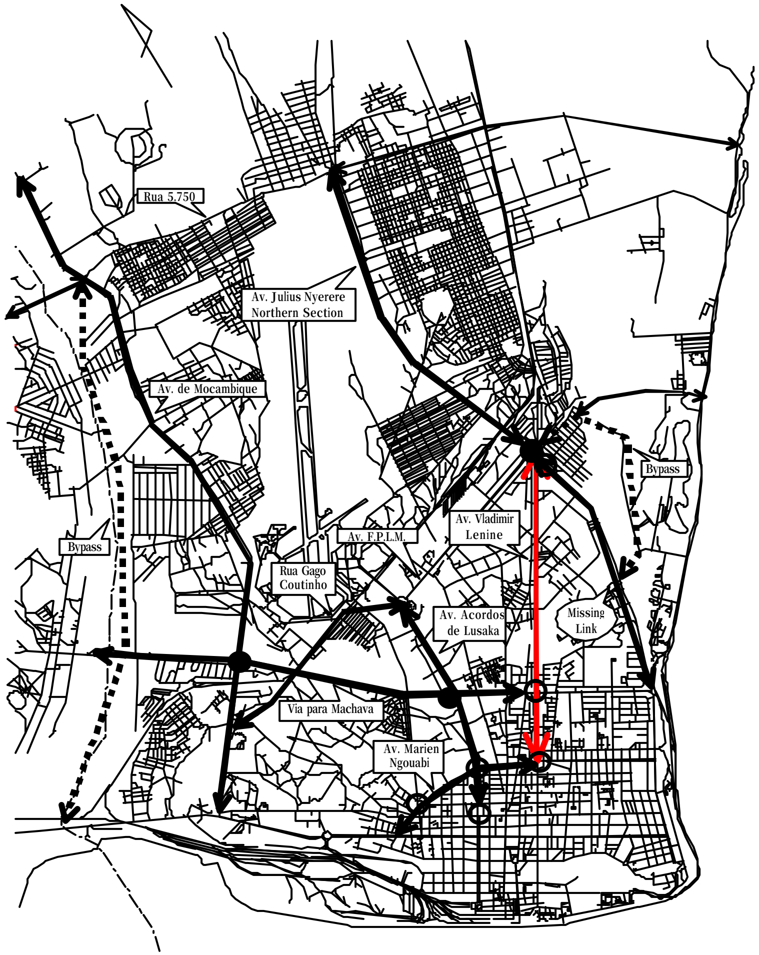


Figure 11.2.5 North-South Corridors and West-East Corridors to Be Improved

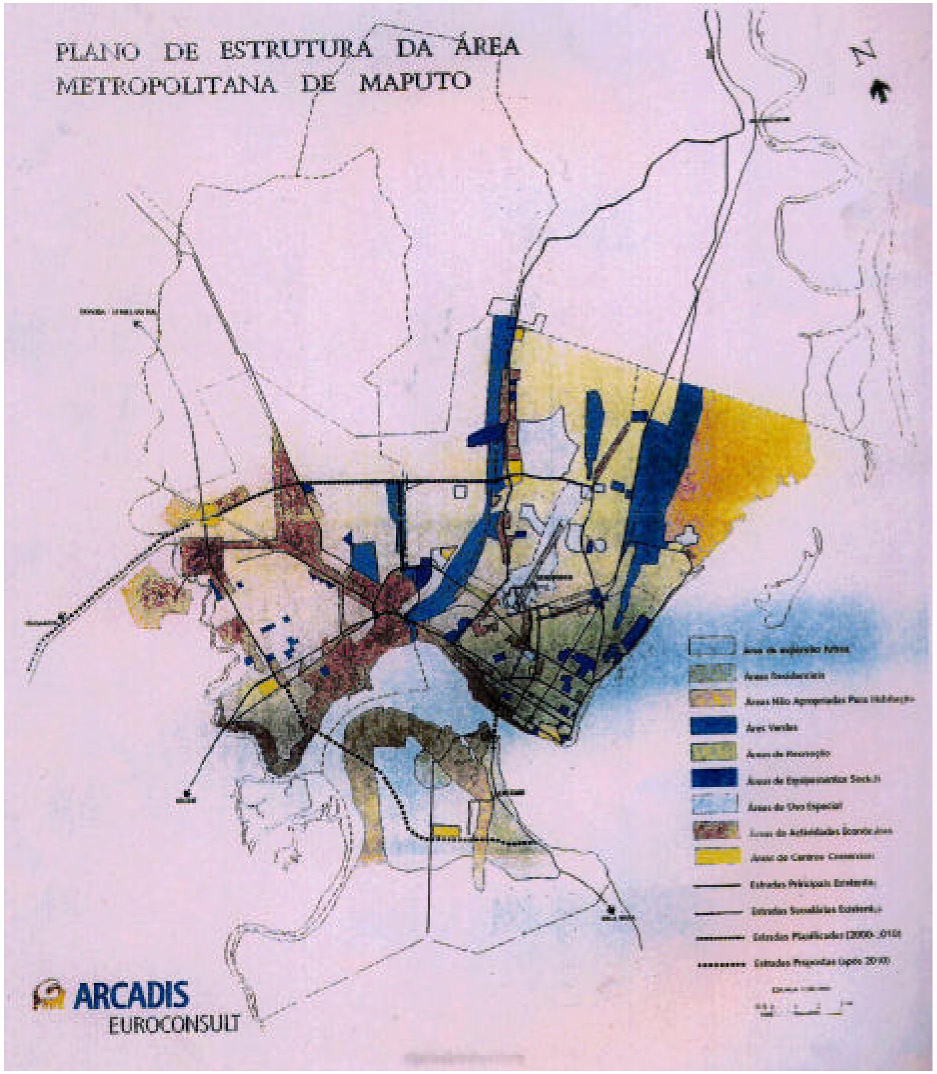


Figure 11.2.6 Metropolitan Maputo Structure Plan

11.3 PUBLIC TRANSPORT DEVELOPMENT CONCEPT

Prier to the Formulation of Road Development Master Plan, a basic concept for Public Transport Development has also been developed.

11.3.1 Development concept of Public Transport

Based on the Future Traffic Estimation, Future Demand of Bus Traffic would grow rapidly. In order to enhance the Future Bus Traffic efficiency, following development concepts for Public Transport are proposed.

Table 11.3.1 Public Transport Development Concept

Existing Problems	Required Measures
Lack of Public Transport Services	Open Public Transport Operation by Road Rehabilitation of existing Bus Route
	Settle un-serviced areas through improvement of Collector Roads
Shortage/congestion of Bus Stops	Construction of proper Bus Stops on Trunk Roads
Congestion/shortage of Bus Terminals	Construction of proper Bus Terminals with enough space for Markets near Trunk Road Intersections
Slow Bus Operation	Introduction of Bus Lanes on Dual Carriageway Roads for smooth operation of Buses
Lack of Bus Information	Installation of Information Boards at each Bus Stop and Terminal

11.3.2 Proposed Bus Route and Facilities

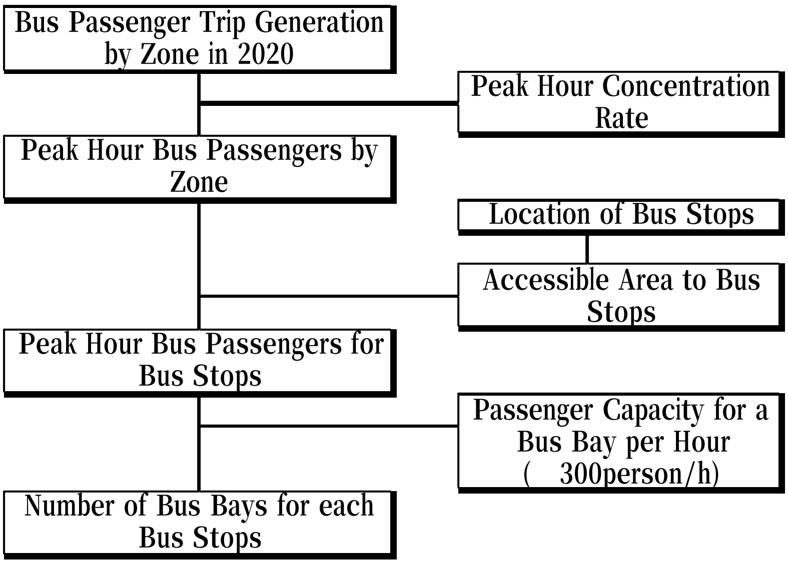
Existing trunk routes of Public Buses operate on the two North-South Corridors and on the two East-West Corridors. Future Trunk Bus Routes should be traced on the existing routes and bus operations on the Missing Link of Av. Julius Nyerere re-opened. And suspended Bus route due to the road surface condition on Av. Angola should be also re-opened. (See Figure 11.3.1)

Furthermore, in order to open the public transport services to un-serviced areas, branch bus routes on Collector Roads, which would be reconstructed during an implementation period of the Road Development Plan, should also be established. Urbanized area should be covered within bus service area of 400m from bus routes, which is defined by the intervals of existing bus stops. Roads for branch bus routes are essential part in defining collector roads in the

Road Development Plan.

Bus stopping on carriageway causes traffic congestion problems at Bus Stops due to shortage of proper bus bay space off the main carriageway. Therefore, construction of properly sized Bus Stops with bus bays and shelters will be necessary.

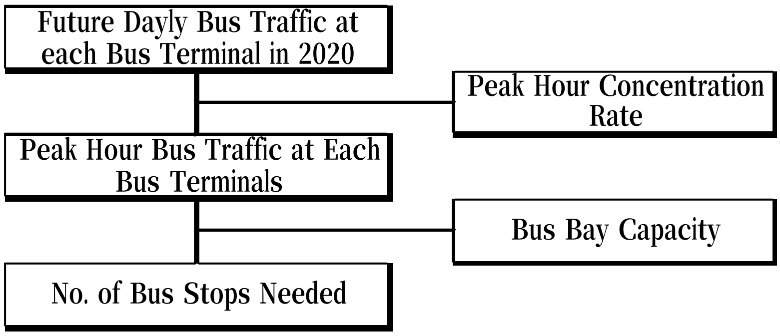
According to the Forecast Bus Passenger Trip Generation in 2020 by the Future Traffic Demand Forecast, numbers of Bus Bays required at each Bus Stop have been calculated by the following method.



Based on the calculation, required Bus Stops on the Trunk Bus Routes have been proposed as shown in Figure 11.3.1.

Existing problems at Bus Terminals are caused by lack of proper spaces for buses, taxis and trucks, and the penetration of market activities. Therefore, existing bus terminals should be equipped with proper stopping and moving spaces for buses, taxis, trucks and market spaces.

In line with future city expansion to north, four additional new Bus Terminals will be necessary. Numbers of Bus Bays required at each Bus Terminals have been calculated by the following method.



Based on the above method, the calculation and evaluation of required taxi, truck and market spaces has been conducted and Development Plan for Bus Terminals has been proposed as shown in Table 11.3.2.

In addition to improvement of bus facilities, following measures are proposed to enhance the Future Bus Transportation efficiency.

- Adoption of Bus lanes along the dual carriageway such as Av. Eduardo Mondane.
- Improvement of Bus Information system and installation of information board at Bus Stops
- Parking restriction at Bus Stops

In addition to these measures, introduction of measures for converting Mini Buses into Midi Buses are necessary to decrease the number of vehicles and improve the conditions of passengers.

In selecting the best Road Development Plan, a preliminary estimation of construction costs for Bus Stops and Bus terminals has been conducted as shown in Table 11.3.2-4.

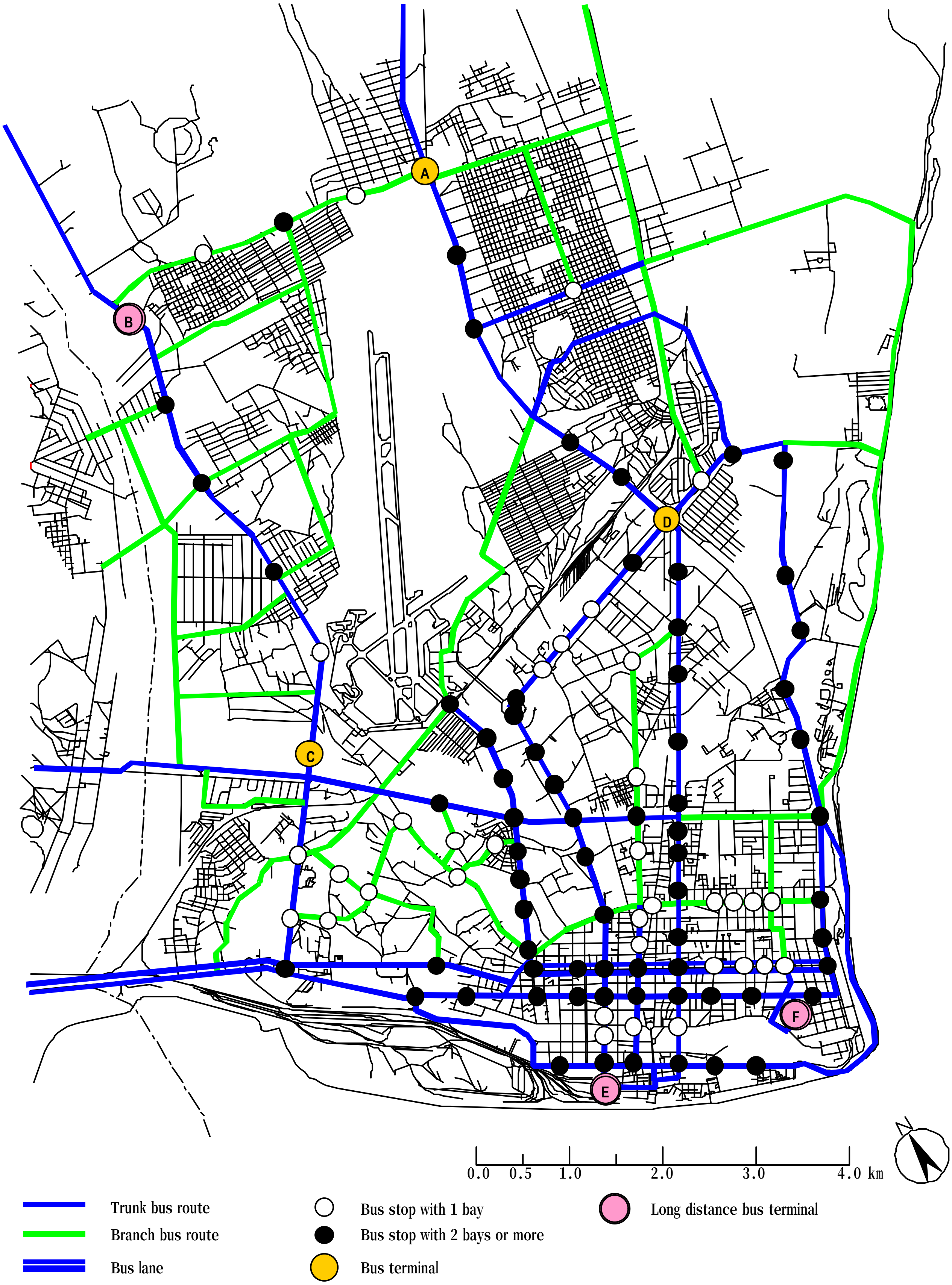


Figure 11.3.1 Public Transport Improvement Plan

Table 11.3.2 Proposed Bus Stop

Size(m) a	b	c	total	d
3.0〜3.5	20n+15	3.0〜3.5	20n+21〜22	3.0〜3.5

n : No. of Bus Bays

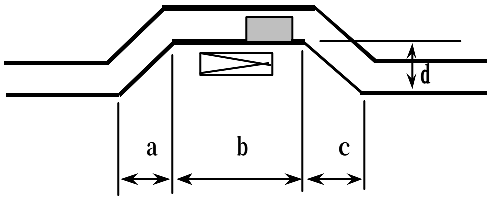


Table 11.3.3 Proposed Bus Terminal Size with Market

Nos. of Parking				Space(m2)					
Place	Bus	Taxi	Truck	Bus	Taxi	Truck	Sub. T	Market	Total
A(Mahotas)	15	5-6	5-6	4,200	300	700	5200〜5500	6,000	12,000
B(Dimitrov)	15	10	5-10	4,200	500	1,000	5700〜6000	10,000	16,000
C(Inhagoia)	15	15	10-15	4,200	800	1,500	6,500〜7,000	15,000	22,000
D(Combatentes)	20	20	10-15	5,600	1,000	1,500	8,100〜8,500	15,000	24,000
E(Trabalhadores)	25	20	15-20	7,000	1,000	2,000	10,000	-	10,000
F(Museu)	35	20	-	9,800	1,000	-	11,000	-	11,000

Table 11.3.4 Preliminary Construction Cost for Public Transport Development

		Unit Price (US$)	Bus Terminal A (6)	B (10)	C (15)	D-1 (20)	D-2 (20)	E (25)
1.Earth Work			$17,374	$28,560	$43,078	$44,030	$11,900	$33,320
Excavation Common	m3	3.20	$3,650	$6,000	$9,050	$9,250	$2,500	$7,000
			$11,680	$19,200	$28,960	$29,600	$8,000	$22,400
Embankment borrow	m3	2.60	$2,190	$3,600	$5,430	$5,550	$1,500	$4,200
			$5,694	$9,360	$14,118	$14,430	$3,900	$10,920
2.Pavement Work			$61,471	$98,890	$151,217	$162,745	$72,250	$149,080
Pre-mix. Aspahlt t=0.09m	m2	20.60	$600	$1,000	$1,600	$2,000	$2,000	$2,000
			$12,360	$20,600	$32,960	$41,200	$41,200	$41,200
Gravel Crush Stone t=0.15m	m2	6.35	$600	$1,000	$1,600	$2,000	$2,000	$2,000
			$3,810	$6,350	$10,160	$12,700	$12,700	$12,700
Stabilized Cement	m2	1.87	$7,300	$12,000	$18,100	$18,500	$5,000	$14,000
			$13,651	$22,440	$33,847	$34,595	$9,350	$26,180
Concrete Block	m2	19.50	$700	$1,000	$1,500	$1,500	$0	$2,000
			$13,650	$19,500	$29,250	$29,250	$0	$39,000
SBST	m2	3.00	$6,000	$10,000	$15,000	$15,000	$3,000	$10,000
			$18,000	$30,000	$45,000	$45,000	$9,000	$30,000
3. Drainage			$6,000	$12,000	$14,400	$14,400	$7,200	$13,200
Concrete Open	m	24.00	$250	$500	$600	$600	$300	$550
			$6,000	$12,000	$14,400	$14,400	$7,200	$13,200
Sub Total			$84,845	$139,450	$208,695	$221,175	$91,350	$195,600
Sub Total 2 (including Bus Bay)			$26,900	$46,000	$69,000	$92,000	$92,000	$115,000
Total			$111,745	$185,450	$277,695	$313,175	$183,350	$310,600
		say	$111,700	$185,400	$278,000	$313,000	$183,300	$310,600
Quantity			1	1	1	1	1	1
Cost			$111,700	$185,400	$278,000	$313,000	$183,300	$310,600
Bus Terminal Total Cost		$1,382,000						
Public transport Total Cost		$2,594,600						

11.4 ROAD DEVELOPMENT ALTERNATIVES

11.4.1 Establishment of Road Development Alternatives

Based on the development concepts with the necessary measures to be improved for Road Development and Public Transport Development, the following six alternatives for Road Development for long-term target (year 2020) have been proposed.

Each alternatives contain the necessary measures identified with development or improvement measures required for Collector Roads and Local Area Roads being equally equipped in each alternative due to heavy deterioration of existing road conditions and emergency necessity of rehabilitation from the stand point of Basic Human Needs.

In case of Trunk Road Development, recommended locations for proposed Trunk Roads has been identified and limited. Therefore, the magnitude of Trunk Road Development including numbers of carriageway, type of major intersection and Road Classification could become a proposed component to be varied in the alternatives as follows; (see Table 11.4.1-2 and Figure 11.4.1-6)

Do Minimum case: On-going road development projects, such as widening of Machava road to be a dual carriageway with grade separation withAv. Mocambique and emergency drainage repair of heavy eroded section (Missing Link) of Av. Julius Nyerere have been included in this case.

Conception Plan : Conception Plan is the basic plan which the Maputo Municipality is expecting and all the necessary measures have been incorporated in the plan. (See Figure 11.4.1)

Plan A case : Based on the preliminary evaluation of the Conception Plan, construction of alternative bypass for the Missing Link of Av Julius Nyerere and shorting of widening sections of extension of Av. F.P.L.M. and Av. Marien Ngoubai have been incorporated in the plan in order to avoide.huge construction cost for the reconstruction of the Missing Link of Av. Julius Nyerere and huge impacts on ressettlment for the widening of the extension of Av. F.P. L.M. and Av. Marien Ngouabi. (See Figure11.4.2)

Plan B case : Adding Grade Separations and Intersection Improvements into the Plan Ain order to strengthen traffic capacity of road network of PlanA. (See Figure 11.4.3)

+ Bypass 1 case : Based on the future traffic assignment on the road network of the Do Minimum Case, the traffic demand on the Av. Mocanbique would become large compared to the traffic capacity of the existing road. Therefore, construction of a new bypass instead of widening of existing Av. Mocanbique to each alternative road networks has been incorporated. (See Figure 11.4.4-6)

Based on the above evaluations of the road development components, following six road development alternatives have been established;

Table 11.4.1 Road Development Alternatives

Alternatives	Components
Do Minimum (base case)	Existing road network plus on-going rod projects
Plan 1	Conception Plan case
Plan 2	Plan A case
Plan 3	Plan B case
Plan 4	Conception Plan case plus Bypass 1 case
Plan 5	Plan A case plus Bypass 1 case
Plan 6	Plan B case plus Bypass 1 case

Table 11.4.2 Comparison of Road Development Components by Alternative

Main components	Section	Existing network	Do Minimum	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6
Primary Trunk Rd. – North-South Corridor –(No. of lane)									
Av. Mocambique Corridor	North	2	2	2	2	2	4	4	4
	South	2	2	4	4	4	2	2	2
	Bypass	-	-	-	-	-	4	4	4
Av. Julius Nyerere	Norht	2	2	4 + GS1	4	4 + GS1	4 + GS1	4	4 + GS1
	Missing link	-	-	4	-	-	4	-	-
	Bypass	-	-	-	4	4	-	4	4
	South	4	4	4	4	4	4	4	4
Trunk Rd..(No. of lane)									
Machava Rd.		2	4 + GS1	4 + GS2	4 + GS1	4 + GS2	4 + GS2	4 + GS1	4 + GS2
Av. FPLM	West	-	-	4	-	-	4	-	-
	Central	4	4	4	4	4	4	4	4
	East	-	-	4	4	4	4	4	4
Av. Marien Ngoabai	West	2	2	4	2	2	4	2	2
	East	2	2	4	4	4	4	4	4
Collector Rd. (Pavement Type)									
	District 1 Rd.	As	As.	As.	As.	As.	As.	As.	As.
	District 2/3 Rd.	E/G	E/G	As.	AS.	As.	As.	As.	As.
	District 4/5 Rd.	E/G	E/G	As.	AS.	As.	As.	As.	As.
	Potential area Rd.	E/G	E/G	E/G	E/G	E/G	E/G	E/G	E/G
Area Rd. (Pavement Type)									
	District 1 Rd.	G/As.	G/As.	As.	AS.	As.	As.	As.	As.
	District 2/3 Rd.	E/G	E/G	G/As.	G/As.	G/As.	G/As.	G/As.	G/As.
	District 4/5 Rd.	E/G	E/G	E/G	E/G	E/G	E/G	E/G	E/G
	Potential area Rd.	E/G	E/G	E/G	E/G	E/G	E/G	E/G	E/G

GS1: One Grade Separation , GS2: Two Grade Separations, As: Asphalt Pavement, E: Earth Road, G: Gravel Roa

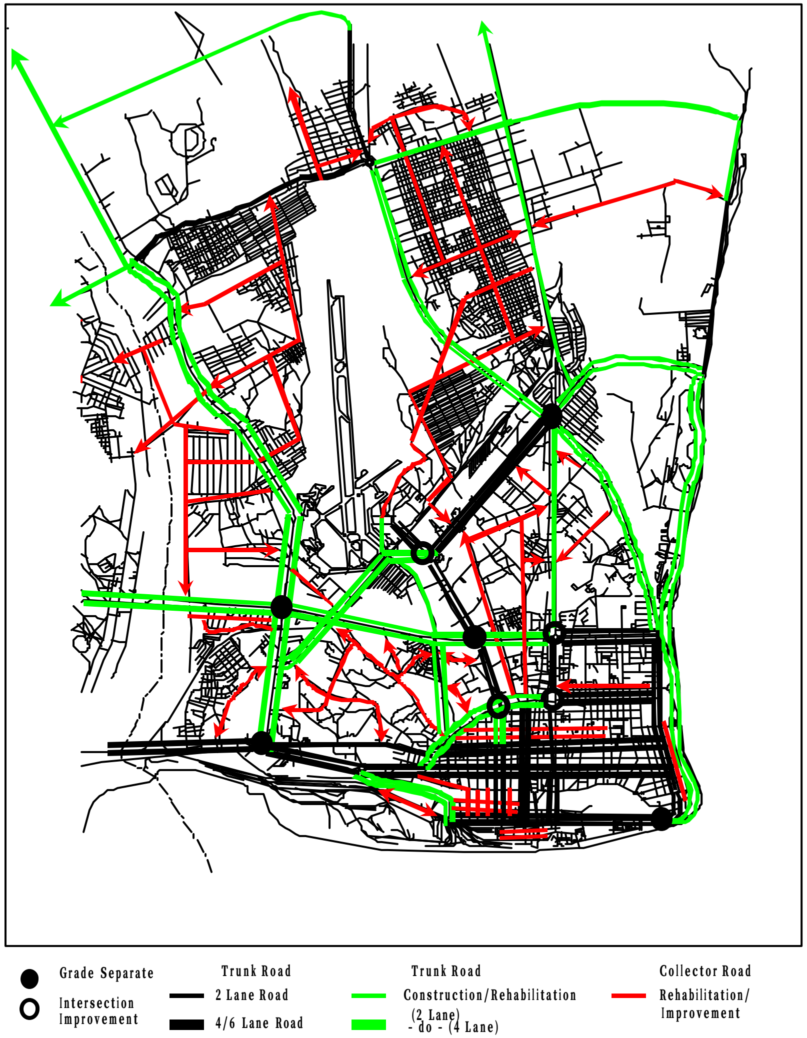


Figure 11.4.1 Proposed Road Development Alternative (Plan 1)

Figure 11.4.2 Proposed Road Development Alternative (Plan 2)

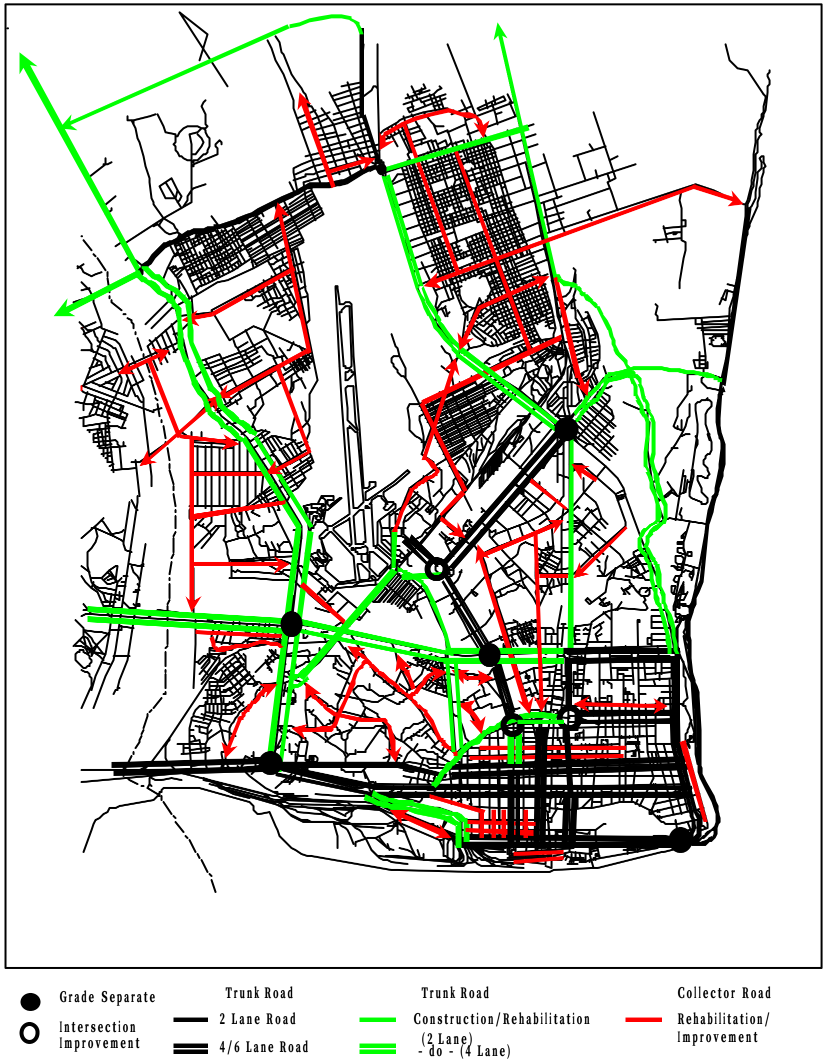


Figure 11.4.3 Proposed Road Development Alternative (Plan 3)

Figure 11.4.4 Proposed Road Development Alternative (Plan 4)

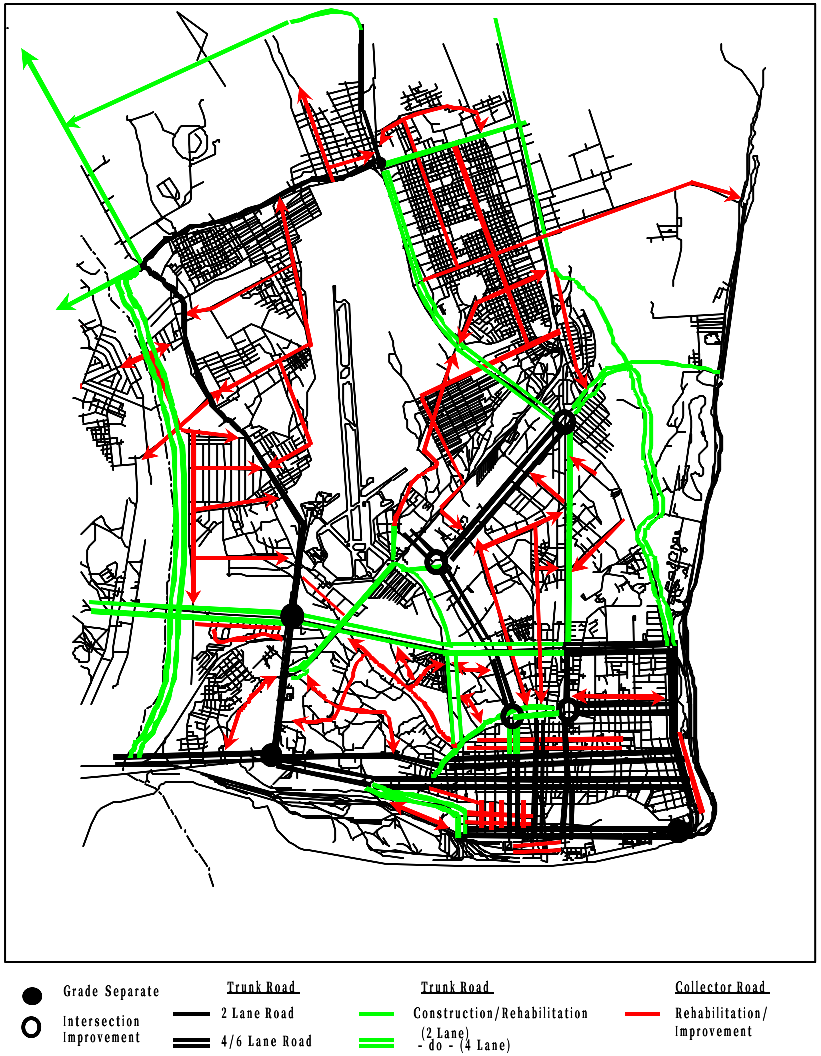


Figure 11.4.5 Proposed Road Development Alternative (Plan 5)

Figure 11.4.6 Proposed Road Development Alternative (Plan 6)

11.4.2 Proposed Typical Cross-sections and Preliminary Cost Estimate

1) Proposed Typical Cross-sections

Typical cross-sections for each road-type have been developed for the year 2020 along with traffic lane numbers determined taking into consideration road classification, type of road, land-use pattern and existing right-of-way conditions.

Figure 11.4.7 shows proposed typical cross-sections as well as required right-of-way width to be applied for each road development plans.

2) Preliminary Cost Estimate

For the purpose of preliminary evaluation as well as the implementation plan of road development, preliminary cost estimates were made for the proposed road development alternatives of the year in 2020.

The unit rates of required works have been developed on the basis of the recent cost data and the bid prices of the similar projects in Maputo currently offered, including the tender prices of the pilot project of this Study.

Cost estimates assume the following;

- All costs for the projects are estimated on the price level at January 2001.
- Exchange rate are shown below:
  US$ 1.0 = J.Yen 117 = MTs 18,000 (As of January, 2001)
- Construction Work will be executed by an international contractor

The unit rates, work quantities and construction costs for major work items are presented in the Appendix.

The preliminary construction costs were estimated applying these unit costs to the estimated quantities of each road development plan. A summary of the preliminary costs for each components of each alternative is presented as shown in Table 11.4.3.

The table also shows the additional costs required for the project implementation and the estimate conditions are as shown below.

- Contingency cost: 10 % of the total construction cost consisting 5 % of physical and 5 %

of price contingencies

- Administration cost: 2 % of the total construction cost for project administration during project implementation and project termination

- Engineering cost: 10 % of the total construction cost for engineering services

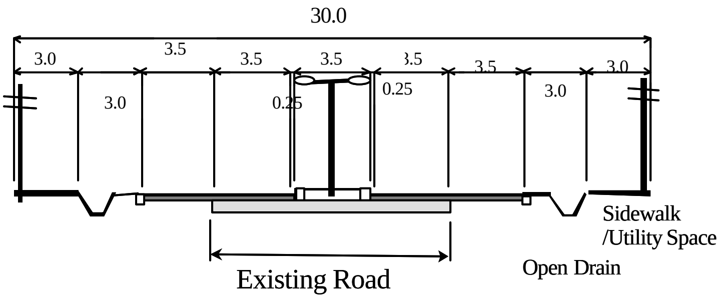
- Relocation cost: Relocation cost for public utilities for each projects has been calculated multiplied with unit relocation rate by quantities by types of utilities.

- House compensation cost:
House compensation cost by each project has been calculated by multiplying the unit rate of compensation by numbers of house to be demolished.

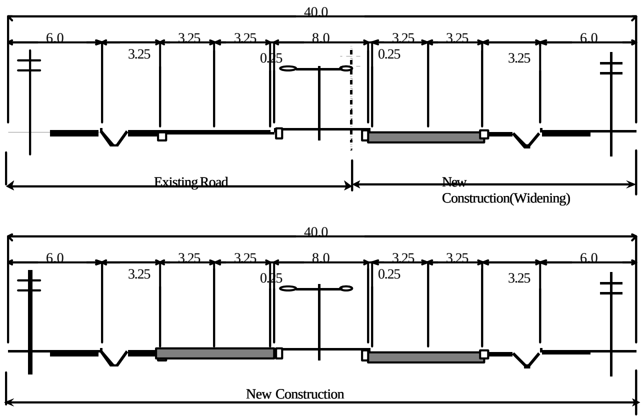
- Maintenance cost 1: Before the implementation of the project roads, approximately 10 years routine maintenance costs for maintaining the existing condition of each road have been calculated based on the existing unit maintenance cost multiplied by length of each roads.

- Maintenance cost 2: After the implementation of the project roads, approximately 10 years routine and periodic maintenance cost, consisting of annual routine maintenance cost of 1.5 % of total construction cost and periodic maintenance cost of 10 % of the total construction cost for 10 years after opening.

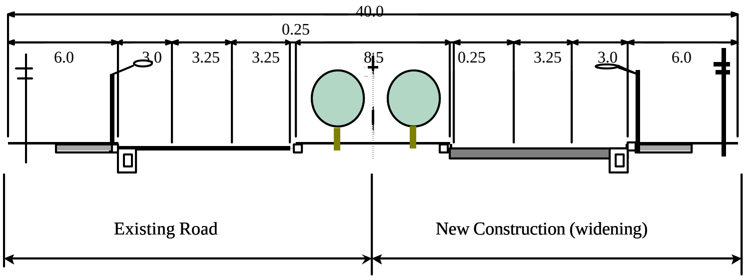
- Maintenance cost 3: After the implementation of the project roads, approximately 10 years routine and periodic maintenance cost for non-project roads has been calculated based on the existing unit maintenance cost multiplied by the length of non-project roads.



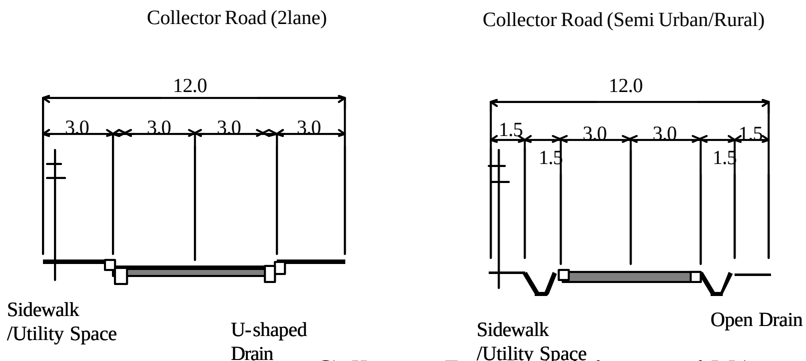
4-lane widening of Av. da Mozambique



4-lane widening of Julius Nyerere



4-lane widening of Inner Ring Road



Collector Roads (minimum width)

Figure 11.4.7 Proposed Typical Cross-sections

Table 11.4.3 Preliminary Construction Costs and Project Costs for each Alternative (1/2)

Plan 1

Project	Road Length (km)	Construction Cost (USD) [C.C]	Contingency (USD) [C.C x 10%]	Administration Cost (USD) [C.C x 2%]	Engineering Service (USD) [C.C x 10%]	Subtotal (USD)	Relocation Cost of Public Utilities (USD)	House Compensation Cost (USD)	Project Cost (USD)	Maintenance Cost 1 (Before Project) (USD) [Project Road: Routine M. 0-10 years]	Maintenance Cost2 (After Project) (USD) [Project Road: Routi.&Period. M. 10-20 years 2%annual+ 10%/10year]	Maintenance Cost3(USD) [Non Project Rd. Routine& Periodic M.]	Cost Grand Total (USD)
1 Public Transport(Bus Terminal)		1,385,000	138,500	27,700	138,500	1,689,700	0	0	1,689,700	0	346,250	0	2,035,950
2 Traffic Circulation(Link Signal)		2,430,000	243,000	48,600	243,000	2,964,600	0	0	2,964,600	0	607,500	0	3,572,100
3 Grade Separation(2 no.)		4,300,000	430,000	86,000	430,000	5,246,000	0	238,900	5,484,900	0	1,075,000	0	6,559,900
4 Construction of Primary Trunk Roads	15.05	16,136,656	1,613,666	322,733	1,613,666	19,686,721	3,027,750	104,100	22,818,571	180,600	4,034,164	0	27,033,335
5 Construction of Trunk Roads	71.92	56,517,004	5,651,700	1,130,340	5,651,700	68,950,745	10,664,311	4,606,100	84,221,156	863,040	14,129,251	0	99,213,447
6 Improvement / Rehabilitation of Collector Roads	92.28	26,722,943	2,672,294	534,459	2,672,294	32,601,991	6,528,849	1,637,900	40,768,739	665,514	6,680,736	19,884,186	67,999,175
6.1 Roads District 1	18.64	7,419,453	741,945	148,389	741,945	9,051,733	0	40,000	9,091,733	223,620	1,854,863	13,488,748	24,658,965
6.2 Roads District 2	10.23	2,346,996	234,700	46,940	234,700	2,863,335	1,239,050	743,200	4,845,586	61,356	586,749	1,729,983	7,223,674
6.3 Roads District 3	9.48	2,681,145	268,115	53,623	268,115	3,270,997	1,148,054	543,900	4,962,952	56,850	670,286	517,733	6,207,821
6.4 Roads District 4	27.26	7,408,405	740,840	148,168	740,840	9,038,254	1,963,946	79,200	11,081,400	163,572	1,852,101	2,016,145	15,113,218
6.5 Roads District 5	26.69	6,866,944	686,694	137,339	686,694	8,377,671	2,177,798	231,600	10,787,069	160,116	1,716,736	2,131,577	14,795,498
7 Improvement of Catembe Roads	9.00	5,119,025	511,903	102,381	511,903	6,245,211	0	0	6,245,211	54,000	1,279,756	0	7,578,967
Total	188.25	112,610,630	11,261,063	2,252,213	11,261,063	137,384,968	20,220,909	6,587,000	164,192,877	1,763,154	28,152,657	19,884,186	213,992,875

Plan 2

Project	Road Length (km)	Construction Cost (USD)	Contingency (USD)	Administration Cost (USD)	Engineering Service (USD)	Subtotal (USD)	Relocation Cost of Public Utilities (USD)	House Compensation Cost (USD)	Project Cost (USD)	Maintenance Cost 1 (Before Project) (USD)	Maintenance Cost2 (After Project) (USD)	Maintenance Cost3(USD)	Cost Grand Total (USD)
1 Public Transport(Bus Terminal)		1,385,000	138,500	27,700	138,500	1,689,700	0	0	1,689,700	0	346,250	0	2,035,950
2 Traffic Circulation(Link Signal)		2,430,000	243,000	48,600	243,000	2,964,600	0	0	2,964,600	0	607,500	0	3,572,100
3 Grade Separation(2 no.)		0	0	0	0	0	0	0	0	0	0	0	0
4 Construction of Primary Trunk Roads	15.05	16,136,656	1,613,666	322,733	1,613,666	19,686,721	3,027,750	104,100	22,818,571	180,600	4,034,164	0	27,033,335
5 Construction of Trunk Roads	53.89	37,164,356	3,716,436	743,287	3,716,436	45,340,514	6,331,962	2,030,300	53,702,775	646,716	9,291,089	0	63,640,580
6 Improvement / Rehabilitation of Collector Roads	92.28	26,722,943	2,672,294	534,459	2,672,294	32,601,991	6,528,849	1,637,900	40,768,739	665,514	6,680,736	21,178,695	69,293,684
6.1 Roads District 1	18.64	7,419,453	741,945	148,389	741,945	9,051,733	0	40,000	9,091,733	223,620	1,854,863	13,488,748	24,658,965
6.2 Roads District 2	10.23	2,346,996	234,700	46,940	234,700	2,863,335	1,239,050	743,200	4,845,586	61,356	586,749	2,076,377	7,570,067
6.3 Roads District 3	9.48	2,681,145	268,115	53,623	268,115	3,270,997	1,148,054	543,900	4,962,952	56,850	670,286	961,804	6,651,892
6.4 Roads District 4	27.26	7,408,405	740,840	148,168	740,840	9,038,254	1,963,946	79,200	11,081,400	163,572	1,852,101	2,016,145	15,113,218
6.5 Roads District 5	26.69	6,866,944	686,694	137,339	686,694	8,377,671	2,177,798	231,600	10,787,069	160,116	1,716,736	2,635,621	15,299,542
7 Improvement of Catembe Roads	9.00	5,119,025	511,903	102,381	511,903	6,245,211	0	0	6,245,211	54,000	1,279,756	0	7,578,967
Total	170.23	93,257,981	9,325,798	1,865,160	9,325,798	108,528,737	15,888,560	3,772,300	128,189,597	1,546,830	22,239,495	21,178,695	173,154,616

Plan 3

Project	Road Length (km)	Construction Cost (USD)	Contingency (USD)	Administration Cost (USD)	Engineering Service (USD)	Subtotal (USD)	Relocation Cost of Public Utilities (USD)	House Compensation Cost (USD)	Project Cost (USD)	Maintenance Cost 1 (Before Project) (USD)	Maintenance Cost2 (After Project) (USD)	Maintenance Cost3(USD)	Cost Grand Total (USD)
1 Public Transport(Bus Terminal)		1,385,000	138,500	27,700	138,500	1,689,700	0	0	1,689,700	0	346,250	0	2,035,950
2 Traffic Circulation(Link Signal)		2,430,000	243,000	48,600	243,000	2,964,600	0	0	2,964,600	0	607,500	0	3,572,100
3 Grade Separation(2 no.)		4,300,000	430,000	86,000	430,000	5,246,000	0	238,900	5,484,900	0	1,075,000	0	6,559,900
4 Construction of Primary Trunk Roads	15.05	16,136,656	1,613,666	322,733	1,613,666	19,686,721	3,027,750	104,100	22,818,571	180,600	4,034,164	0	27,033,335
5 Construction of Trunk Roads	53.89	37,164,356	3,716,436	743,287	3,716,436	45,340,514	6,331,962	2,030,300	53,702,775	646,716	9,291,089	0	63,640,580
6 Improvement / Rehabilitation of Collector Roads	92.28	26,722,943	2,672,294	534,459	2,672,294	32,601,991	6,528,849	1,637,900	40,768,739	665,514	6,680,736	21,178,695	69,293,684
6.1 Roads District 1	18.64	7,419,453	741,945	148,389	741,945	9,051,733	0	40,000	9,091,733	223,620	1,854,863	13,488,748	24,658,965
6.2 Roads District 2	10.23	2,346,996	234,700	46,940	234,700	2,863,335	1,239,050	743,200	4,845,586	61,356	586,749	2,076,377	7,570,067
6.3 Roads District 3	9.48	2,681,145	268,115	53,623	268,115	3,270,997	1,148,054	543,900	4,962,952	56,850	670,286	961,804	6,651,892
6.4 Roads District 4	27.26	7,408,405	740,840	148,168	740,840	9,038,254	1,963,946	79,200	11,081,400	163,572	1,852,101	2,016,145	15,113,218
6.5 Roads District 5	26.69	6,866,944	686,694	137,339	686,694	8,377,671	2,177,798	231,600	10,787,069	160,116	1,716,736	2,635,621	15,299,542
7 Improvement of Catembe Roads	9.00	5,119,025	511,903	102,381	511,903	6,245,211	0	0	6,245,211	54,000	1,279,756	0	7,578,967
Total	170.23	93,257,981	9,325,798	1,865,160	9,325,798	113,774,737	15,888,560	4,011,200	133,674,497	1,546,830	23,314,495	21,178,695	179,714,516

Table 11.4.3 Preliminary Construction Costs and Project Costs for each Alternative (2/2)

Plan 4

Project	Road Length (km)	Construction Cost (USD) [C.C]	Contingency (USD) [C.C x 10%]	Administration Cost (USD) [C.C x 2%]	Engineering Service (USD) [C.C x 10%]	Subtotal (USD)	Relocation Cost of Public Utilities (USD)	House Compensation Cost (USD)	Project Cost (USD)	Maintenance Cost 1 (Before Project) (USD) [Project Road: Routine M. 0-10 years]	Maintenance Cost2 (After Project) (USD) [Project Road: Routi.&Period. M. 10-20 years 2%annual+ 10%/10year]	Maintenance Cost3(USD) [Non Project Rd. Routine& Periodic M.]	Cost Grand Total (USD)
1 Public Transport(Bus Terminal)		1,385,000	138,500	27,700	138,500	1,689,700	0	0	1,689,700	0	346,250	0	2,035,950
2 Traffic Circulation(Link Signal)		2,430,000	243,000	48,600	243,000	2,964,600	0	0	2,964,600	0	607,500	0	3,572,100
3 Grade Separation(2 no.)		4,300,000	430,000	86,000	430,000	5,246,000	0	238,900	5,484,900	0	1,075,000	0	6,559,900
4 Construction of Primary Trunk Roads	15.1	30,515,476	3,051,548	610,310	3,051,548	37,228,881	0	0	37,228,881	180,600	7,628,869	0	45,038,350
5 Construction of Trunk Roads	71.9	56,517,004	5,651,700	1,130,340	5,651,700	68,950,745	10,664,311	4,606,100	84,221,156	863,040	14,129,251	0	99,213,447
6 Improvement / Rehabilitation of Collector Roads	92.3	26,722,943	2,672,294	534,459	2,672,294	32,601,991	6,528,849	1,637,900	40,768,739	665,514	6,680,736	19,884,186	67,999,175
6.1 Roads District 1	18.6	7,419,453	741,945	148,389	741,945	9,051,733	0	40,000	9,091,733	223,620	1,854,863	13,488,748	24,658,965
6.2 Roads District 2	10.2	2,346,996	234,700	46,940	234,700	2,863,335	1,239,050	743,200	4,845,586	61,356	586,749	1,729,983	7,223,674
6.3 Roads District 3	9.5	2,681,145	268,115	53,623	268,115	3,270,997	1,148,054	543,900	4,962,952	56,850	670,286	517,733	6,207,821
6.4 Roads District 4	27.3	7,408,405	740,840	148,168	740,840	9,038,254	1,963,946	79,200	11,081,400	163,572	1,852,101	2,016,145	15,113,218
6.5 Roads District 5	26.7	6,866,944	686,694	137,339	686,694	8,377,671	2,177,798	231,600	10,787,069	160,116	1,716,736	2,131,577	14,795,498
7 Improvement of Catembe Roads	9.0	5,119,025	511,903	102,381	511,903	6,245,211	0	0	6,245,211	54,000	1,279,756	0	7,578,967
Total	281	126,989,449	12,698,945	2,539,789	12,698,945	154,927,128	17,193,159	6,482,900	178,603,187	1,763,154	31,747,362	19,884,186	231,997,890

Plan 5

Project	Road Length (km)	Construction Cost (USD)	Contingency (USD)	Administration Cost (USD)	Engineering Service (USD)	Subtotal (USD)	Relocation Cost of Public Utilities (USD)	House Compensation Cost (USD)	Project Cost (USD)	Maintenance Cost 1 (Before Project) (USD)	Maintenance Cost2 (After Project) (USD)	Maintenance Cost3(USD)	Cost Grand Total (USD)
1 Public Transport(Bus Terminal)	0.0	1,385,000	138,500	27,700	138,500	1,689,700	0	0	1,689,700	0	346,250	0	2,035,950
2 Traffic Circulation(Link Signal)	0.0	2,430,000	243,000	48,600	243,000	2,964,600	0	0	2,964,600	0	607,500	0	3,572,100
3 Grade Separation(2 no.)	0.0	0	0	0	0	0	0	0	0	0	0	0	0
4 Construction of Primary Trunk Roads	15.1	30,422,876	3,042,288	608,458	3,042,288	37,115,909	0	0	37,115,909	180,600	7,605,719	0	44,902,228
5 Construction of Trunk Roads	53.9	37,164,356	3,716,436	743,287	3,716,436	45,340,514	6,331,962	2,030,300	53,702,775	646,716	9,291,089	0	63,640,580
6 Improvement / Rehabilitation of Collector Roads	92.3	26,722,943	2,672,294	534,459	2,672,294	32,601,991	6,528,849	1,637,900	40,768,739	665,514	6,680,736	21,178,695	69,293,684
6.1 Roads District 1	18.6	7,419,453	741,945	148,389	741,945	9,051,733	0	40,000	9,091,733	223,620	1,854,863	13,488,748	24,658,965
6.2 Roads District 2	10.2	2,346,996	234,700	46,940	234,700	2,863,335	1,239,050	743,200	4,845,586	61,356	586,749	2,076,377	7,570,067
6.3 Roads District 3	9.5	2,681,145	268,115	53,623	268,115	3,270,997	1,148,054	543,900	4,962,952	56,850	670,286	961,804	6,651,892
6.4 Roads District 4	27.3	7,408,405	740,840	148,168	740,840	9,038,254	1,963,946	79,200	11,081,400	163,572	1,852,101	2,016,145	15,113,218
6.5 Roads District 5	26.7	6,866,944	686,694	137,339	686,694	8,377,671	2,177,798	231,600	10,787,069	160,116	1,716,736	2,635,621	15,299,542
7 Improvement of Catembe Roads	9.0	5,119,025	511,903	102,381	511,903	6,245,211	0	0	6,245,211	54,000	1,279,756	0	7,578,967
Total	263	103,244,200	10,324,420	2,064,884	10,324,420	125,957,925	12,860,810	3,668,200	142,486,935	1,546,830	25,811,050	21,178,695	191,023,509

Plan 6

Project	Road Length (km)	Construction Cost (USD)	Contingency (USD)	Administration Cost (USD)	Engineering Service (USD)	Subtotal (USD)	Relocation Cost of Public Utilities (USD)	House Compensation Cost (USD)	Project Cost (USD)	Maintenance Cost 1 (Before Project) (USD)	Maintenance Cost2 (After Project) (USD)	Maintenance Cost3(USD)	Cost Grand Total (USD)
1 Public Transport(Bus Terminal)	0.0	1,385,000	138,500	27,700	138,500	1,689,700	0	0	1,689,700	0	346,250	0	2,035,950
2 Traffic Circulation(Link Signal)	0.0	2,430,000	243,000	48,600	243,000	2,964,600	0	0	2,964,600	0	607,500	0	3,572,100
3 Grade Separation(2 no.)	0.0	4,300,000	430,000	86,000	430,000	5,246,000	0	238,900	5,484,900	0	1,075,000	0	6,559,900
4 Construction of Primary Trunk Roads	15.1	30,422,876	3,042,288	608,458	3,042,288	37,115,909	0	0	37,115,909	180,600	7,605,719	0	44,902,228
5 Construction of Trunk Roads	53.9	37,164,356	3,716,436	743,287	3,716,436	45,340,514	6,331,962	2,030,300	53,702,775	646,716	9,291,089	0	63,640,580
6 Improvement / Rehabilitation of Collector Roads	92.3	26,722,943	2,672,294	534,459	2,672,294	32,601,991	6,528,849	1,637,900	40,768,739	665,514	6,680,736	21,178,695	69,293,684
6.1 Roads District 1	18.6	7,419,453	741,945	148,389	741,945	9,051,733	0	40,000	9,091,733	223,620	1,854,863	13,488,748	24,658,965
6.2 Roads District 2	10.2	2,346,996	234,700	46,940	234,700	2,863,335	1,239,050	743,200	4,845,586	61,356	586,749	2,076,377	7,570,067
6.3 Roads District 3	9.5	2,681,145	268,115	53,623	268,115	3,270,997	1,148,054	543,900	4,962,952	56,850	670,286	961,804	6,651,892
6.4 Roads District 4	27.3	7,408,405	740,840	148,168	740,840	9,038,254	1,963,946	79,200	11,081,400	163,572	1,852,101	2,016,145	15,113,218
6.5 Roads District 5	26.7	6,866,944	686,694	137,339	686,694	8,377,671	2,177,798	231,600	10,787,069	160,116	1,716,736	2,635,621	15,299,542
7 Improvement of Catembe Roads	9.0	5,119,025	511,903	102,381	511,903	6,245,211	0	0	6,245,211	54,000	1,279,756	0	7,578,967
Total	263	107,544,200	10,754,420	2,150,884	10,754,420	131,203,925	12,860,810	3,907,100	147,971,835	1,546,830	26,886,050	21,178,695	197,583,409

11.4.3 Results of Future Traffic Assignment

Figure 11.4.8-13 shows the results of Future Traffic Congestion of each road development alternatives in the year of 2020.

In case of the Do Minimum, the bottleneck links having more than 1.5 volume to capacity ratio could be identified as almost all links on the Trunk Roads by the year 2020. This shows the road network of the Do Minimum will not functioned well against the long-term traffic demand.

In case of Plans 1 and 3, the bottleneck links would become minimum on the Trunk Road network except in the city center. These bottlenecks especially at the intersections would be settled out through the improvement of intersections and Traffic Management Plan. Therefore, Plans 1 and 3 would be well matched to the long-term traffic demand and are recommendable road network option for long-term period.

In case of Plan 2, bottlenecks could be identified on the Trunk Road network and in the city center. This network is not so well matched to the long-term traffic demand and accordingly Plan2 alternative is not recommendable from the viewpoint of traffic efficiency.

In case of Plan 4, bottlenecks would become minimum on the Trunk Road network and this also could become one of the recommendable road network for further consideration.

Bottlenecks on the Trunk Road networks could be identified in Plan 5 and 6 in the year of 2020 and this shows both of these road networks are not recommendable from the viewpoint of traffic efficiency.

On the other hand, the total average speed of the Do Minimum network in the year of 2020 would drop down to 13.5 km/hr from existing average speed of 30.6 km/hr due to the total congestion rate of 1.51 compared to the existing rate of 0.59. (see Figure 11.4.14)

While the total average speeds of each alternative networks in the year of 2020 would become almost same level of the existing average speed and the total congestion rates of each alternative networks shows slightly lower than 1.0 except Plans 2 and 5.

From these evaluations, the road networks which could meet the future traffic demand efficiently would be the road networks of Plans 1, 3 and 4 from the viewpoint of traffic functions required for long-term road development. The details of the future traffic assignment on each alternative road networks are shown in the Chapter 9.

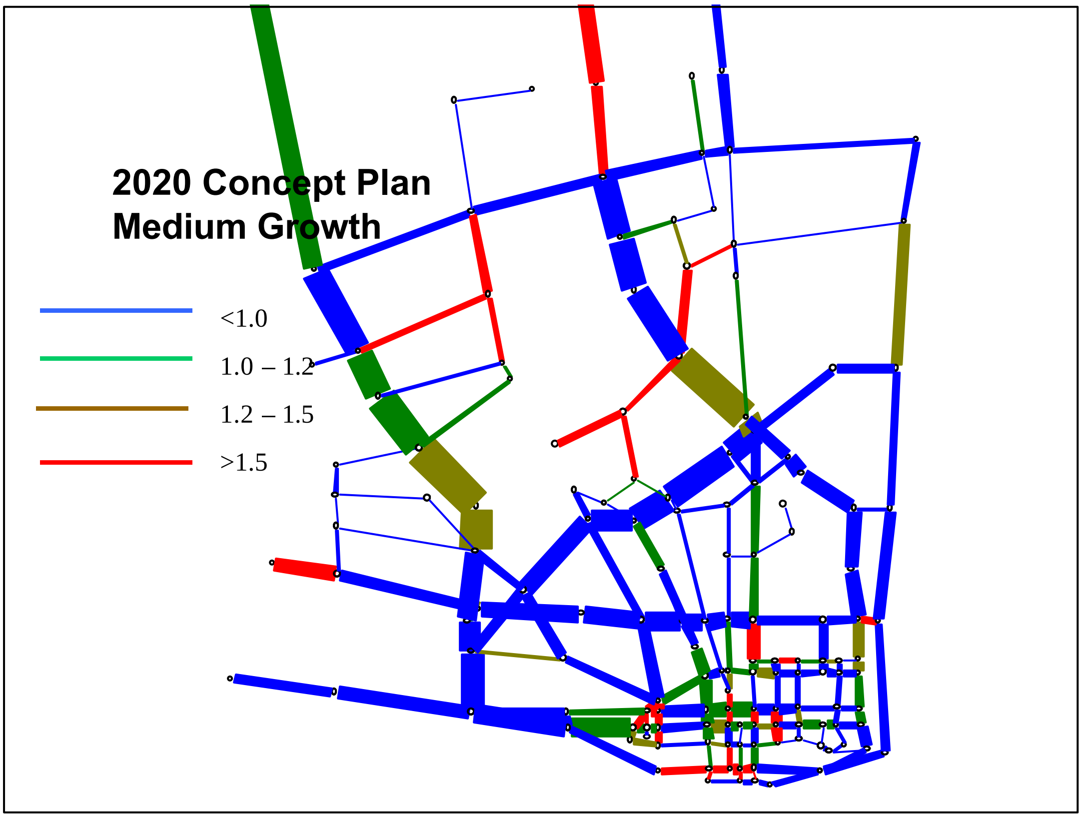


Figure 11.4.8 Future Traffic Assignment on Plan 1

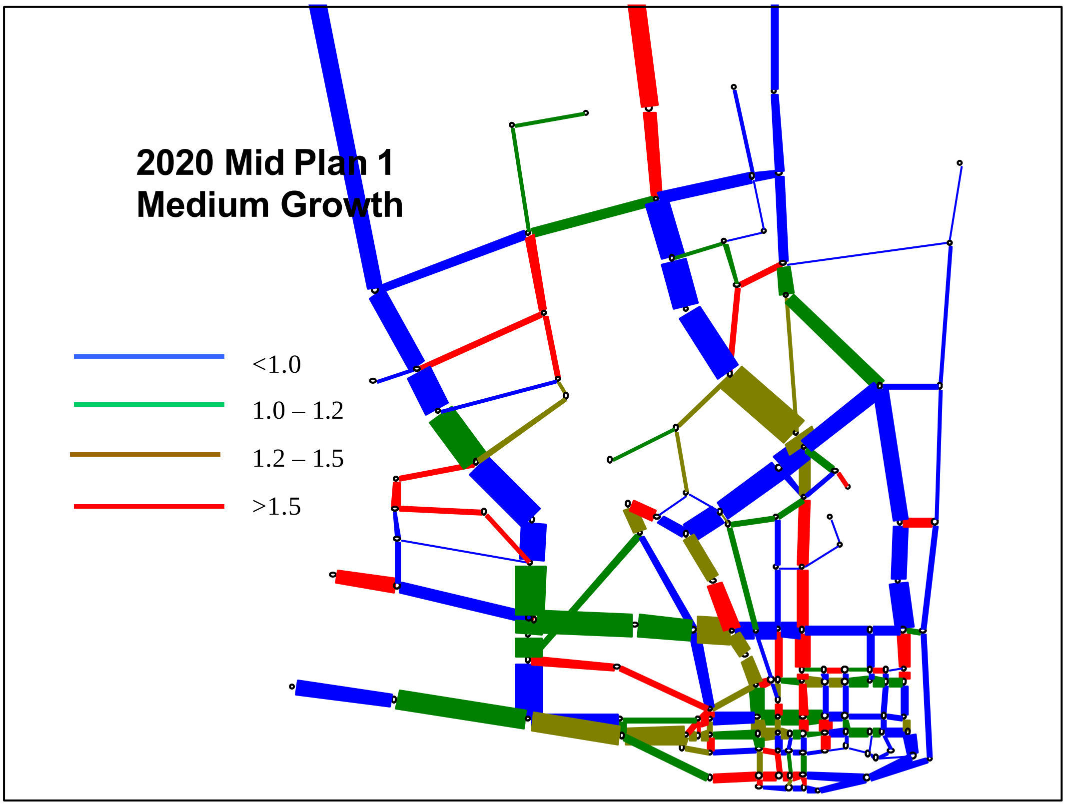


Figure 11.4.9 Future Traffic Assignment on Plan 2

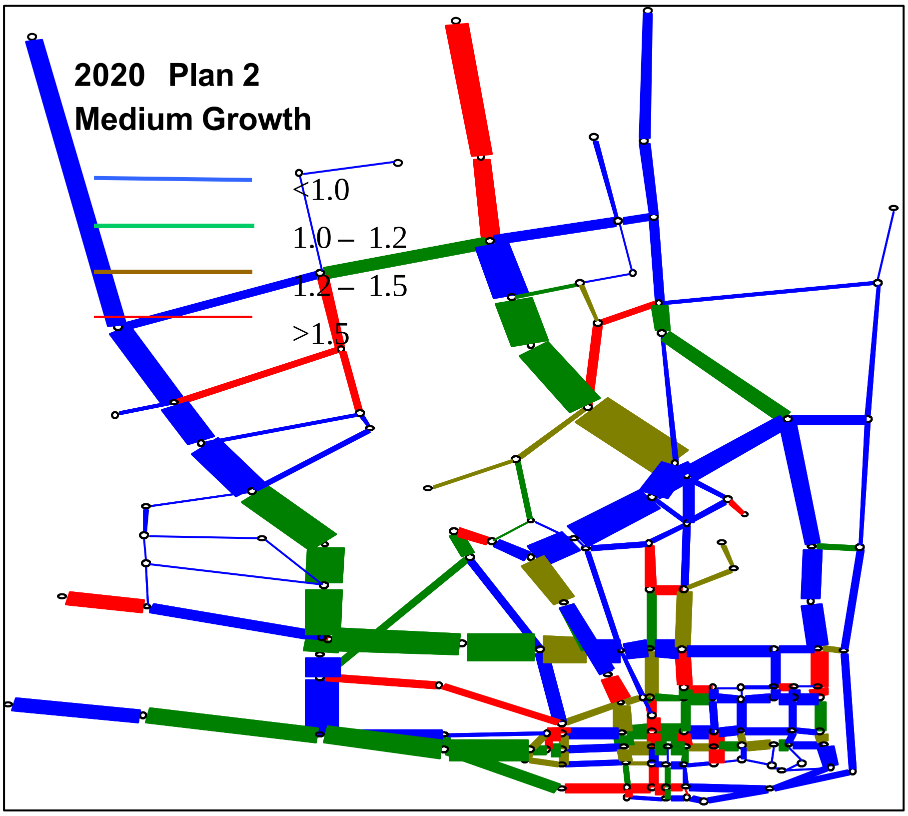


Figure 11.4.10 Future Traffic Assignment on Plan 3

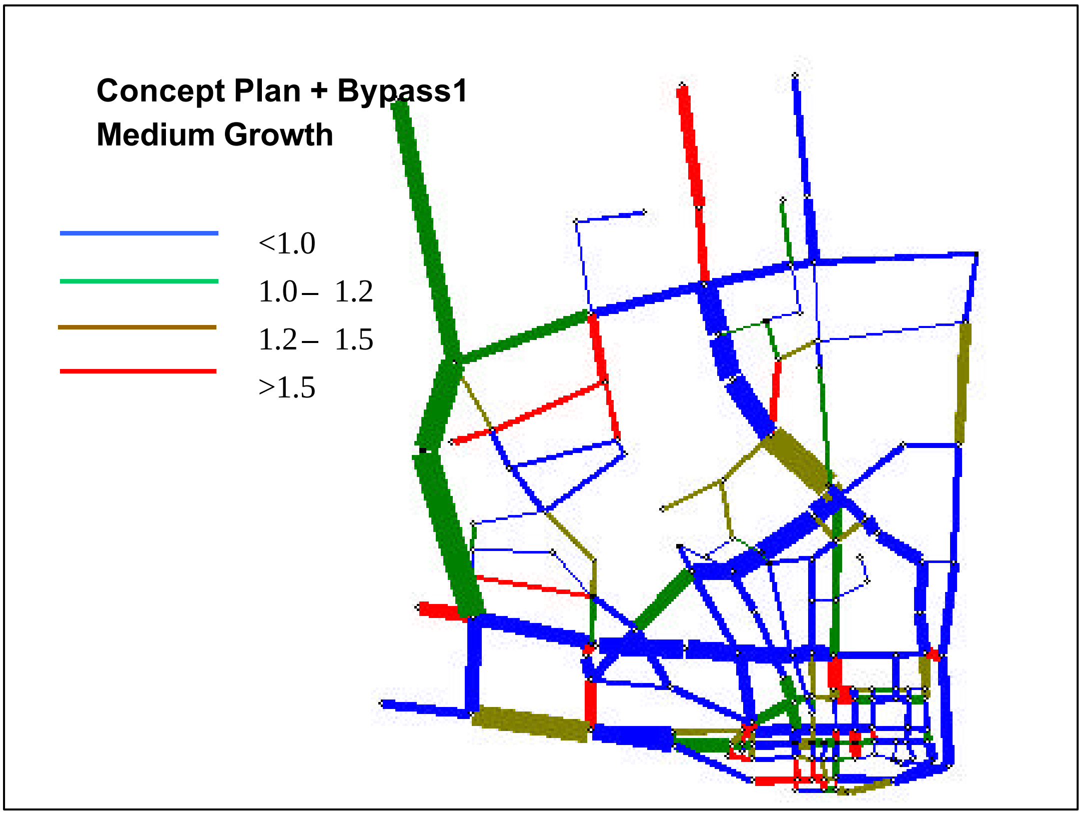


Figure 11.4.11 Future Traffic Assignment on Plan 4

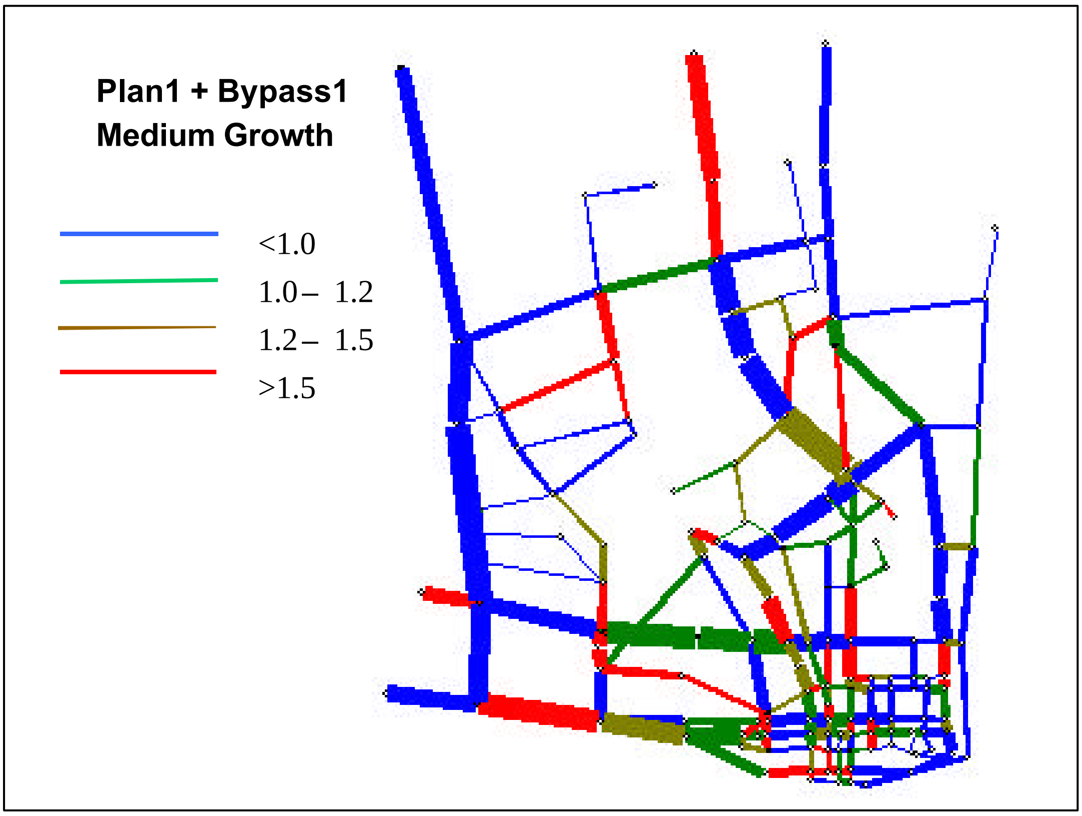


Figure 11.4.12 Future Traffic Assignment on Plan 5

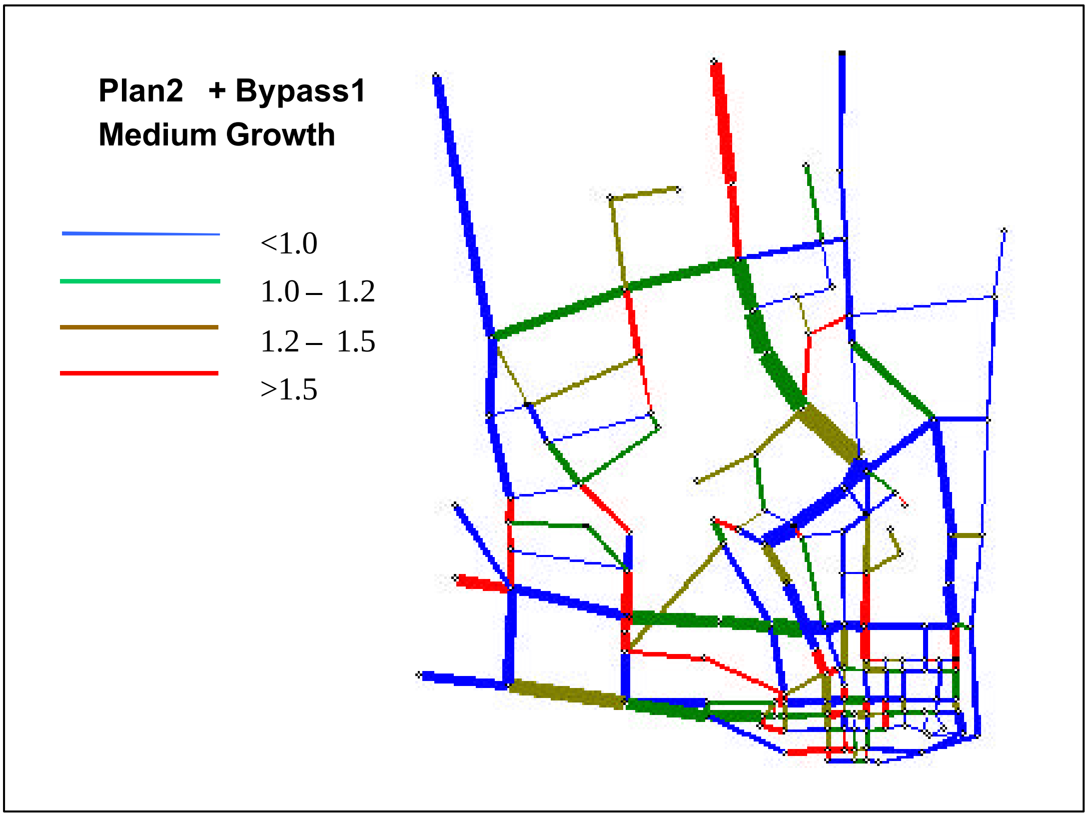
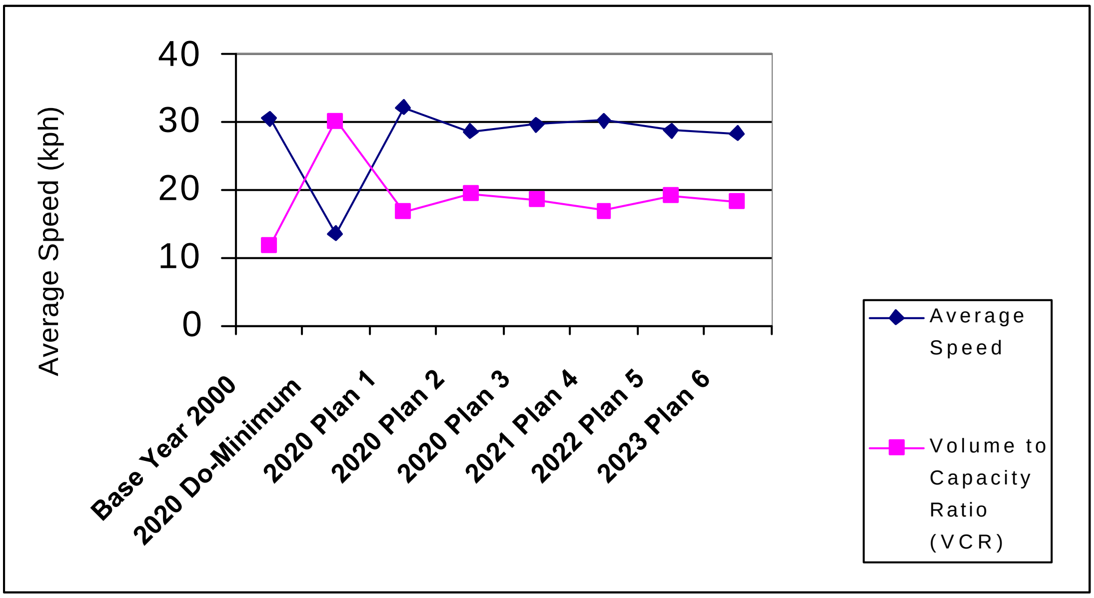


Figure 11.4.13 Future Traffic Assignment on Plan 6



	Average Speed	Volume to Capacity Ratio (VCR)
Base Year 2000	30.6	0.59
2020 Do-Minimum	13.5	1.51
2020 Plan 1	32.2	0.84
2020 Plan 2	28.6	0.97
2020 Plan 3	29.7	0.93
2021 Plan 4	30.3	0.85
2022 Plan 5	28.8	0.96
2023 Plan 6	28.4	0.91

Fig.11.4.14 Total Average Speed and Service Level of each Alternatives

11.5 ECONOMIC ANALYSIS

11.5.1 General

In this section, economic analysis is conducted to evaluate economic viability of alternative long-term road network plans and to identify the best alternative network plan in terms of economic performance. The economic evaluation is carried out by estimating and comparing the benefit-cost ratio (B/C) for each alternative road network in year 2020, which is target year for the formulation of long term road network plan.

For economic analysis of a road or a road network, it has been established that the benefit is calculated from savings of costs related to vehicle transport, named "Vehicle Operating Cost". It must be easily understood that vehicle transport consumes several items such as fuel, oil, tires, and body itself in the long run. Not only goods but evenly it contains other invisible items such as time of passengers, drivers, and maintenance crews, while a vehicle needs car insurance and car registration when it needs to run. These are all costs related to the vehicle, and such costs are inevitable to accrue with the running of a vehicle, but substantially it is varied when the surface of road or traffic flow speeds change.

Table 11.5.1 List of Costs Incurred by the Running of Vehicle

Vehicle	Time	Overhead
Fuel cost	Values of	Insurance cost
Tire cost	Passenger's time	Administration cost
Oil / Lubricant cost	Driver's time	
Maintenance cost	Crew's time	
Depreciation cost		

Source: JICA Study Team

Thus, this study calculates the benefit of alternative plans mainly from savings of such costs (VOC) by implementation of each alternative plan in comparison with "Do minimum" plan. Here "Do minimum" is defied as to that only recurrent maintenance is conducted to keep the current situation of roads. By letting the "Do minimum plan" be a base case, benefits of six plans from Plan1 to Plan 6 are calculated.

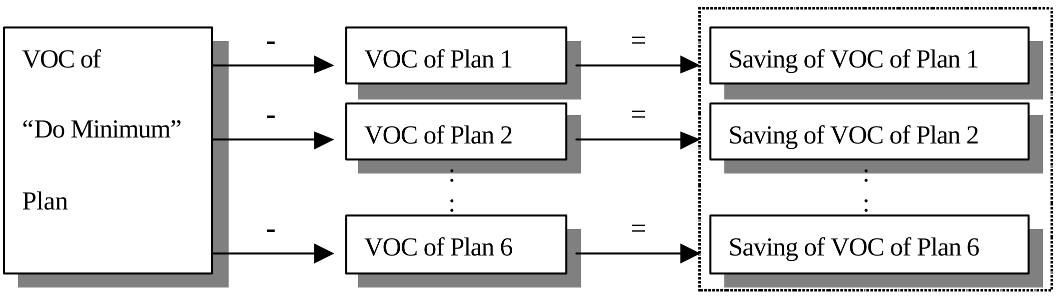


Figure 11.5.1 Benefit of Alternative Road Network Plans

Besides, there are current arguments that road network development must have produced various other types of benefits while incurring other types of costs. For example, some studies showed that road development is quite effective to incubate small enterprises in developing countries. There are also some evidences that well planned road network that make the traffic flow smooth, would reduce the air pollution. Indeed, some developed countries have started to take into account of these environmental benefits into the benefits. Meanwhile, there is a criticism of road network development in guilty of destroying social community by resettling traditional community.

While it seems to be quite right to admit that these benefits and costs accrued from the road network development exist as a concept, they are still called "intangible" benefits and costs, because simply it is quite difficult to calculate the economic values of these items. There have been a lot of attempts to do so, but it seems to be fair to conclude that any attempt cannot reach the point to become the standard method such as VOC.

Therefore, this economic analysis takes only the tangible benefits and costs into the calculation.

11.5.2 Economic Price

In economic analysis, all market (or financial) prices should be transformed into economic prices. Its rationale is that the market price contains various "disturbances" such as tax, subsidy, price regulation etc. Economic analysis aims to examine the real benefit and cost for the society (or the nation). Therefore, real values of goods and services have to be measured in economic prices.

For economic analysis of roads, it is required that both construction and maintenance costs, and vehicle operating costs are quoted net of all taxes, duties, government subsidy, price control and the effects of shortages of labor and foreign exchange.

In practice, however, this task is tedious to accomplish in a strict term and it is quite often the case that the effort to pursue the "accurate" economic price is fruitless compared with amount of works needed.

Thus, in the case of that a country has already established the model of economic price calculation, it has been thought as proper to follow the established model, rather than establishing a new model in erratic and temporal manner. Using an established model is also appreciated in the sense that the value calculated from the established model is consistent and capable of being compared with similar projects out of the study.

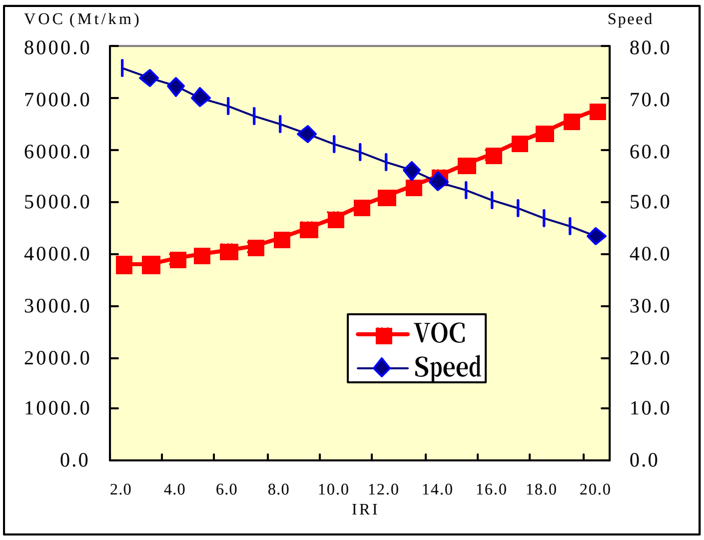
In this study, the Mozambican has already established a model of calculating the VOC, which will be reviewed in the following section and applied as a base model in this economic analysis.

11.5.3 HNMS-VOC Model

For calculation of VOC, Mozambique has already established a computerized model of calculating VOC within advanced computer software, named “Highway Network Management System (HNMS)”. HNMS is a set of customized computer programmes for Mozambique’s highway development and substantially developed in the ROCS programmes supported by World Bank. HNMS is the integrated computerized system, which allocates various modules, including VOC calibration module.

The HNMS has built a VOC model within the system by utilizing HDMIII, which is one of the leading computer programs for calculating VOC, developed by the World Bank.

The HNMS-VOC model calculates VOC along with the level of the International Roughness Index (IRI). IRI is one of the world standards of measuring roughness on the surface of road, and it ranges from 2 to 20 m/km. The larger IRI it measures, the more roughness the road gets. The VOC model presents also the desired speed of each IRI. The relationship among VOC, IRI, and speed can be visualized as follows.



$$VOCi = DCi + TCi$$
$$DCi = a + b(\max(IRIi - 3{,}0)) + g(\max(IRIi - d))$$
$$TCi = t / SPi$$
$$SPi = (a - b(IRIi))$$

where,

VOCi= Vehicle Operating cost (Mt./Km)

DCi = Distance-related cost

TCi = Time-related cost

SPi = Speed

IRI = International roughness index

Others are coefficients given by HNMS

Figure 11.5.2 Relationship of IRI, VOC, and Speed in HNMS-VOC Model

This VOC contains passenger time cost in its value as one of the time-related costs.

Since the VOC model of the HNMS has been formulated for evaluating road projects in Mozambique and currently used as a de-facto model, the model seems to be substantially related to this study, too. According to the manual of the HNMS-VOC, the all data for the VOC model were taken from a survey conducted in Maputo.

The study team conducted a supplement survey on the data used in the model, and found that the data is reasonable and stable for its application into the study. Thus, the HNMS-VOC model is applied in this study, although some modification is needed for full application.

11.5.4 Methodology

The economic analysis of alternative plans shall be conducted by comparing the VOC saving of alternative plans to the base plan.

While the HNMS-VOC model is used in calibration of VOC in this analysis, there are some modification needed for full application.

Firstly, while the basic estimates of the cost components in the VOC have to be adjusted with travelling speeds, the original HNMS-VOC model is not capable to calculate the VOC in different ranges of speed. Thus, additional calibration is needed in order to set the VOC in each speed range. By the calibration of the VOC in each speed range in each IRI group, the output image of the VOC is in a form of matrix. Secondly, the input data in the HNMS-VOC model is expressed in price level of year 1998, therefore, some consumer price inflation rate is applied to adjust the price into the price of year 2000. Through the above modification, the VOC matrix for each traffic mode is composed.

Meanwhile, the traffic assignment result is also summed into the same fashion, i.e., the vehicle-km of each traffic mode on each link is diversified into each respective speed range in each respective IRI category. IRI categorization is made for each link from the road inventory survey result. This process produces the Vehicle-km matrix for each traffic mode.

Calculation of VOC of alternative network is made by multiplying the VOC matrix and Vehicle-km matrix of each traffic mode. The process is described as follows.

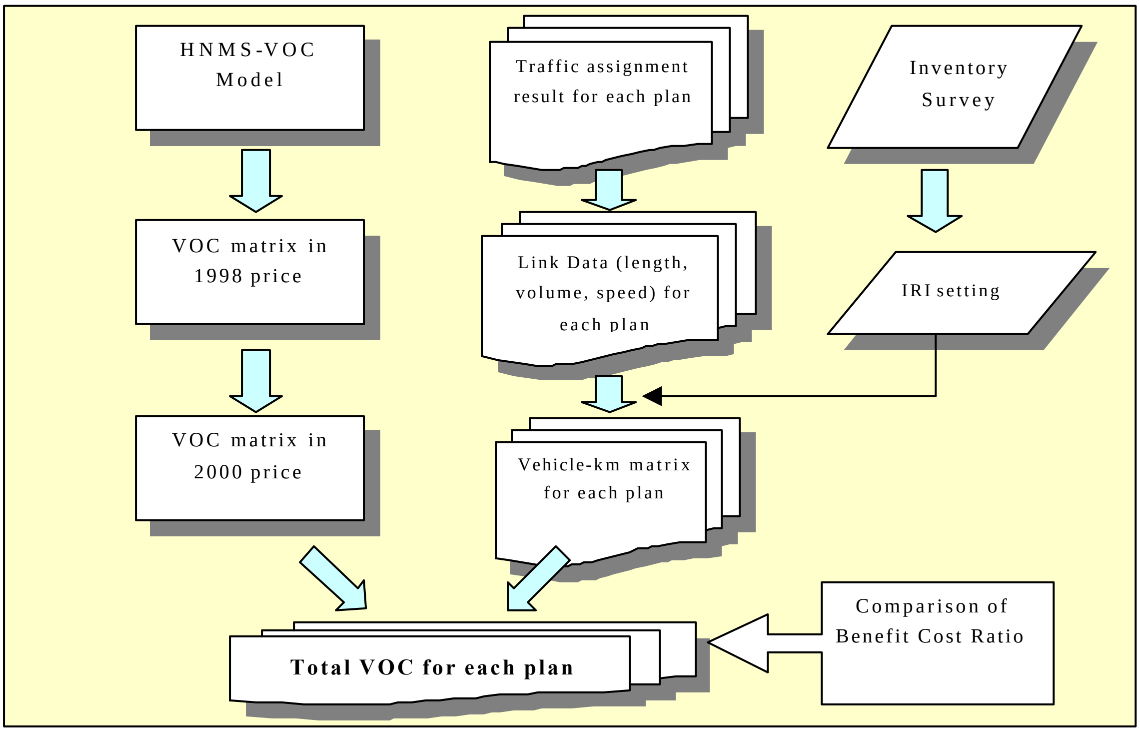


Figure 11.5.3 The Process of Economic Analysis

11.5.5 VOC Model

1) Input data for the HNMS-VOC model

Input data for the HNMS-VOC model is described in Table 11.5.2.

Table 11.5.2 Input Data in the HNMS-VOC Model

Meticas In 1998 Price

Economic Costs	Cars	Pickups	Minibuses	Buses	2-3 axle	4 axle trucks	Artics
Typical Model	Toyota Corolla	Toyota Hilux	Toyota Hiace	Toyota Coaster	Mitsubishi Canter	Hino 8 tonne	Mercedes 2024
Tyre Size	165/13	185/14	165/13	315-80 R22.5	650-16	1000-20	1000-20
New Vehicle Price	176,101,852	197,926,440	261,895,062	813,105,967	410,083,333	650,000,000	715,000,000
Tyre Cost	390,432	556,790	390,432	3,394,383	706,173	2,237,346	2,237,346
Maintenance Labour Cost	6,875	13,021	6,875	21,875	21,875	21,875	21,875
Operating Overheads	8,558,875	9,603,479	12,665,250	43,348,208	16,103,250	25,460,000	32,870,000
Crew Cost	10,417	31,250	51,708	51,708	41,938	41,938	41,938
Passenger Time Value	8,778	15,015	568	568	1,746	1,746	1,746

Basic Characteristics	Cars	Pickups	Minibuses	Buses	2-3 axle	4 axle trucks	Artics
Gross Vehicle Weight (tonnes)	1.5	2	2	12	12	24	40
No of Axles	2	2	2	2	2	4	6
No of Tyres	4	4	4	6	6	14	22
Equivalent Standard Axles	0	0	0	1.25	2.2	3	4.4
No of Passengers	3	3	12	50	1	1	1

Vehicle Utilisation Data	Cars	Pickups	Minibuses	Buses	2-3 axle	4 axle trucks	Artics
Service Life (yrs)	8	6	7	7	8	8	8
Hours Driven per Year	300	350	2000	2000	700	900	900
Kms Driven per Year	20000	25000	100000	130000	40000	55000	55000
Hourly Utilisation Ratio	0.6	0.5	0.7	0.7	0.5	0.5	0.5
Annual Interest Rate %	21.55%	21.55%	21.55%	21.55%	21.55%	21.55%	21.55%

Fuel Information	Cars	Pickups	Minibuses	Buses	2-3 axle	4 axle trucks	Artics
Fuel Type Used	Petrol	Diesel	Petrol	Diesel	Diesel	Diesel	Diesel

Fuel Costs (Economic)	Petrol	Diesel	Lubricants
Cost per litre	4,173	2,425	22,082

Source: HNMS of ANE

2) VOC in HNMS

With these input data, HNMS uses the HDM III model to calculate the VOC and the desired speed in each group. The calculation output is summarized as follows.

Table 11.5.3 VOC in HNMS

unit: Meticas / km

	IRI	2	4	6	8	10	12	14	16	18	20
Car	*Speed*	*74.3*	*73.6*	*63.7*	*68.5*		*58.3*	*52.7*	*47.7*	*43.5*	*39.6*
	VOC	3,789	3,871	4,058	4,326	4,694	5,086	5,513	5,935	6,341	6,775
Bus	*Speed*	*62.5*	*61.9*	*60.4*	*57.4*	*53.2*	*48.6*	*43.8*	*39.6*	*36.0*	*32.8*
	VOC	5,795	5,929	6,191	6,562	7,056	7,656	8,403	9,210	10,036	10,954
M-truck	*Speed*	*56.9*	*55.8*	*53.8*	*50.6*	*46.7*	*42.6*	*38.5*	*34.9*	*32.0*	*29.2*
	VOC	5,163	5,446	5,982	6,607	7,316	8,078	8,939	9,807	10,655	11,559
L-truck	*Speed*	*53.0*	*51.8*	*49.6*	*46.5*	*42.7*	*38.9*	*35.2*	*31.9*	*29.2*	*26.8*
	VOC	7,448	7,843	8,570	9,391	10,295	11,248	12,313	13,383	14,427	15,540

3) Calibration of VOC matrix

From the relationship among IRI, VOC, and the desired speed in the HNMS-VOC model, the VOC matrix is calibrated to be capable in consideration of speed change and it is also consistent with the VOC in the HNMS model. The VOC matrix is adjusted into the price of year 2000 by multiplying the inflation rate of 1.174. The final VOC matrix is composed as follows.

Table 11.5.4 VOC Matrix for each Traffic Mode

MODE 1 (Car) VOC matrix (2000 price) Unit: 000 Meticas / 1000 kim

Speed/IRI	2	4	6	8	10	12	14	16	18	20
-5	10,351	10,440	10,619	10,864	11,309	11,755	12,201	12,646	13,092	13,537
5-10	8,772	8,862	9,040	9,285	9,731	10,176	10,622	11,067	11,513	11,959
10-15	6,667	6,757	6,935	7,180	7,626	8,071	8,517	8,962	9,408	9,854
15-20	5,878	5,967	6,146	6,391	6,836	7,282	7,728	8,173	8,619	9,064
20-25	5,457	5,546	5,725	5,970	6,415	6,861	7,307	7,752	8,198	8,643
25-30	5,194	5,283	5,462	5,707	6,152	6,598	7,043	7,489	7,935	8,380
30-35	5,014	5,103	5,281	5,526	5,972	6,417	6,863	7,309	7,754	8,200
35-40	4,882	4,971	5,150	5,395	5,840	6,286	6,731	7,177	7,623	8,068
40-45	4,782	4,871	5,049	5,295	5,740	6,186	6,631	7,077	7,522	7,968
45-50	4,703	4,792	4,970	5,216	5,661	6,107	6,552	6,998	7,443	7,889
50-55	4,639	4,728	4,907	5,152	5,597	6,043	6,488	6,934	7,380	7,825
55-60	4,586	4,676	4,854	5,099	5,545	5,990	6,436	6,881	7,327	7,773
60-65	4,542	4,631	4,810	5,055	5,501	5,946	6,392	6,837	7,283	7,728
65-70	4,505	4,594	4,772	5,017	5,463	5,909	6,354	6,800	7,245	7,691
70-75	4,472	4,561	4,740	4,985	5,431	5,876	6,322	6,767	7,213	7,658
75-80	4,444	4,533	4,712	4,957	5,402	5,848	6,294	6,739	7,185	7,630
80-	4,431	4,520	4,699	4,944	5,389	5,835	6,280	6,726	7,171	7,617

MODE 2 (Truck) VOC matrix (2000 price) Unit: 000 Meticas / 1000 kim

Speed/IRI	2	4	6	8	10	12	14	16	18	20
-5	9,056	9,238	9,601	10,031	10,676	11,326	11,976	12,627	13,277	13,927
5-10	8,034	8,216	8,580	9,009	9,654	10,304	10,955	11,605	12,255	12,906
10-15	6,672	6,854	7,217	7,647	8,292	8,942	9,592	10,243	10,893	11,543
15-20	6,161	6,343	6,706	7,136	7,781	8,431	9,081	9,732	10,382	11,032
20-25	5,888	6,070	6,434	6,864	7,508	8,159	8,809	9,459	10,110	10,760
25-30	5,718	5,900	6,264	6,693	7,338	7,988	8,639	9,289	9,939	10,590
30-35	5,601	5,783	6,147	6,576	7,221	7,871	8,522	9,172	9,822	10,473
35-40	5,516	5,698	6,062	6,491	7,136	7,786	8,437	9,087	9,737	10,388
40-45	5,451	5,633	5,997	6,426	7,071	7,721	8,372	9,022	9,672	10,323
45-50	5,400	5,582	5,946	6,375	7,020	7,670	8,321	8,971	9,621	10,272
50-55	5,359	5,541	5,904	6,334	6,979	7,629	8,279	8,930	9,580	10,230
55-60	5,325	5,507	5,870	6,300	6,945	7,595	8,245	8,896	9,546	10,196
60-65	5,296	5,478	5,842	6,271	6,916	7,566	8,217	8,867	9,517	10,168
65-70	5,272	5,454	5,817	6,247	6,892	7,542	8,192	8,843	9,493	10,143
70-75	5,251	5,433	5,796	6,226	6,871	7,521	8,171	8,822	9,472	10,122
75-80	5,233	5,414	5,778	6,208	6,853	7,503	8,153	8,804	9,454	10,104
80-	5,224	5,406	5,770	6,199	6,844	7,494	8,145	8,795	9,445	10,096

MODE 3 (Bus) VOC matrix (2000 price) Unit: 000 Meticas / 1000 kim

Speed/IRI	2	4	6	8	10	12	14	16	18	20
-5	13,029	13,197	13,532	13,868	14,331	15,174	16,018	16,862	17,705	18,549
5-10	11,327	11,495	11,830	12,166	12,629	13,472	14,316	15,160	16,004	16,847
10-15	9,058	9,225	9,561	9,897	10,359	11,203	12,047	12,891	13,734	14,578
15-20	8,207	8,374	8,710	9,046	9,508	10,352	11,196	12,040	12,883	13,727
20-25	7,753	7,921	8,256	8,592	9,055	9,898	10,742	11,586	12,429	13,273
25-30	7,469	7,637	7,973	8,308	8,771	9,615	10,458	11,302	12,146	12,989
30-35	7,275	7,442	7,778	8,114	8,576	9,420	10,264	11,108	11,951	12,795
35-40	7,133	7,301	7,636	7,972	8,435	9,278	10,122	10,966	11,809	12,653
40-45	7,025	7,192	7,528	7,864	8,327	9,170	10,014	10,858	11,701	12,545
45-50	6,940	7,107	7,443	7,779	8,241	9,085	9,929	10,773	11,616	12,460
50-55	6,871	7,039	7,374	7,710	8,173	9,016	9,860	10,704	11,547	12,391
55-60	6,814	6,982	7,318	7,653	8,116	8,960	9,803	10,647	11,491	12,334
60-65	6,766	6,934	7,270	7,606	8,068	8,912	9,756	10,599	11,443	12,287
65-70	6,726	6,894	7,229	7,565	8,028	8,872	9,715	10,559	11,403	12,246
70-75	6,691	6,859	7,195	7,530	7,993	8,837	9,680	10,524	11,368	12,211
75-80	6,661	6,828	7,164	7,500	7,963	8,806	9,650	10,494	11,337	12,181
80-	6,646	6,814	7,150	7,486	7,948	8,792	9,636	10,479	11,323	12,167

The relationship among IRI, VOC, and speed can be easily understood in the following figure.

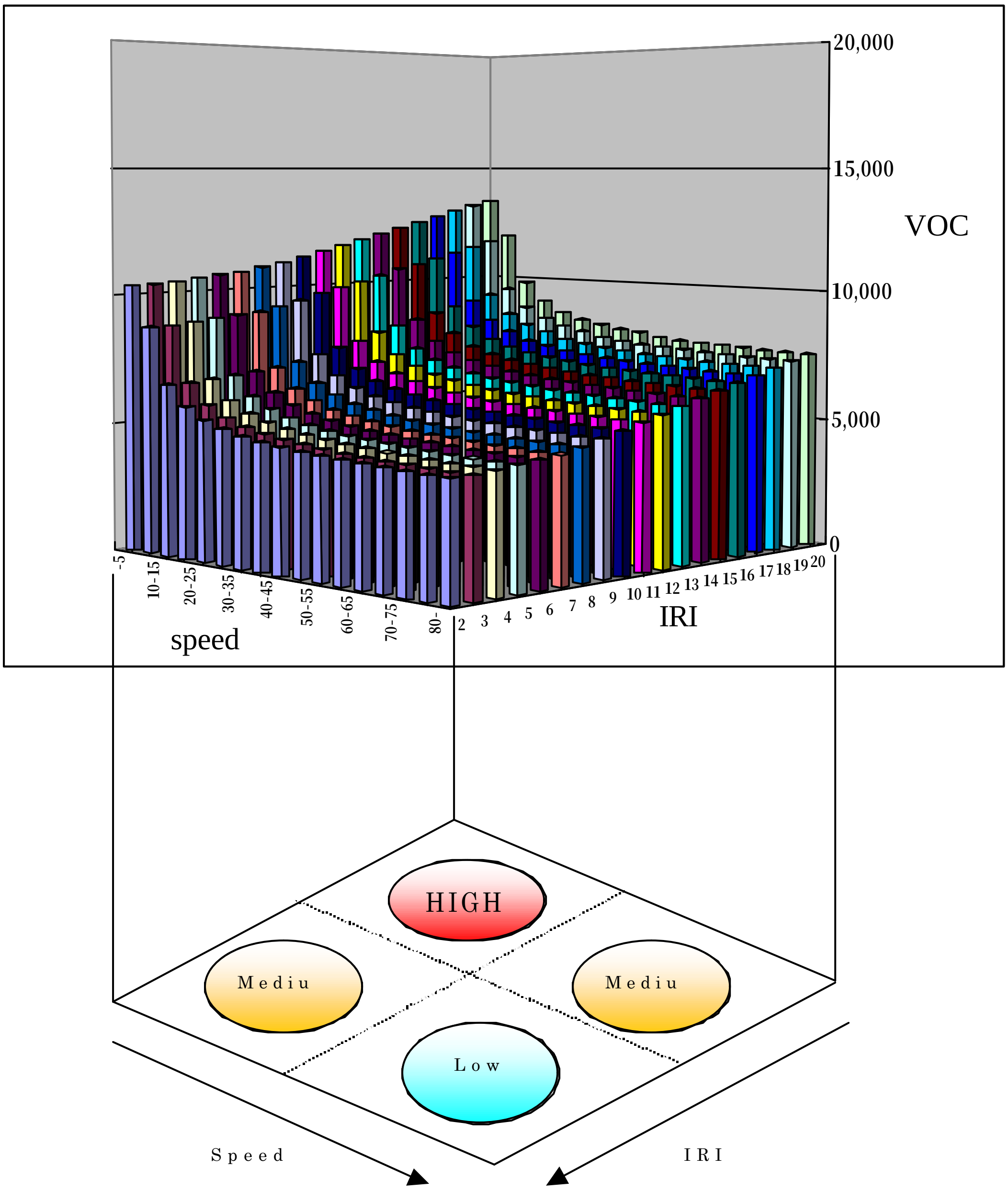


Figure 11.5.4 VOC in Relationship with Speed and IRI for Cars

As seen in the Figure 11.5.4, VOC is changed with speed and IRI. The better IRI and the faster speed, the less VOC it accrues. The less VOC means the less cost and it means effective transport. It seems, therefore, that the road development and maintenance should be taken into account not only of the improvement IRI through physical maintenance of roads, but also of the improvement of traffic speeds through the development of effective road "network".

11.5.6 Vehicle-Km Matrices of Alternative Plans

The study team has formulated six network plans from Plan 1 to Plan 6, while "Do-minimum plan" is also prepared as a base case, which is used to calculate the saving of VOC of each plan.

From traffic assignment results, the vehicle-km matrices of alternative plans are calculated. A vehicle-km matrix shows the total vehicle-km accrued within a network in each speed and each IRI group. IRI grouping is made on the results of road inventory survey conducted by the study team.

Needless to say, less vehicle-km in less IRI group and higher speed group mean less VOC, which produce much more benefit. An example is shown in the following figure, with which a reader can visualize the difference of vehicle-km not only in speed but also in IRI.

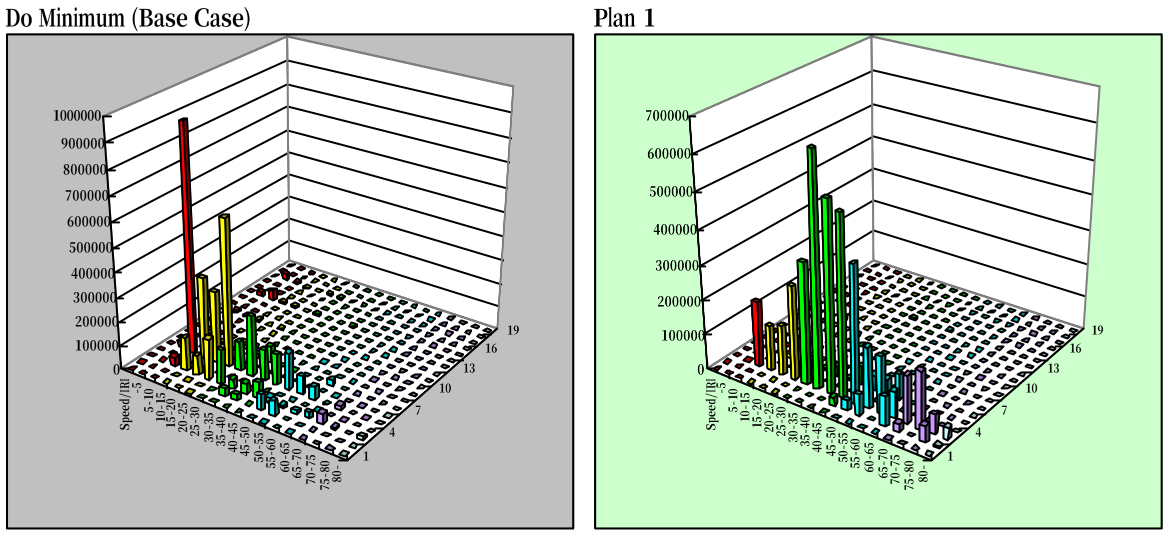


Figure 11.5.5 Comparison of Vehicle-Km in Base Case and Plan 1

The vehicle-km matrix of "Do minimum" plan shows very high volume of traffic with in very low speed, less than 10km/h, and "Do minimum plan" also shows some traffic is running on very rough roads with more than 10 of IRI.

On the other hand, Plan 1 obviously improve the situation, where most of traffic are running in fair speed from 20 to 30 km/h, and virtually all of traffic are running on smooth roads.

For calculation of total VOC of each alternative plan, each vehicle-km matrix of alternative plans is multiplied with the VOC matrix.

11.5.7 Economic Analysis of Alternative Master Plans

The study team has formulated six network plans from Plan 1 to Plan 6, while the network of "Do minimum" case is also made as a base case.

The benefit is calculated by subtracting the VOC of respective plan from the VOC of the "Do minimum" case. This would be thought as a surplus that the society acquires by implementation of the respective plan.

The cost is needed to be discounted into economic cost, which deduct the fringe value of market price, such as import tax, subsidy and wage regulation. Since all alternative plans have virtually the same cost structure and the aim of this analysis is to prioritize the best alternatives, a standardized conversion factor of 0.9 is applied to all alternatives, while Base case contains much of labor-oriented maintenance so that SCF of 0.7 is applied.

From the total economic cost, annual cost is estimated by assuming 5 years of the investment period and an interest rate of 12% per annum. The following equation is used.

Annualized Cost = Total Cost x R x [(1+R)^n]/[(1+R)^n - 1]

Where, R = discount rate (12%) and n = investment period (5 years)

From this context, the comparison of economic analysis results is described as follows.

Table 11.5.5 Comparison of economic analysis results

	PCU-km	PCU-hour	VOC ($/day)	VOC (mil.$ / year)	① **Benefit (mil.$ / year)**	Total Cost (mil.$)	Net Total Cost (mil. $)	② **Cost (mil.$ / year)**	①/②
Do minimum (Base Case)	*4,543,801*	*337,439*	*1,850,576*	*675.5*	***0.0***	*12.0*	-	**-**	**-**
Plan 1	4,506,895	140,114	1,489,253	543.6	**131.9**	192.6	180.6	**50.1**	**2.63**
Plan 2	4,619,160	161,354	1,530,305	558.6	**116.9**	155.8	143.8	**39.9**	**2.93**
Plan 3	4,562,664	153,613	1,505,729	549.6	**125.9**	161.7	149.7	**41.5**	**3.03**
Plan 4	4,521,176	149,241	1,498,949	547.1	**128.3**	208.8	196.8	**54.6**	**2.35**
Plan 5	4,595,195	159,284	1,520,195	554.9	**120.6**	171.9	159.9	**44.4**	**2.72**
Plan 6	4,661,212	166,181	1,550,304	565.9	**109.6**	177.8	165.8	**46.0**	**2.38**

Source: JICA Study Team

When comparing the cost-benefit ratios of alternative plans, it can be concluded that "Plan 3" is the most recommended plan in terms of economic efficiency.

In a strict term, it is remarked that above cost-benefit ratio is not the same to B/C in a cash flow analysis, which needs primarily to formulate an implementation schedule as explained in the following chapter. From high values of annual benefits, however, it is quite obvious that the road development project, in almost any type, is quite beneficial in Maputo, where the traffic demands are going to grow and swell rapidly.

11.6 FINANCIAL ANALYSIS

11.6.1 General

In this section, financial analysis is conducted in order to formulate a financial arrangement plan for the Master Plan's implementation.

As seen in the financial review of the MCM, the funding source of the MCM for road development and maintenance is limited due to the lack of stable source of revenue and the lack of institutional ability of the MCM. It is practically impossible to expect the MCM to cover the all costs accrued from the implementation of the Master Plan.

The situation is the same even in the national highway development, which has been heavily funded by the foreign donors and has been conducted organizationally in the name of ROCS led by World Bank. It is quite common that at the initial stage of growth, a developing country is depending on the foreign aid in order to construct infrastructure such as road development.

Therefore, this study considers that a part of the implementation costs especially in road construction shall be covered by foreign aids. Other financial sources such as fuel tax is also counted.

Even though the external financial resource is expected, it is fundamental that the MCM shall share its burden at utmost of their ability. Thus, while the initial stage of financing shall be proceeded substantially by the external financial resources, it is emphasized for the MCM to pursue the state of self-financing in the long-run.

11.6.2 Rationales for External Funding for the Master Plan

There may well be arguments that the road development of the Maputo city should not rely on the international funding sources or national fuel tax revenue, since the urban road development is not legitimate matter for the nation but the city municipal, the MCM. There are, however, some rationales for the Maputo city to receive such funding beyond the administrative boundary. Firstly, the Maputo is the capital of Mozambique and the capital's importance in the economic growth process is second to none.

While Maputo is expected to play a leading role of economic development, the road condition in this capital city is very much worse than it should have been. Secondly, the road development is not accomplished by ignoring the concept of network. Even though the rehabilitation programme is completed at the national highways, it is not fully functioned if it lacks of proper network linked with urban roads.

Currently, the national road development is much more progressed by ROCS programme and it is the time to pursue the fully functioning of the network by developing the capital road net work. Thirdly, the heavy funding only on national highways is not "fair" in the macro point of view. As seen in the financial review, it is estimated that roughly 40% of total fuel tax have been paid by the Maputo's drivers.

It would give a plausible reason for Maputo's drivers to ask much more benefits from fuel tax. In other words, some part of the fuel tax should be used for development of urban roads, and foreign aid for roads development should be distributed properly according to the scientific point of view such as trip-lengths or population rather than the administrative boundary.

11.6.3 Estimation of Financial Resources

The Master Plan shall be funded by 3 components of financial sources, such as the MCM's road budget, fuel tax revenue, and foreign aid. Other sources will be also considered.

1) The Road Budget of MCM

As discussed in the financial review in chapter 2, it is estimated that the MCM has approximately 1.8 million USD of road related budget, which consists of 1.6 million USD of investment budget and 0.2 million USD of salary budget.

An estimation of the future road budget can be roughly made on the assumption that the MCM's revenue and the road budget scale are increased along with the growth of GRDP. The table below indicates that around 55 millions USD is accumulated for road budget from 2000 to 2020.

Table 11.6.1 Estimation of the MCM's Total Budget Sale and Road Budget Scale

Unit: million USD

/ year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GRDP Growth	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	3%
Total Budget	8.5	8.8	9.2	9.6	9.9	10.3	10.8	11.2	11.6	12.1	12.5
Road Budget	1.8	1.9	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.6
Accumulated	*1.8*	*3.7*	*5.6*	*7.6*	*9.7*	*11.9*	*14.2*	*16.6*	*19.0*	*21.6*	*24.2*

/ year	-	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GRDP Growth	-	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Total Budget	-	12.8	13.2	13.6	14.0	14.4	14.9	15.3	15.8	16.3	16.7
Road Budget	-	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5
Accumulated	-	*27.0*	*29.8*	*32.7*	*35.6*	*38.7*	*41.8*	*45.1*	*48.4*	*51.9*	*55.4*

Source: JICA Study Team

2) Fuel Tax Distribution

As discussed in the financial review section, the road development of Maputo should be covered partly by the fuel tax revenue, in the sense that the Maputo car users deserve to receive the benefits accrued from the tax, which they have paid in purchase of fuel.

By using the traffic assignment results of 2000, it can be stipulated that Maputo's drivers pay about 40% of total fuel tax revenues in 2000, none of which is, of course, used for Maputo's road development. It can be argued that some part of such revenue should be returned to the tax payers benefit, i.e. development of Maputo's roads.

The following table is an estimation of future fuel tax revenue paid by Maputo's drivers, by using the traffic assignment results of 2000 and 2020.

Table 11.6.2 Estimation of the Fuel Tax Revenue from Maputo's Drivers

Unit: million USD

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Fuel Tax Revenue from Maputo	22.4	23.4	24.4	25.6	26.7	27.9	29.2	30.5	31.9	33.3	34.8
Accumulated	*22.4*	*45.8*	*70.2*	*95.8*	*122.5*	*150.4*	*179.6*	*210.1*	*241.9*	*275.2*	*310.1*
6% of which	**1.3**	**2.7**	**4.2**	**5.7**	**7.3**	**9.0**	**10.8**	**12.6**	**14.5**	**16.5**	**18.6**

Year	-	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fuel Tax Revenue from Maputo	-	36.4	38.0	39.8	41.5	43.4	45.4	47.4	49.6	51.8	54.2
Accumulated	-	*346.4*	*384.5*	*424.2*	*465.8*	*509.2*	*554.6*	*602.0*	*651.6*	*703.4*	*757.6*
6% of which	**-**	**20.8**	**23.1**	**25.5**	**27.9**	**30.6**	**33.3**	**36.1**	**39.1**	**42.2**	**45.5**

Source: JICA Study Team

There must be controversial arguments about how much of the fuel tax revenue should be used for Maputo. The study team stipulates that 6% of the tax fuel revenue "from Maputo" should be disbursed, or in a more proper word "returned", into Maputo's roads, with consideration of Maputo's population size, which is 6% of national population.

3) Foreign Aid

Currently the road development at the national level has been conducted in the programme named "Roads and Coastal Shipping Projects" (ROCS) and it has been extensively funded by foreign countries and multilateral organizations such as IDA.

Table 11.6.3 Project Finance of ROCS1&2

Unit: 000 USD

No.	Organization	No. Projects	Expected Amount	Available Amount	(Rate)	Expense Amount	(Rate)
1	IDA	1	238,000	228,301	(31%)	140,800	(30%)
2	**GOM**	**1**	**233,000**	**111,002**	**(15%)**	**111,002**	**(23%)**
3	ADF	5	32,000	92,335	(13%)	38,976	(8%)
4	EDF	6	84,000	63,899	(9%)	33,706	(7%)
5	Japan	3	52,000	43,515	(6%)	23,067	(5%)
6	ASDI	3	24,000	33,435	(5%)	16,233	(3%)
7	USAID	1	64,000	31,380	(4%)	20,764	(4%)
8	BADEA	6	18,000	24,730	(3%)	10,941	(2%)
9	KFW	2	35,000	23,860	(3%)	23,746	(5%)
10	KFAED	1	20,000	22,317	(3%)	18,317	(4%)
11	ODA	1	14,000	14,000	(2%)	9,563	(2%)
12	OPEC	3	10,000	10,600	(1%)	8,037	(2%)
13	BID	1	0	10,277	(1%)	0	(0%)
14	PNUD	1	10,000	10,130	(1%)	8,567	(2%)
15	UNCDF	2	6,000	8,426	(1%)	7,487	(2%)
16	IFAD	1	4,000	2,676	(0%)	0	(0%)
17	WFP		6,000	1,043	(0%)	837	(0%)
18	SDC	1	1,000	886	(0%)	814	(0%)
19	France	1	1,000	200	(0%)	200	(0%)
20	NORAD	1	0	0	(0%)	96	(0%)
21	INDIVATIVO		157,000	0	(0%)	0	(0%)
	TOTAL		1,009,000	733,012	(100%)	473,153	(100%)

Source: ROCS reports

The ROCS has been commenced from 1992 and the details of finance are described in Table 11.6.3.

As seen in the table, more than 3 quarters (75%) of the funding for the ROCS has been invested by the foreign donors, and the Mozambique government is sharing less than 25% of the total cost by covering internal finance such as staff salaries and office equipment. In other words, most of investment costs have been covered by the foreign aids. This seems to be inevitable for the country that has been suffering a constitutive fiscal deficit after experiencing political turmoil.

Therefore, the Master Plan, which formulates the future road network of the capital city of Mozambique, is also eligible to institute the same funding structure, so that a remaining part of the total cost shall be covered by the foreign aids in form of grants.

Meanwhile, it is emphasized that such international aid is provided only at the early phase of the implementation, and in the long-run, the MCM and the Mozambican government have to shift the funding structure of this project to much more self-funding.

11.6.4 Financial Arrangement

From the context of the previous estimation, the study team recommends that the financial arrangement of the Master Plan's implementation be structured as displayed in Table 11.6.4.

As seen in the Table, about one third of the total cost can be covered by the road budget of the MCM. Meanwhile, fuel tax revenue and foreign aid are expected to cover of 25% and 44% of the total cost respectively. Even though the foreign aid is playing an important role in the first term, it is the MCM's self budgeting which is taking a leading role in the later term.

Table 11.6.4 Financial Arrangement for the Implementation of the Master Plan

Unit: Million USD

	Term (2003 ~ 2010	Term (2011 ~ 2020)	Total (2003 ~2020)	%	Remarks
Cost					
Development	68.3	65.4	133.7	74%	
Maintenance	20.7	25.3	46.0	26%	
TOTAL	89.0	90.7	179.7	100%	
Finance					
The MCM Budget	24.2	31.2	55.4	31%	Road Budget
Fuel Tax Revenue	18.6	26.9	45.5	25%	6% of fuel tax revenue from Maputo
Foreign Aid	46.1	32.7	78.8	44%	For imported materials
Other					Additional, if needed
TOTAL	89.0	90.7	179.7	100%	

Source: JICA Study Team

11.6.5 Other Source of Finance

Even though the total implementation cost of the Master Plan seems to be covered by the components of foreign aid, fuel tax revenue, and the MCM's road budgets, it is essential for the MCM to find other sources of finance. There are several potentials described as follows.

1) Urban Development Tax

Most of the urban cities in developed countries, urban development tax has been introduced to preserve a stable funding source for urban development. As seen in the financial review, the MCM is suffering from a lack of stable funding source while it faces a lot of challenges for urban development such as growing size of population, great demands for better urban infrastructure, traffic congestion, etc.

Thus, it is recommended for the MCM to consider the introduction of urban development tax levied on every enterprise or business in the city. This type of tax is also expected to function as impedance against new migrants flocking in the city.

2) On-road Parking Charge

Currently, a lot of cars are parking freely in city roads of Maputo. There are a few places which now charges parking fees, but most of shops and office buildings let the customers and the visitors use the part of roads free of charge. Here a complexity is that it is not completely free of charge in real terms, because most of busy road-side parking places are "guarded" by informal people, who collect a sum of money to keep a watch the car. Therefore, the car user has to pay some for parking in spite of that the collected money does not go to anywhere for road development.

Such informal parking charge is not very much welcomed by the car users, and parking spaces tends to be scarce with the growing number of flocking cars recently. According to the study team's survey, it is estimated that the car users in Maputo pay around 2 million USD a year for such informal car parking. Of course, the 2 million USD are vanished into the pockets of the informal car-parking guards.

There is a potential for the MCM to use this opportunity to raise a sum of revenue by preparing a suitable and safe parking system and collecting parking charges. It is cumbersome and hard work if the MCM try to collect charges directly by its personnel. Currently, the MCM is collecting "vehicle parking tax" from some shops and buildings which wish to use a part of municipal properties including roads, and the revenue from this tax reaches more than 1% of the total revenue.

Therefore, it seems to be one way to charge the same type of tax on shops and restaurants in busiest roads and give them the right to collect parking charges by their own. More practical issues for application are very sensitive, and it would be necessary to conduct a careful analysis and make political discussions with related organizations on this matter.

3) Development of better public transport

While the parking charge policy is considered, it is emphasized to improve the current public transport system. The parking charge would be a significant burden on the car drivers. Some people use cars because of the fact that there is no alternative means of transport. Even if there is a mean of transport such as a bus, the condition of current bus service is not sufficient, not reliable and not conformable.

The study team has witnessed so many buses packing a full of passengers, and some of them were obviously overloaded. If the parking charge is introduced, the alternative bus service should be introduced and increased in terms of quantity and quality. Without such alternative mode, the parking charge would let the Maputo city lose virtually the movement of people, that means the lost of urban activity.

Even in the current situation, the demand for bus transport is very much high, and the introduction of parking charge will stimulate the demand substantially. Thus, the reliable bus service can be a supplement potential to raise revenues if the MCM commits the public transport service, although it needs further discussions with related organizations. Therefore, the improvement of public transport seems to be also a rationale in the financial point of view.

4) Organization of road budgetary planning and management body

There is a substantial lack of management body responsible for comprehensive management of road development and maintenance in Maputo. Currently, there are seven institutions related to Maputo's roads and they diverse the works into their specialties. Even though this division of works seems to be suitable in detailed tasks, there is a need to have a kind of manager to grasp the information of roads, control its quality, and undertake the road development strategies with a comprehensive view on "a road as an unit", not diverted into sections such as road surface, road signs, road drainage, and so on.

In order to consider the financing of road development, there should be the manager who has all related information of urban roads to construct a proper development program with tangible cost estimates. Without these program and estimates, the demand for distribution of budget seems to be a baseless request.

ANE (Administration of National Road), the national organization for highways, has an advanced computerized management system of national roads, named Highway Network Management System (HNMS). HNMS has all information related to road, such as data of road's condition, unit prices of road construction, vehicle operation costs, etc. With this series of information, ANE has a comprehensive road development program. In addition, ANE charges one personnel as a semi-permanent officer mainly for this road management system, and two engineers to maintenance of the computer program for the system.

It would be unnecessary for the MCM to introduce such advanced system, but at least it can introduce some methods of ANE's management system for its road development management. Currently, the DSM of Road and Bridge is in charge of main part of road development, thus it can be fair to allocate a kind of comprehensive management authority into this institution. For more detailed matters, there is a need for all road-related institutions to discuss after the Master Plan is finalized.

5) Value Engineering

It is essential for the MCM and engineers to purse the most cost-effective measures to implement the Master Plan. In this study, the estimates of construction and maintenance cost are based on the empirical data which is gathered from the previous experience or other similar projects.

Thus, there will always be some rooms of improvement in economic efficiency to consider more cost-effective measures in practice. For example, some machine works can be modified into labor intensive rather than using a machine when the low-cost labor population is very much available.

Such "value engineering", which aims to attain the same effect with lower cost, is mostly needed for this financially limited country.

11.7 ESTABLISHMENT OF ROAD DEVELOPMENT MASTER PLAN

11.7.1 Conclusive Evaluation of Road Development Master Plan

As the results of the future traffic estimations on each alternative road networks, the road networks of the Plan 1, 3 and 4 are well suited to the future traffic demand in the year 2020. The results of the economic evaluation of the road development alternatives and the financial sustainability of the funding show that the road development Plan 2 is the most economically efficient and financially sustainable.

In order to select a most efficient, effective, consistent and sustainable road development plan, a conclusive evaluation of road development plans has been developed based on the following five criteria:

(1) Efficiency
Efficiency is the economic viability of the investment for the implementation of the road development plan on the viewpoint of the national economy. The indicator is the B/C ratio from the economic evaluation.

(2) Effectiveness
Effectiveness is the degree to which the road development achieves its purposes and objectives from the viewpoint of engineering aspects. The indicators consist following three sub-criteria:

- Road passable in rainy day; Total pavement length / Total road length of trunk and collector roads
- Accessibility; Total average speed adopted in the future traffic estimation
- Settlement of bottleneck; Numbers of bottlenecks on the Trunk Roads network

(3) Impact
Impacts are the effects whether the road development has effects on its surroundings in term of economic, social and environmental factors. The indicators are evaluated and selected as following three sub-criteria:

- Vitalization of local economy: Total Benefit bone by the road development
- Improvement of accessibility to major industry
- Environmental impact: Numbers of houses and factories which need to be re-located for the road development

(4) Relevance

Relevance is the degree of consistency with national and regional policy.

(5) Sustainability

Sustainability is the degree whether the government can achieve its target of financially self-reliance.

The indicators are selected as following two sub-criteria:

- Availability of development fund: External resources required
- Sustainability of maintenance fund: Total maintenance cost/Financial capacity of MCM

Table 11.7.1 shows the result of the total evaluation of the road development alternatives and the Plan 3 is selected as the most efficient, effective, relevant and sustainable plan for the long-term road development master plan.

Table 11.7.1 Conclusive Evaluation of Road Development Plans

Items	Indicator	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6
1.Efficiency (Economic viability)	Cost-benefit ratios	A (2.63)	A (2.93)	A (3.03)	A (2.35)	A (2.72)	A (2.38)
2.Effectiveness (Engineering Viewpoint)							
2.1 Road passable	Pavement % of trunk/ collector Rd.	A (100.0)	A (100.0)	A (100.0)	A (100.0)	A (100.0)	A (100.0)
2.2 Accessibility	Av. Speed (km/hr)	A (32.2)	B (28.6)	A (29.7)	A (30.3)	B (28.8)	B (28.4)
2.3 Bottleneck Decreeing	No. of bottleneck	A (1)	B (5)	A (2)	A (1)	B (5)	C (10)
3. Impact							
3.1 Vitalization of local economy	Total benefit (mil.$/year)	A (132)	A (117)	A (126)	A (128)	A (121)	A (110)
3.2 Improvement of accessibility to major industry		A	A	A	A	A	A
3.3 Environmental impact	No. of house/factories demolished	C (760/9)	B (642/-)	B (677/-)	C (760/9)	B (642/-)	B (677/-)
4. Relevance							
4.1 National Development policy	Consistency	A	A	A	B	B	B
4.2 Regional development policy	Consistency	A	A	A	B	B	B
5. Sustainability							
5.1 Availability of development fund	External resources required (mil.$)	C (113.1)	A (72.3)	A (78.8)	D (131.1)	B (90.1)	B (96.7)
5.2 Sustainability of maintenance fund	Total maintenance cost/Financial scale of MCM (mil.$/mil.$)	B (0.89)	A (0.81)	A (0.83)	B (0.96)	B (0.87)	B (0.89)
Total evaluation		**C**	**B**	**A**	**D**	**C**	**C**
A: Very high	B: High	C: Medium	D: Low				

11.7.2 Project Components of the Road Development Master Plan

The objectives of the road development master plan have been established as shown below;

- **Classified Road Development to improve Basic Human Needs and Environment**
- **Road Development to settle Existing Road Problems**
- **Road Development to enhance Future Traffic Efficiency**
- **Road Development to promote the Metropolitan Development**

The components of the road development master plan consists the followings;

A. Construction of Primary Trunk Road

A-1 Widening and Reconstruction of Av. Mozambique

In order to establish the basic frame of the urban road network system in Maputo as well as to cope up with the anticipated traffic demand in future, it is recommended either to widen from 2 to 4 lane or to reconstruct Av. Mozambique as follows;

- Widening from Av. Do Trabalho junction to Rue 5750 junction (8.3km)

- Reconstruction Existing road from Rue 5750 junction up to the border (6.8km)

Construction of Grade Separation with Machava road will be done during the implementation of the on-going Machava road project.

B. Construction of Trunk Roads

Bv-1 Widening and New Construction of Av. Julius Nyerere

In order to establish the basic frame of the urban road network system as well as to cope up with the future traffic demand, it is inevitably necessary to widen from 2 to 4 lane for existing sections and to construct a new dual carriageway bypass for the alternative solution of the Missing Link of Av. Julius Nyerere as follows;

- Widening from Rue 5750 junction to Av. FPLM junction (4.9km)
- Construction of Grade Separated Junction with Av. FPLM
- Reconstruction of Rue 4685 (2.8km)
- Construction of new dual carriageway bypass from Av. FPLM junction to the existing 2lane section of Av. Julius Nyerere. (4.8km)
- Widening of the existing 2lane section of Av. Julius Nyerere. (2.2km)

Bv-2 Improvement of Av.V.Lenine

Due to secure the heavy traffic congestion occurring by the lack of Bus-bay and the concentration of traffic, Av. V.Lenineis should be improved through a construction of proper size of Bus-bay and a improvement of the intersection with Av. Julius Nyerere.

Bv-3 Rehabilitation of Av. Acordos do Lusaka and Widening of Av. Guerra Popular

The pavements of Av. A. do Lusaka and Av. Guerra Popular start deterioration and the traffic congestion on Av. Guerra Popular become critical, therefore followings are necessary.

- Rehabilitation of Av. A. do Lusaka (2.9km)
- Construction of Grade Separation with Machava road
- Widening from 2 to 4 lane carriageway with construction of proper size of Bus-bay the existing 2 lanes section of Av. Guerra Poprlar. (0.7km)

Bv-4 Reconstruction of Av. Angola and Rua S. Cabral/Largo de Deta

- The pavement of Av. Angola requires reconstruction. (3.1km)
- The pavement of Rua S. Cabral/Largo de Deta requires reconstruction. (0.6km)

Bv-5 Reconstruction of Rua de Igreja

Existing Rua de Igreja is heavily deteriorated, required the total reconstruction (7.5km)

Bv-6 Reconstruction of Rue 5751

For the future expansion of the city to the north and to improve the existing pavement deterioration, the reconstruction of Rue 5751 is necessary. (5.9km)

Bh-1 Reconstruction of Rua Paulino Santos Gil and Av.ONU

In order to streamline the heavy goods vehicles from the industrial and the port area, the heavy deterioration of the pavement of Rua Paulino Santos Gil and Av. ONU should be reconstructed.

- Reconstruction of Rua Paulino Santos Gil (0.2km)
- Reconstruction of Av. ONU (1.5km)

Bh-2 Widening and Reconstruction of Av.Marien Ngouabi

Due to the heavy congestion and deterioration, Av. Marien Ngouabi should be widened to dual carriageway and be reconstructed.

- Widening from Av. Mao Tse Tung junction to Av. A. de Lusaka (0.9km)
- Reconstruction from Av. A. de Lusaka to Av. de Angola (1.0km)

Bh-3 Rehabilitation and Extension of Rue 5750

In order to improve the existing pavement deterioration and to promote the Maputo Metropolitan Development, Rue 5750 should be improved as follows:

- Rehabilitation of existing Rue 5750 (3.8km)
- Extension of Rue 5750 to Matora border (0.7km)

Bh-4 New construction of Maputo Border Road

In order to provide an access serve to the northern potential development area, new construction of Maputo Border Road is necessary. (7.6km)

C. Reconstruction of Collector Roads

Based on the road development concept in terms of Basic Human Needs and Environment, the following collector roads in each area should be reconstructed due to heavy deterioration.

- Reconstruction of collector and selected area roads in District 1 (18.7kn)
- Reconstruction of collector roads in District 2 (10.2km)
- Reconstruction of collector roads in District 3 (9.5km)
- Reconstruction of collector roads in District 4 (30.7km)
- Reconstruction of collector roads in District 5 (25.5km)
- Reconstruction of collector roads in Catembe area (9.0km)

Table 11.7.2 Project Components of Road Development Master Plan (1/2)

	Project		Road Length (km)	Lane No.	Construction Cost (million USD)	Project Cost (million USD)	Remarks
1	**Construction/Improvement of Bus Terminas**				**1.39**	**1.69**	
2	**Instration of linked signals**				**2.43**	**2.96**	
3	**Construction of two Grade Separations**				**4.30**	**5.48**	
4	**Construction of Primary Trunk Roads**		**15.05**		**16.14**	**22.82**	
A-1	Reconstruction of Av. Mozambique (North Section)		6.80	2	5.22	6.37	
A-1	Widening of Av. Mozambique (South Section)		8.25	4	10.92	16.45	
5	**Construction of Trunk Roads**		**51.59**		**35.51**	**51.15**	
Bv-1	Av. Julius Nyerere		11.90		18.84	26.58	
		Widening of Av. Julius Nyerere(1257) (South Section)	2.20	4	2.55	3.92	
		Reconstruction and Extension of Rua 4685	2.80	4	2.51	3.06	
		New construction of New J. Nyerere 1	3.00	4	4.11	5.33	
		New construction of New J. Nyerere 2(t)	1.80	4	2.49	3.42	
		New J. Nyerere (Box)	0.00	4	0.18	0.22	
		Widening of Av. Julius Nyerere(4001) (North Section)	4.90	4	5.40	8.68	
		New construction of Bridge on Av. Julius Nyerere	0.00	4	1.60	1.95	
Bv-2	Improvement of Av. V. Lenine		0.00	2	0.60	0.73	
Bv-2	Improvement of FPLM		2.85	4	0.15	0.19	
Bv-3	Rehabilitation of Av. Acordes do Lusaka(3013)		2.44	4	1.06	1.30	
Bv-3	Rehabilitation of Av. Acordes do Lusaka(4057)		0.42	4	0.13	0.16	
Bv-3	Widning and Improvement of Av. Guerra Popular(1189)		0.70	4	0.41	0.77	
Bv-4	Reconstruction of Av. Angola(3077)		3.09	4	2.31	2.82	
Bv-4	Rehabilitation of Rua S. Cabral(3081)/Largo.Deta(3079)		0.61	2	0.41	0.50	
Bv-5	Reconstruction of Rua de Igreja(North Section)		5.75	2	1.92	3.04	
Bv-5	Reconstruction of Rua de Igreja(South Section)		1.75	2	0.58	0.93	
Bv-6	Reconstruction of Rua 5751		5.90	2	1.97	3.60	
Bh-1	Reconstruction of Rua Paulino Santos Gil (1207)		0.23	4	0.12	0.19	
Bh-1	Rehablitation of ONU(1040)		0.52	4	0.27	0.43	
Bh-1	Rehabilitation of ONU(2002)		1.02	4	0.52	0.84	
Bh-2	Widening and Rehabilitation of Av. Marien Ngouabi(1166)		1.88	4	1.57	3.09	
Bh-3	Rua 5750		0.65		1.34	1.64	
		Improvement of Rua 5750	0.00	2	0.07	0.08	
		New construction of Rua 5750 extension(t)	0.65	2	0.47	0.57	
		New construction of Rua 5750 extension(Box)(t)	0.00	2	0.81	0.98	
Bh-4	New construction of Maputo Border Road		7.60	2	3.31	4.34	
6	**Reconstruction of Collector Roads**		**94.58**		**28.38**	**43.33**	
	6.1 Roads in District 1		**18.64**		**7.42**	**9.09**	
		Av. Milagre Mabote(1369)	1.00	2	0.23	0.32	
		Av. da Malhangalene(1357)	0.94	2	0.22	0.26	
		Av. Para O Palmar(1426)	1.40	2	0.32	0.40	
		Av. Kawame Nkrumah(1250)	1.61	2	0.58	0.71	
		Av. Paulo Samuel Kankhomba(1152)	0.55	2	0.20	0.24	
		Av. Emilia Dausse(1138)	0.85	2	0.31	0.37	
		Av. de Maguiguana(1130)	0.75	2	0.27	0.33	
		Av. Josina Michel(1070)	0.90	2	0.32	0.39	
		Av. Fernao de Magalhaes(1038)	1.30	2	0.47	0.57	
		Av. Zedequias Manganhela(1034)	1.30	2	0.47	0.57	
		Av. Mohamed Siad Barre(1203)	0.85	2	0.31	0.37	
		Av. RomaoFernandes(1199)	0.85	2	0.31	0.37	
		Av. Filipe Samuel Magaia(1183)	0.40	2	0.14	0.18	
		R. Consiglieri Pedroso(1022)/R. Joaquim Lapa(1020)	0.80	2	0.29	0.35	
		R. do Bagamayo(1016)/R. de Timor Leste(1014)	0.80	2	0.52	0.63	
		Av. Martires de Inhaminga(1006)	0.80	2	0.52	0.63	
		Port Area(6 roads)	1.50	2	0.77	0.94	
		Rua 1229	0.25	2	0.32	0.39	
		Av. das Estancias(1030)	0.58	2	0.44	0.53	
		Av. Friedrich Engels(1009)	1.20	2	0.43	0.53	

Table 11.7.2 Project Components of Road Development Master Plan (2/2)

Project		Road Length (km)	Lane No.	Construction Cost (million USD)	Project Cost (million USD)	Remarks
6.2	**Roads in District 2**	**10.23**		**2.35**	**4.85**	
	Rua 2282/2265	2.36	2	0.53	1.16	
	Rua 2275	2.01	2	0.45	0.79	
	Rua de Xipamanine(2291)	1.13	2	0.25	0.61	
	Rua dos Imaos Roby(2289)	1.30	2	0.29	0.51	
	Rua 2315/2313	0.70	2	0.16	0.32	
	Rua 2309/2324	1.00	2	0.22	0.41	
	Rua 2522	1.25	2	0.28	0.77	
	Av. das Estancias(2000)	0.49	2	0.18	0.27	
6.3	**Roads in District 3**	**9.48**		**2.68**	**4.96**	
	Rua da Goa(3027)	0.80	2	0.20	0.37	
	Rua da Lixeira(3030)	0.79	2	0.18	0.38	
	Av. Milagre Mabote(3001)	1.98	2	0.70	1.22	
	Av. da Malhangalene(3259)	1.83	2	0.66	1.16	
	Rua 1 de Maio(3374)	1.49	2	0.35	0.76	
	Rua 3306	0.49	2	0.11	0.22	
	Rua 3523	1.00	2	0.23	0.40	
	Rua 3576	1.10	2	0.26	0.45	
6.4	**Roads in District 4**	**29.56**		**9.07**	**13.64**	
	Rua 4029/4040/CFM(4027)	2.50	2	0.58	0.92	
	Rua 4160	1.11	2	0.26	0.40	
	Rua 4453/4821	2.40	2	0.56	0.88	
	Rua 4935/4844/4755	2.55	2	0.59	0.93	
	Rua 4412	2.10	2	0.49	0.77	
	Rua 4787/4433/4345	3.10	2	0.72	1.13	
	Rua 4286/4282	1.40	2	0.32	0.51	
	Rua do Aeroport(4109)	1.13	2	0.26	0.41	
	Rua da Beira(4113)	1.60	2	0.37	0.59	
	Rua da Beira(4397)	0.62	2	0.14	0.23	
	Rua 4395/4342	1.40	2	0.32	0.51	
	Rua das Mahotas(4060)	1.45	2	0.34	0.53	
	Rua 4680	3.60	2	0.97	1.18	
	New Road	2.30	2	1.49	2.08	
	Reconstruction of Rua 4870 extension	2.30	2	1.66	2.56	
6.5	**Roads in District 5**	**26.69**		**6.87**	**10.79**	
	Rua 5578	0.70	2	0.17	0.27	
	Rua 5578 extension(Matola)	1.20	2	0.39	0.56	
	Rua 5650/5584	2.00	2	0.45	0.71	
	Rua 5512	0.90	2	0.22	0.35	
	Rua 5512 extension (Matola)	1.20	2	0.39	0.56	
	Rua 5578-5512(new road)	1.30	2	0.32	0.48	
	Rua 5514	1.75	2	0.43	0.84	
	Rua da Paz(5501)	1.75	2	0.43	0.72	
	Rua do Bagamayo((5319)	1.35	2	0.33	0.51	
	Rua de Sao Paulo(5312)	0.69	2	0.17	0.26	
	Rua 5500	0.90	2	0.21	0.33	
	Rua 5280/5296	1.50	2	0.35	0.55	
	Rua 5260	1.65	2	0.38	0.60	
	Rua 5315	2.90	2	0.67	1.06	
	Rua 5003/5021	1.90	2	0.42	0.68	
	Rua do Jardin(5088)	1.45	2	0.52	0.76	
	Rua da Agricultura(5086)	1.60	2	0.58	0.84	
	Rua 5763	1.15	2	0.27	0.42	
	Rua 5754	0.80	2	0.19	0.29	
	Reconstruction of Catembe Roads	**9.00**	2	**5.12**	**6.25**	
7	**Total**	**170.23**		**93.27**	**133.68**	

11.7.3 Establishment of Public Transport Development Plan

The objectives of the public transport development plan have been established as shown below:

- Public Transport Development to service in un-serviced area
- Public Transport Development to improve Bus Stop facilities
- Public Transport Development to streamline the congestion of Bus Terminal
- Public Transport Development to improve slow bus operation efficiently
- Public Transport Development to provide information properly

The components of the public transport development plan consists the followings:

A. Public Transport Development to service in un-serviced area

In order to solve the existence of un-service area of Public Bus Operation, Road Rehabilitation and new construction of Trunk and Collector Roads have been proposed in the road development master plan for the smooth operation of bus transport even in each community area.

B. Public Transport Development to improve Bus Stop facilities

Traffic congestions occur on the existing single carriageway trunk roads, due to lack of proper size of Bus Stop facilities. Therefore, construction of proper size of Bus Stop with bus-bay is necessary and these measures have been incorporated into the proposed projects of the road development master plan

C. Public Transport Development to streamline the congestion of Bus Terminal

In order to solve the congestion of Bus terminals, Construction of four new bus terminals and improvement of three bus terminals have been proposed with proper spaces for buses, taxis, trucks and markets.

Detailed identification of Development Plan for Bus Terminals will be conducted during the Feasibility Study of this study.

D. Public Transport Development to improve slow bus operation

In order to improve the slow bus operation on the trunk roads, an introduction of Bus Lane on a dual carriageway trunk road, which will be improved during the implementation of the road development master plan, is recommendable measure.

Detailed identification of Bus Lane will be conducted during the Feasibility Study of this study.

E. Public Transport Development to proved information properly

In order to solve the lack of information of bus operation, installation of information board at each Bus Stop and Bus terminal should be conducted.

The public transport plan has been prepared based on the future traffic assignment result on the road network of Plan3 with the traffic demand of the year 2010. Although the future demand of public transport will grow in the year 2020, an introduction of the bus lane together with a policy of exchanging bus size to large will bring efficient bus operation and planed bus facilities efficiently.