3.2.2 Socioeconomic Framework

(1) Population Growth

As mentioned earlier, Malawi's population is estimated at over 10 million and has been increasing at a high rate of 3.1-3.6% per annum during the 1990s. This rapid increase in population has had far-reaching effects in terms of difficulties in achieving food self-sufficiency, providing adequate employment opportunities, and improving the level of social services.

One of the major objectives of the National Population Policy is to achieve a lower population growth rate that is compatible with the attainment of the country's social and economic development objectives. The aim is to bring down the annual rate of population growth to 2.4% by the year 2002.

(2) GDP and Foreign Trade Growth

As mentioned earlier, real GDP growth in 1998 and 1999 is expected to reach 4.8% and 5.8% respectively, according to estimates prepared by the EIU. The World Bank has forecast a more conservative average annual real GDP growth rate of 4.0% for 1998-2005, and the Ministry of Economic Planning and Development has forecast real GDP growth rates for 1998, 1999, and 2000 of 5.6%, 4.3%, and 4.1% respectively. For this study, it is suggested that real GDP growth rates shown in Table 3.18 be adopted; they were prepared with due consideration of these various forecasts. This table also includes forecasts for exports as a percentage of GDP, as estimated by the World Bank for the period 1998-2005, and forecasts of real export and real import growth rates, as estimated by the Ministry of Economic Planning and Development.

Table 3.18 Forecasts of GDP and Foreign Trade

Year/Period	Average Annual Real GDP Growth Rate	Exports as a Percentage of GDP	Average Annual Real Export Growth Rate	Average Annual Real Import Growth Rate
1998	4.8%	25.5%	3.1%	5.5%
1999	4.7%	25.1%	4.0%	3.8%
2000	4.1%	24.9%	3.5%	3.9%
2001	4.0%	24.3%	3.5%	3.9%
2002	4.0%	24.0%	3.5%	3.9%
2003	4.0%	23.6%	3.5%	3.9%
2004	4.0%	23.3%	3.5%	3.9%
2005	4.0%	23.1%	3.5%	3.9%
2006-2020	3.5%	23.0%	3.0%	3.4%

Source: JICA Study Team, based on estimates performed by the EIU, World Bank, and Ministry of Economic Planning and Development.

3.2.3 Transport Plans

(1) Recent and/or Ongoing Road Projects

a) Liwonde-Naminga-Nsanama-Chiponde-Mangochi Road

This project, to be funded by the Kuwait Fund, BADEA Fund, and OPEC Fund, will result in significant improvement of the road between the Mangochi Bridge and Chiponde at the border with Mozambique. The alignment will be improved, and the entire road will be paved. Of all road projects in Malawi, this project alone will have by far the greatest impact on traffic on the Mangochi Bridge. Most importantly, improvement of the Mangochi-Chiponde segment will further promote international transport between Malawi and the port of Nacala and enable road to better compete with rail along this corridor. Additionally, improvement of the Chiponde-Nsanama-Naminga-Liwonde segment will promote the road as a tourist route by facilitating tourist travel around Mangochi, through the Mangochi Forest Reserve, and to Liwonde National Park—one of Malawi's main tourist attractions. The cost of this project, not including the Liwonde-Naminga section, is estimated at about US$30 million. This project is expected to be completed by the opening year of the new Mangochi Bridge.

b) Rehabilitation of Route 8 from Nampula to Mandimba, Mozambique

Currently, the National Road and Bridges Department (DNEP) of Mozambique is undertaking a major rehabilitation project on Route 8 from Nampula to Mandimba (513 km). This road is considered an emergency route by Mozambique, and its improvement to a high-standard earth road (including rehabilitation of all bridge structures) will enable goods to travel more easily by truck between Nacala port and Malawi via Chiponde and the Mangochi Bridge, especially in the dry season when traffic is heaviest. Like the Mangochi-Chiponde road improvement project, this project will have a major impact on traffic on the Mangochi Bridge. It is important to note that the remaining 179-km section of Route 8 between Nampula and Nacala port has already been rehabilitated to a paved road and is in very good condition. This project is also expected to be completed by the opening year of the new Mangochi Bridge.

c) District Roads Improvement and Maintenance Programme (DRIMP)

There have been several phases of DRIMP since 1977 that precede the recent one, and all have been funded by the World Bank. The recent Phase IV ran from 1989 to 1995. The main objectives of DRIMP were to (i) build road maintenance capacity in the local authorities (District Councils); (ii) train personnel from the local authorities to carry on with road maintenance activities after the project has come to an end; and (iii) construct district roads using labor intensive methods. The overall target was to construct and maintain about 700 km of road nationwide. Under the same program, an extra 500 km of roads have been maintained using minor contractors. It is the intention of the Ministry of Works to hand over the responsibilities undertaken by DRIMP to the local councils once the modalities have been finalized.

d) Village Access Roads and Bridges Programme III (VARBAU)

This project is funded by the United Nations Development Programme (UNDP) and UNCDF. The first two phases covered the Northern and Central Regions of the country. The main objective of this project is to improve access for rural people to economic and social amenities such as farms, markets, schools, and hospitals. The third phase in the Southern Region covered the districts of Mangochi, Thyolo, Nsanje, and Mwanza. At the end of its construction program in December 1996, the project had completed 19 bridges and 62 km of roads.

In order to sustain VARBAU type of construction works, the Government was granted an extension of the project to September 1997 during which time nationwide training workshops were conducted. The target groups included all district supervisors, foremen from various Government departments and NGOs, contractors, and villagers who may in future be involved in implementing similar programs through other funding agencies.

Other road improvement and/or construction projects in Malawi include those for the following road sections, listed in order from north to south:

- Karonga-Chitipa Road
- Karonga-Chilumba-Chiweta Road
- Msulira-Nkhotakota Road
- Msokera-Lifupa Lodge Road
- Mchinji-Kasungu-Msulira Road
- Ntcheu-Tsangano-Neno-Mwanza-JCT Road
- Midima-Ngululdi-PIM-Mainala Road
- Limbe-Midima-Chisitu Road
- Limbe-Thyolo-Muloza Road
- Chikwawa-Bangula Road
- Bangula-Nsanje-Marka Road

(2) Relevant Projects in Other Subsectors

a) Rehabilitation of the Port of Nacala

With financial assistance from FINNIDA and Mozambique, rehabilitation of deepwater port of Nacala was completed in 1994 at a cost of US$42 million. Work included design and construction of container facilities, purchase of container handling equipment, technical assistance to the management, and general improvement of the port. Additional restoration work at a cost of US$28 million financed by NORAD and Mozambique was later undertaken to repair damage to the general cargo berths caused by the cyclone Nadia in early 1994.

b) Rehabilitation of the Nkaya-Nayuchi Rail Line

Rehabilitation of the Nkaya-Nayuchi rail line to the border of Mozambique (44 km) is going ahead following agreement in mid-1995 of

World Bank and USAID credits totaling US$28.6 million. Of the total, US$9.53 million is being spent on track rehabilitation, which includes bridge and structure strengthening, points and crossing work, production of 17,000 sleepers, rental of a track tamper, and purchase of gang and inspection trolleys. The current rail service on this line is one import train per day, and four export trains per week.

c) Rehabilitation of the Cuamba-Entre Lagos Rail Line

Plans for rehabilitation of the Cuamba-Entre Lagos rail line in Mozambique (77 km) are still being considered. This rail line is part of the Nacala rail corridor. The European Union has reportedly shown some interest in this project.

d) New Mangochi Airport

Because Mangochi is the center of tourism attraction along Lake Malawi and currently lacks a fully serviced airport, the Ministry of Transport has identified the New Mangochi Airport project to ensure safety operation of aircraft in the Lake Shore tourist area. Estimated at a total cost of US$10.2 million and presently unfunded, the project would involve the construction of an all weather airport with necessary facilities to handle aircraft of ATR 42 size. The project would involve civil works for the runway, terminal facilities, and provision of necessary equipment. The airport would also enable direct tour charters from other countries to Mangochi, thereby contributing to economic growth.

3.3 Traffic Surveys and Future Traffic Demand

3.3.1 Traffic Surveys

(1) Brief Description

A total of seven traffic survey sites were chosen, all located in south-central Malawi. Four of the sites are located in close proximity to the existing Mangochi Bridge: (i) Site 1 on Route M10 immediately north of the M3 junction; (ii) Site 2 on Route T385 just west of the M3 junction; (iii) Site 3 on Route M3 immediately south of the M10 junction; and (iv) Site A at the Mangochi Bridge itself. Three additional sites are located on Route M3 at the M3-S131 intersection near the Malawi-Mozambique border in Chiponde (Site B), on Route M6 immediately west of the M1-M6 junction (Site C), and on Route M1 immediately north of the M1-M6 junction (Site D). The approximate location of each traffic survey site is shown in Figures 3.3 and 3.4.

The traffic surveys comprised the following:

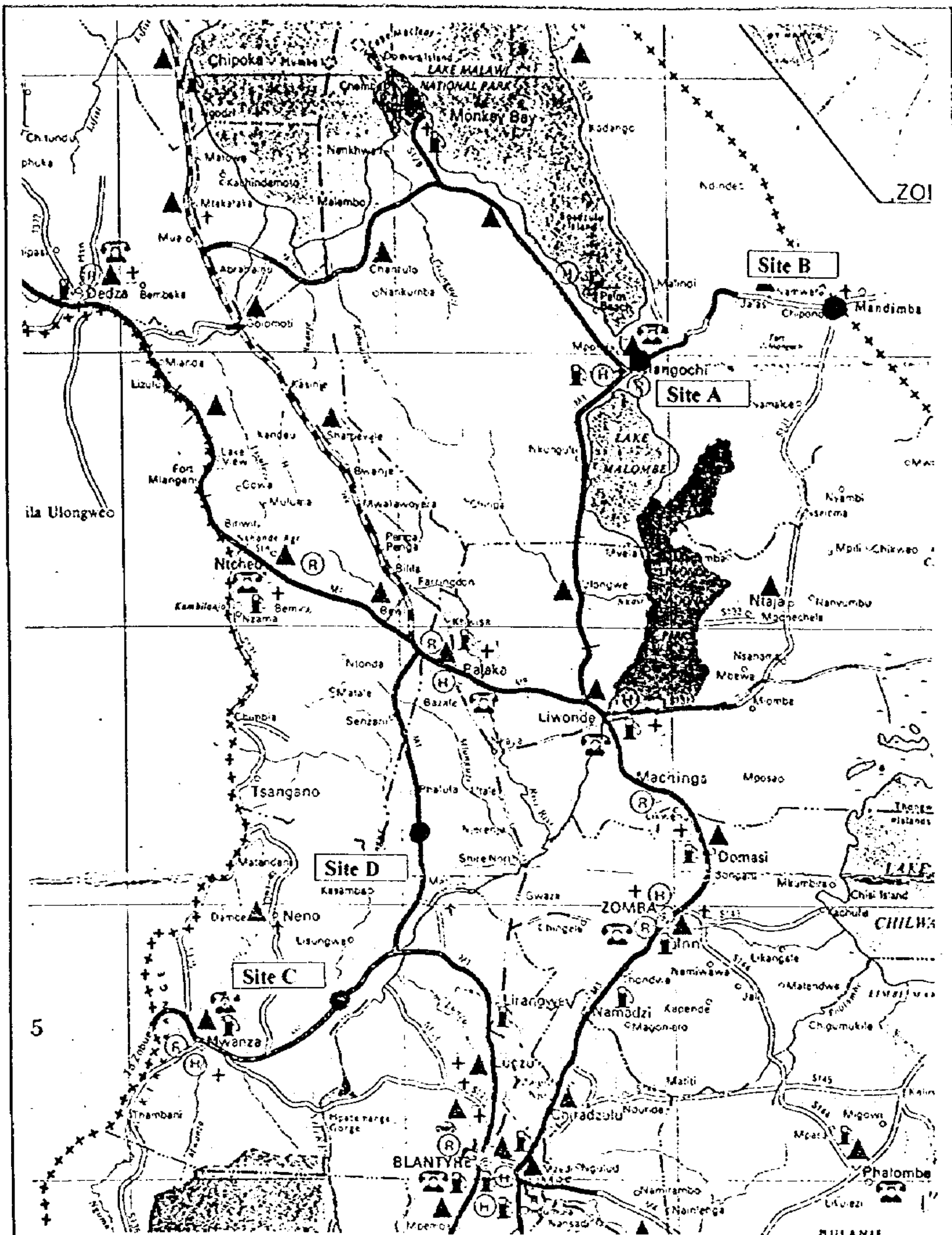
- 12-hour roadside traffic count surveys at sites 1, 2, and 3;
- 24-hour roadside traffic count surveys at sites A, B, C, and D; and
- 12-hour roadside origin-destination surveys at sites A, B, C, and D.

With respect to the traffic count surveys, the hourly traffic volume of pedestrians and vehicles by type and direction were counted and recorded at 60-minute intervals. The 12-hour surveys were performed between the hours of 07:00 and 19:00 for 1 weekday in early March 1998 at sites 1, 2, and 3. The 24-hour surveys were performed between the hours of 07:00 and 07:00 of the following day for 1 weekday in early March 1998 at sites A, B, C, and D.

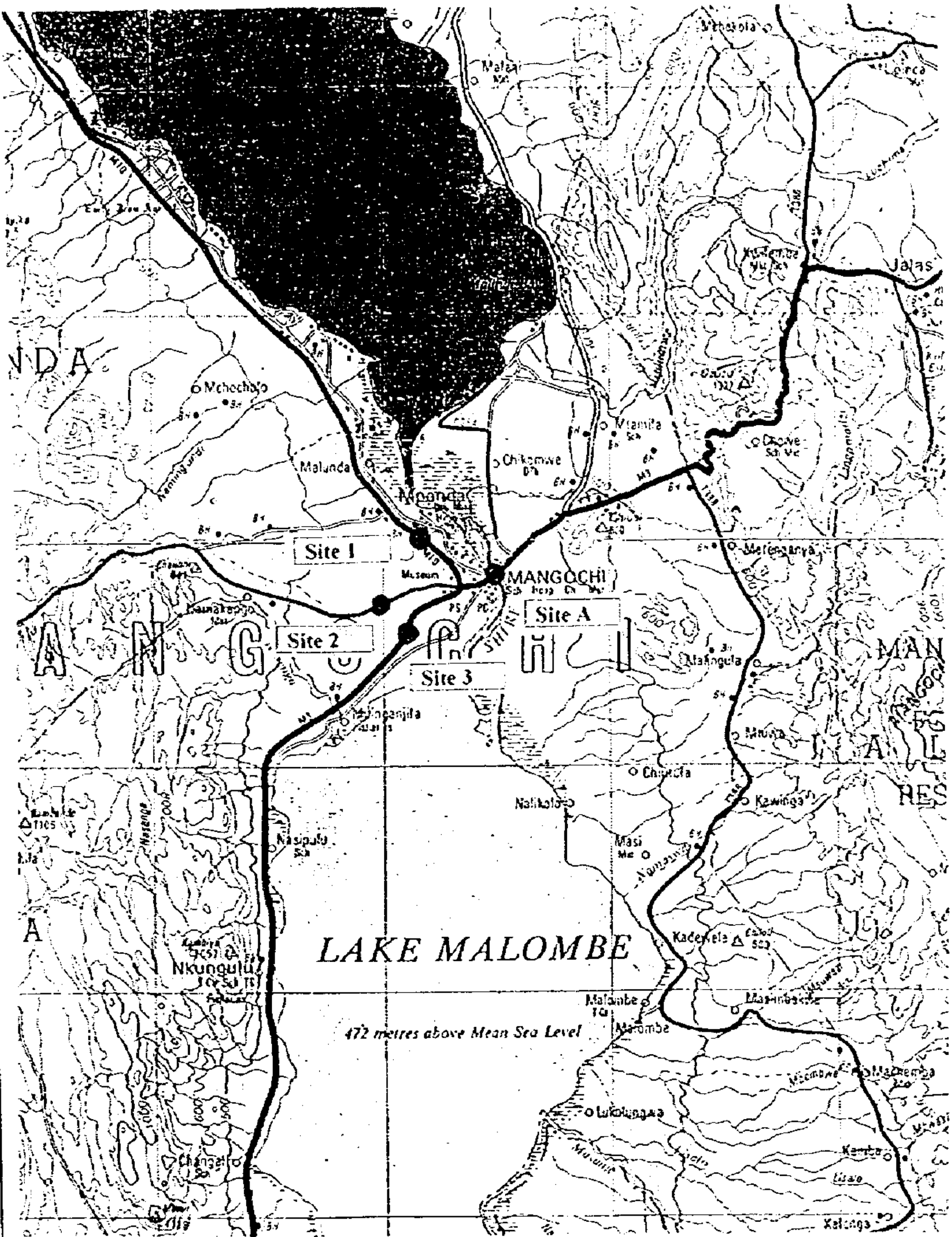
For the roadside origin-destination surveys, drivers of vehicles were stopped by traffic police and interviewed by the surveyors about the following items: (1) type of vehicle, (2) origin and destination, (3) time left origin and expected time of arrival at destination, (4) vehicle capacity in tons and passengers, (5) vehicle occupancy, including children (6) main cargo, including load in tons, (7) trip purpose, and (8) trip frequency. The surveys were performed between the hours of 07:00 and 19:00 for 1 weekday in March 1998 at sites A, B, C, and D.

(2) Traffic Volumes

Average daily traffic (ADT) results, not yet adjusted to reflect the seasonal variation in traffic volumes, are summarized in Table 3.19. The majority of traffic crossing the Mangochi Bridge (Site A) consists of pedestrians and bicycles with traffic shares of 63% and 31% respectively. Their high volumes demonstrate the importance of this bridge for local residents in carrying out daily activities. Motorized vehicles currently represent only 6% of the total traffic using the bridge. Of the total 452 motorized vehicles crossing the Mangochi bridge, pickup trucks have the largest share at 49%, followed by motorcycles and 4WD wagons at 12% each, 2-axle trucks at 11%, passenger cars at 8%, minibuses at 6%, and 3-axle and 4-axle trucks at 1% each. Only one 5-axle truck and one 6-axle truck were observed crossing the bridge.



The Feasibility Study on the Reconstruction of Mangochi Road Bridge in the Republic of Malawi	Figure 3.3 Traffic Survey Location Map for Sites A, B, C, and D



The Feasibility Study on the Reconstruction of Mangochi Road Bridge in the Republic of Malawi	Figure 3.4 Traffic Survey Location Map for Sites 1, 2, 3, and A

Of the seven traffic count locations, motorized traffic is clearly highest at Sites 1, 3, and D, which represent respectively Route M10 immediately north of Mangochi, Route M3 immediately south of Mangochi, and Route M1 north of the M6 junction. Motorized traffic is lowest at Chiponde (Site B) near the Mozambican border, reflecting the remoteness of this area. The high number of 6+ axle trucks on Route M6 west of the M1 junction (Site C) reflects the high patronage of the Mwanza border crossing for road-based international freight traffic. Many of these large trucks are hauling 40-foot (12-m) containers. Truck traffic is highest on Route M1 (Site D), since this is the main route for traffic between the Southern and Central Regions of Malawi. Much of this traffic is between Blantyre and Lilongwe.

Table 3.19 Summary of Average Daily Traffic Count Results, March 1998

Vehicle Type	12-Hour Traffic Counts			24-Hour Traffic Counts			
	Site 1	Site 2	Site 3	Site A	Site B	Site C	Site D
Pedestrian	1,892	2,762	3,141	4,362	3,970	390	1,205
Bicycle	983	1,628	2,071	2,154	2,219	124	258
Motorcycle	71	109	86	54	5	12	52
Passenger Car/Sedan	218	82	167	37	12	52	229
4WD Wagon/Landcruiser	82	83	148	52	16	42	154
Pickup Truck	492	248	643	222	50	91	172
Minibus	146	22	186	29	6	111	125
Standard Bus	17	0	14	0	2	13	62
Standard Bus with Trailer	0	0	1	0	0	2	3
2-Axle Truck	102	55	94	50	25	33	146
3-Axle Truck	15	4	18	3	8	8	37
4-Axle Truck	4	3	4	3	0	2	26
5-Axle Truck	0	0	0	1	1	3	29
6+ Axle Truck	0	0	3	1	3	129	140
Total	4,022	4,996	6,576	6,968	6,317	1,012	2,638
Total No. of Vehicles	2,130	2,234	3,435	2,606	2,347	622	1,433
Total No. of MVs	1,147	606	1,364	452	128	498	1,175
Total No. of MVs (not incl. MCs)	1,076	497	1,278	398	123	486	1,123

Notes: 2-axle trucks do not include pickups; MVs is motorized vehicles; MCs is motorcycles; these figures are not adjusted to take into account the seasonal variation in traffic volumes.

Historical traffic count data at several locations on Route M3 were made available by the Road Planning Unit of the Ministry of Works and Supplies (Table 3.20). It is important to note that none of these traffic counts were adjusted to average annual daily traffic (AADT). For example, the first three traffic counts conducted 2 km east of the Mangochi Bridge were performed in November 1989, May 1990, and April 1991. Consequently, it is necessary to adjust these figures to take into account the seasonal variations of traffic volumes.

Table 3.20 Historical Traffic Count Data on Route M3
(Unadjusted Average Daily Traffic)

Location	Year				
	1989	1990	1991	1992	1996
2 km north of M8 junction in Liwonde	354	336	264	-	-
3 km south of M10 junction in Mangochi	315	-	-	-	-
2 km east of Mangochi Bridge	242	260	220	-	370
Namwera trading center	-	-	-	-	202
2 km west of Chiponde and S131 junction	26	26	-	92	-

Sources: Road Planning Unit, Ministry of Works and Supplies; *Economic Feasibility Study, Detailed Design & Preparation of Tender Documents of Selected Rural Roads Development Project, Economic Feasibility Study Final Report*, UNETEC, March 1997, p. 5-6.

Using the monthly truck volumes through the Mwanza Border Post as a base (Table 3.7), seasonal adjustment factors were estimated and applied to the March 1998 traffic count survey results and to the four traffic counts at the Mangochi Bridge shown in Table 3.20. Table 3.21 summarizes the results for passenger vehicles (not including motorcycles) and freight vehicles.

Table 3.21 Average Annual Daily Traffic Trends at the Mangochi Bridge, 1989-1998
(Adjusted for Seasonal Variation)

Vehicle Type	Year					Avg. Annual Growth Rate
	1989	1990	1991	1996	1998	
Passenger Vehicles	165	187	212	348	483	12.7%
Freight Vehicles	55	65	45	44	82	4.6%
Total	220	252	257	392	565	11.0%

Source: JICA Study Team.

These results clearly indicate that traffic on the Mangochi Bridge has been consistently increasing at a rapid rate: 12.7% per year for passenger vehicles and 4.6% per year for freight vehicles. The overall traffic growth rate from 1989 to 1998 is 11.0% per year.

(3) Vehicle Utilization

Average vehicle occupancies, determined from the origin-destination survey results, are shown in Table 3.22 for six different vehicle types at the four OD survey locations. From this table, it is clear that most vehicles have relatively high person/passenger occupancy rates. Consider, for example, that the overall average occupancy is 3.3 for passenger cars and 4WD wagons, 4.9 for pickups, 15.7 for minibuses, and 44.7 for standard buses.

Table 3.22 Average Vehicle Occupancies by Vehicle Type, March 1998

Vehicle Type	Site A (Mangochi)	Site B (Chiponde)	Site C (M6)	Site D (M1)	Weighted Average
Motorcycle	1.5	1.0	1.4	1.4	1.4
Passenger Car and 4WD	3.8	3.9	3.4	3.0	3.3
Pickup Truck	6.2	6.0	3.4	3.3	4.9
Minibus	15.2	16.5	12.8	18.0	15.7
Heavy Bus	-	57.0	23.3	50.6	44.7
Truck	6.4	3.7	2.7	4.2	3.9

Note: Vehicle occupancies shown in this table include the driver.

Source: JICA Study Team.

Truck utilization figures, summarized in Table 3.23, indicate that the average truck load for loaded trucks is highest at Site C at 20.5 tons, followed by Site D at 13.0 tons. Similarly, the empty-truck ratio (i.e., percentage of empty trucks) is lowest at Site C. The average empty-truck ratio for trucks crossing the Mangochi Bridge was determined to be 25%.

Table 3.23 Truck Utilization Results, March 1998

Category	Site A (Mangochi)	Site B (Chiponde)	Site C (M6)	Site D (M1)	Weighted Average
Average Load (tons)	5.0	8.8	20.5	13.0	15.2
Load:Capacity Ratio	67%	68%	83%	78%	80%
Empty-Truck Ratio	25%	27%	5%	28%	18%

Note: Average load and load:capacity ratio are for loaded trucks.

Source: JICA Study Team.

Additional truck utilization results are shown in Table 3.24. At present, medium and articulated (very heavy) trucks are the predominant truck types, comprising 28% and 51% respectively of tonnage hauled.

Table 3.24 Truck Utilization Results by Truck Type, March 1998

Vehicle Type	Avg. Load (tons)	Avg. Load: Capacity Ratio	Avg. Empty-Truck Ratio	Percentage Share of All Trucks	
				No. of Trucks	Tonnage Hauled
Light Truck (LT)	2.4	75%	34%	18%	5%
Medium Truck (MT)	6.9	84%	19%	32%	28%
Heavy Truck (HT)	15.1	80%	16%	15%	15%
Articulated Truck (VHT)	26.9	79%	9%	35%	51%
Average or Total	15.2	80%	18%	100%	100%

Note: Average load and load:capacity ratio are for loaded trucks.

Source: JICA Study Team.

(4) Trip Purposes and Types of Commodities

The percentage shares of different vehicle trip purposes, also ascertained from the origin-destination survey results, are shown for motorcycles, sedans, 4WD wagons, and pickups combined in Table 3.25. On Route M3 at the Mangochi Bridge and in Chiponde, personal business reasons were those most frequently observed with shares of 41% and 39% respectively. On Routes M6 and M1, employer's business reasons were those more frequently observed. The Mangochi Bridge also has a relatively high percentage of trips made for family/social (18%), recreation/tourism/ leisure (10%), religion (6%), and medical (5%) reasons.

Table 3.25 Shares of Vehicle Trip Purposes for Motorcycles, Sedans, 4WD Wagons, and Pickups Combined, March 1998

Trip Purpose	Site A (Mangochi)	Site B (Chiponde)	Site C (M6)	Site D (M1)	Weighted Average
To/From Work	1%	9%	6%	10%	5%
Employer's Business	18%	19%	50%	36%	31%
Personal Business	41%	39%	34%	30%	42%
Education/School/Training	1%	7%	2%	6%	2%
Medical	5%	0%	1%	1%	2%
Family/Social	18%	3%	7%	10%	9%
Recreation/Leisure/Tourism	10%	15%	2%	1%	5%
Religion (Church, Mosque)	6%	0%	0%	4%	2%
Shared Taxi/Bus	2%	14%	0%	1%	2%
Total	100%	100%	100%	100%	100%

Source: JICA Study Team.

The percentage shares of different commodity types hauled by trucks at the four locations are shown in Table 3.26. There appears to be quite a variety of products being hauled, with no commodity type dominant at all four locations. However, the weighted average of all locations indicates that for March 1998 the main commodity types are maize and construction materials with shares of 23% and 18% respectively. Trucks across the Mangochi Bridge are primarily hauling construction materials (46%), maize (22%) and steel/machinery (15%). Because of the seasonality of traffic volumes and commodity types being hauled, it is important to recognize that the timing of this origin-destination survey has a significant impact on the types of commodities recorded; therefore, these results cannot be considered to represent an annual average.

Table 3.26 Commodity Types Weighted by Tonnage per Week, March 1998

Commodity Type	Site A (Mangochi)	Site B (Chiponde)	Site C (M6)	Site D (M1)	Weighted Average
Tobacco	0%	0%	8%	5%	5%
Maize	22%	39%	28%	8%	23%
Other Agricultural Products	2%	3%	17%	10%	11%
Ready-to-Eat Food/Drinks	3%	29%	7%	21%	9%
Fertilizer	2%	0%	3%	0%	2%
Timber/Wood	0%	0%	0%	4%	1%
Steel/Machinery	15%	12%	8%	7%	10%
Petroleum Products	6%	3%	6%	14%	8%
Construction Materials	46%	12%	6%	11%	18%
General Freight	3%	0%	17%	20%	13%
Total	100%	100%	100%	100%	100%

Source: JICA Study Team.

(5) Origins and Destinations

At the Mangochi Bridge (Site A), 94% of all motorized vehicle trips were observed to have origin and destination within Mangochi District on a trip per week weighted basis. The most common OD pairs are Mangochi-M'Baluku, Mangochi-Malindi, and Mangochi-Namwera. About 5% of all motorized vehicle trips were between Mangochi District and other parts of Malawi, typically Blantyre and Lilongwe. Only 1% of all motorized vehicle trips had origin and/or destination outside Malawi. These routings included Blantyre-Lichinga, Lilongwe-Mandimba, Harare-Mandimba, Tete-Lichinga, and Beira-Lichinga. OD surveys were also conducted at Sites B, C, and D to better understand the potential for certain types of traffic to divert their travel path and switch to Route M3 across the Mangochi Bridge.

On Route M3 at Chiponde (Site B), the results indicate that there are three categories of traffic that could use the Mangochi Bridge: Malawian domestic traffic, Mozambican domestic traffic that travels through Malawi, and international traffic between Malawi and Mozambique. In the case of Malawian domestic traffic, there were 7 vehicle trips (per day, unweighted) between Chiponde and Mangochi comprising 4WD wagons, pickups, and minibuses. However, all of these vehicle trips were also observed at the Mangochi Bridge survey point. For Mozambican transit traffic, there were 8 vehicle trips between Lichinga and a combination of Tete, Beira, and Maputo; 1 heavy bus trip between Mandimba and Maputo (weekly service); and 1 vehicle trip between Cuamba and Tete. Of these 10 vehicle trips, only 2 were observed to have traveled across the Mangochi Bridge. With respect to international traffic, 8 vehicle trips were between Mangochi and Mozambique

(Mandimba, Lichinga, and Nampula), 1 vehicle trip was between Blantyre and Lichinga, and 1 vehicle trip was between Lilongwe and Lichinga. Of these 10 vehicle trips, only 3 were also observed on the Mangochi Bridge. Therefore, of the total 27 vehicle trips identified in Chiponde as having potential to use the Mangochi Bridge, 12 or 44% actually traveled across the Mangochi Bridge.

Along Route M6 just west of the M1 junction (Site C), the OD survey results also indicate three categories of traffic that could use the Mangochi Bridge: Mozambican domestic traffic that travels through Malawi, international transit traffic through Malawi, and international traffic to/from Malawi. While some of this traffic was already captured at the Chiponde survey location (e.g., Mandimba-Maputo bus), most was not observed due to overnight stopovers in Blantyre due to the long nature of these trips. Consider, for example, that there were vehicle trips between Nampula and Tete, Mocuba and Tete, Pemba and Beira, and Quelimane and Tete. With respect to international transit traffic through Malawi, there was a passenger car trip between Nampula and Johannesburg. International traffic to/from Malawi of interest is truck traffic that may divert from a distant sea port to the port of Nacala and thereby travel by road across the Mangochi Bridge. This traffic included 14 articulated (very heavy) trucks between Beira and Blantyre and 4 articulated trucks between Lilongwe and Beira. The OD survey on Route M1 north of the M6 junction (Site D) provided similar results, including data on vehicle trips between Blantyre and Nampula and truck traffic between Lusaka and Quelimane.

More detailed summaries of the origin-destination survey results are provided in the Appendix.

3.3.2 Procedures of Traffic Demand Forecast

(1) Types of Traffic

Traffic forecasts are made for normal and development traffic, diverted traffic, and induced traffic. Normal traffic is the traffic that currently uses the existing Mangochi Bridge, and development traffic is the traffic that will be generated by any planned and programmed industrial or agricultural development zones in the study area. Both of these types of traffic would be expected to grow regardless of whether or not the bridge is reconstructed. Diverted traffic is traffic that currently travels by other modes or via other routes and would be attracted to use the bridge. It is expected that some international freight traffic would be diverted from Beira port (Mozambique), Durban port (South Africa), and Dar-es-Salaam port (Tanzania) to the Nacala port (Mozambique), resulting in a diversion of freight traffic to the Mangochi Bridge. It is also expected that some traffic would be diverted from Route S131 to Route M3 (and the Mangochi Bridge) with bridge reconstruction. Induced traffic is traffic that would arise due to lower costs and greater convenience resulting from bridge reconstruction. Typically, a bridge project of this nature would be expected to generate some local and long-distance passenger and freight traffic.

Both passenger and freight traffic are analyzed. Further, average traffic volumes are individually forecast for different vehicle types. The methods of estimating normal, development, diverted, and induced traffic are described in the subsections that follow.

(2) Vehicle Type

The vehicle types considered are the following:

- passenger car/sedan (PC)
- pickup truck (PU)
- minibus (LB)
- heavy bus (HB)
- light truck (LT)
- medium truck (MT)
- heavy truck (HT)
- articulated truck (VHT)

The first four types of vehicles are considered primarily as passenger transport vehicles, and the last four types are commodity transport vehicles. Passenger cars include only normal sedans or estate cars with typically 4-5 seats, although they may be overloaded with more than 5 occupants. Buses that carry 16-35 passengers are classified into the minibus category, and buses with passenger capacities of 40-70 passengers belong to the heavy bus category. Light, medium, heavy, and articulated (very heavy) trucks have average carrying capacities of respectively 3-5 tons, 6-10 tons, 11-25 tons, and 26-55 tons.

(3) Forecast Year

Traffic demand forecasting is carried out for years 2002, 2012, and 2022 on the horizon of 20 years from the opening year (i.e., 2002). Values for other years, including that for the target year of 2005 as specified in the TOR, are determined by interpolation.

(4) Zoning

The study area was divided into 40 traffic zones (Table 3.27), representing the seven nations of Botswana, Malawi, Mozambique, South Africa, Tanzania, Zambia, and Zimbabwe, including external gateways for main ports (e.g., Nacala, Beira, Durban, Dar-es-Salaam). Mangochi District was also disaggregated by town where appropriate, based on results of the OD surveys.

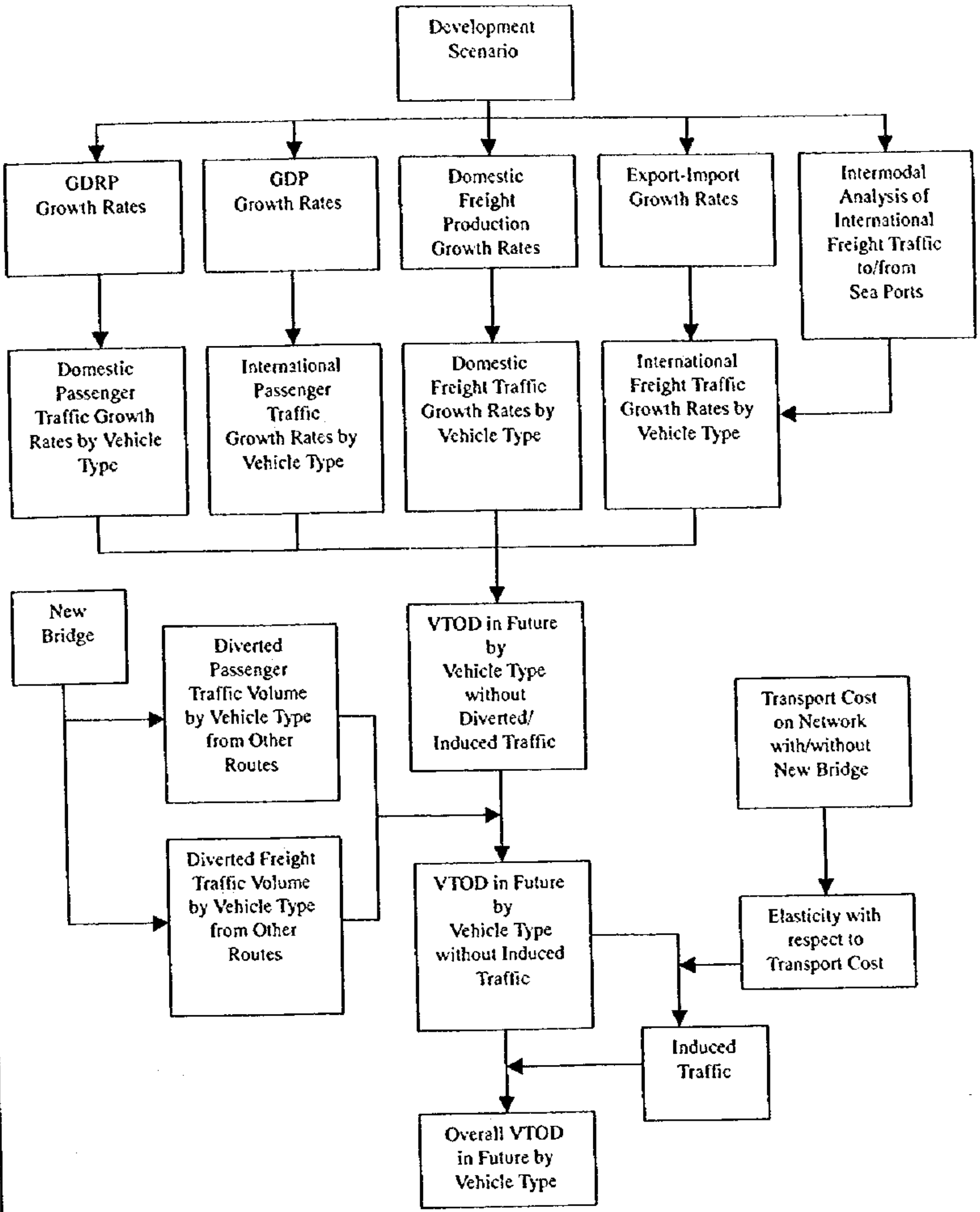
(5) Forecast Procedure

The conceptual forecast procedures, illustrated in Figure 3.5, are the following:

- Development scenarios of economic growth and international trade in Malawi are prepared for the initial base case;
- Normal and development traffic demand in the form of origin-destination (OD) matrices based on estimated growth rates are forecast by zone and vehicle type for domestic passenger traffic, domestic freight traffic, international passenger traffic, and international freight traffic;
- Diverted traffic from other routes and modes are then forecast for domestic passenger traffic, domestic freight traffic, international passenger traffic, and international freight traffic;
- Basic traffic matrices are forecast by summing the normal and development traffic OD matrices and the diverted traffic OD matrices;
- The reduction of travel cost between cases with and without a new Mangochi Bridge are estimated, and induced traffic in the future is forecast by applying elasticities with respect to reduction of travel cost to the basic traffic OD matrices;
- Future traffic matrices by vehicle type are constructed by adding the induced traffic OD matrices to the basic future traffic OD matrices; and

Table 3.27 Traffic Zones

Country	City or Town	Zone No.
Botswana	Gaborone	1
Malawi	Balaka	2
	Blantyre (and Limbe)	3
	Chimbende	4
	Chimwala	5
	Chingo	6
	Chiponde	7
	Chowe	8
	Jalasi	9
	Kwilembe	10
	Lilongwe	11
	Machinga	12
	Makanjila	13
	Masuku	14
	Malindi	15
	Mangochi (West of Bridge)	16
	Mbaluku	17
	Monkey Bay	18
	Mwanza	19
	Namalaka	20
	Namiasi/Palm Beach	21
	Namwera	22
	Ntaja	23
	Zomba	24
Mozambique	Beira	25
	Cuamba	26
	Lichinga	27
	Mandimba	28
	Maputo	29
	Mocuba	30
	Nacala	31
	Nampula	32
	Pemba	33
	Quelimane	34
	Tete	35
South Africa	Durban	36
	Johannesburg-Pretoria	37
Tanzania	Dar-es-Salaam	38
Zambia	Lusaka	39
Zimbabwe	Harare	40



The Feasibility Study on the Reconstruction of Mangochi Road Bridge in the Republic of Malawi	Figure 3.5 Procedure of Traffic Demand

- Traffic volumes at the bridge are then forecast by assigning the traffic OD matrices by vehicle type to the "without" new bridge and "with" new bridge networks.

(6) Intermodal Analysis of Traffic

Transport systems are rarely independent. Because different modes of transport often compete or complement each other, it is desirable to analyze the transport system including roads, railways, and waterways. The transport of cargo by air is considered negligible due to its high cost at present and in the foreseeable future.

Because ongoing and planned road improvement projects are expected to promote international freight traffic by road between Malawi and the Mozambican port of Nacala, the diversion of international freight traffic requires special analysis. These road improvement projects include the rehabilitation of Route 8 in Mozambique from Nampula to Mandimba and the planned rehabilitation of Routes M3 and S131 in Malawi. It is assumed that this diversion of international freight traffic will take place with or without the new Mangochi Bridge, since the alternative Route S131 will be available in the case without a new Mangochi Bridge. It is important to note that because the M3 route is significantly shorter than the S131 route (i.e., a savings of 25 km to/from Lilongwe and 19 km to/from Blantyre), the new Mangochi Bridge will bring about a diversion in route choice from S131 to M3. This type of diverted traffic is determined during the network assignment procedure and does not require exogenous analysis.

Historically, the Nacala and Beira ports in Mozambique handled over 90% of Malawi's external trade. However, the civil war in Mozambique interrupted this service, and by 1985 both routes had stopped functioning. As an alternative, Malawi had to resort to much longer trade routes, mostly to the port of Durban, South Africa, and later to the port of Dar-es-Salaam, Tanzania, as part of the Northern Transport Corridor Project. With renewed peace in Mozambique, the Nacala and Beira ports have started to make a comeback. Currently, transport to/from Nacala port is almost entirely by rail, while transport to/from Beira port is either entirely by road or some combination of road and rail.

To international cargo shippers, the key concerns in determining which route(s) to utilize for the transport of goods are the total cost, the time taken in transit, and the reliability of service. Not only transport by land and sea is involved, but also collection, handling, insurance, customs, and many other activities take place. Therefore, minimizing the number of transshipments between different modes and minimizing the number of cross-border checks is also important. Clearly, the Nacala, Beira, and Dar-es-Salaam ports are advantageous in that they require only one international border crossing, either through Mozambique or Tanzania. Transport by land to Durban port involves at least three border crossings.

Because it has proven very difficult to obtain reliable data on international freight transport costs for the different modes and routes serving Malawi, several assumptions have been made to estimate these transport costs. First, it was assumed that rail transport costs twice that of sea transport per ton carried, and that road transport costs twice that of rail transport (four times that of sea transport) per ton carried. Mooring costs, agent costs, and port charges for sea transport as well as transshipment costs for both sea and rail transport were estimated based on cost relationships from previous studies in developing countries. These generic costs, which are not expressed in terms of a specific currency (i.e., no denomination), are summarized in Table 3.28.

Table 3.28 Comparison of Generic International Freight Transport Costs

Item	Unit	Road	Rail	Sea
Transport Cost	cost per ton-km	4	2	1
Mooring Cost	cost per ton	-	-	15
Agent Cost	cost per ton	-	-	10
Port Charge	cost per ton-day	-	-	50
Transshipment Cost	cost per ton	-	500	500

Source: JICA Study Team.

The advantage of sea transport for long distances is clear, while road and railways compete with each other for short- and medium-distance freight transport. Railway becomes more favorable as the transport distance increases. The choice of transport mode basically depends on the characteristics of the commodities being transported, but the generic unit costs shown in Table 3.28 can be used as a guide for estimating overall freight mode shares.

The methodology adopted for estimating the volume of diverted international freight traffic was based on AASHTO's standard empirical diversion formula tailored to conditions in Malawi. The basic equation is shown below, followed by the revised equation for Malawi, which assumes that the diversion factor (i.e., expected traffic share) for each origin-destination pair is a function of the travel cost for the Malawi-Nacala-Durban route by road and sea and the travel costs of all other feasible routes between Malawi and Durban.

$$P_i = \frac{1}{1+\sum_{i=1}^{n}\left(\frac{C_i}{C_{i+1}}\right)^6}$$

where	Pi	=	Probability of using route i from origin O to destination D
	Ci	=	Operating cost of using route i from origin O to destination D
	n	=	Number of routes from origin O to destination D

$$P_{na,rd} = \frac{1}{1+\left(\frac{C_{na,rd}}{C_{be,rd}}\right)^6+\left(\frac{C_{na,rd}}{C_{da,rd}}\right)^6+\left(\frac{C_{na,rd}}{C_{du,rd}}\right)^6+\left(\frac{C_{na,rd}}{C_{na,rl}}\right)^6+\left(\frac{C_{na,rd}}{C_{be,rl}}\right)^6+\left(\frac{C_{na,rd}}{C_{da,rdrl}}\right)^6}$$

where	Pna,rd	=	Probability of using road to Nacala then sea to Durban from origin O to destination D
	Cna,rd	=	Operating cost of using road to Nacala then sea to Durban from origin O to destination D
	Cbe,rd	=	Operating cost of using road to Beira then sea to Durban from origin O to destination D
	Cda,rd	=	Operating cost of using road to Dar-es-Salaam then sea to Durban from origin O to destination D
	Cdu,rd	=	Operating cost of using road to Durban from origin O to destination D
	Cna,rl	=	Operating cost of using rail to Nacala then sea to Durban from origin O to destination D
	Cbe,rl	=	Operating cost of using rail to Beira then sea to Durban from origin O to destination D
	Cda,rdrl	=	Operating cost of using road to Mbeya, then rail to Dar-es-Salaam, then sea to Durban from origin O to destination D

Applying this equation to the seven different routes between Malawi and Durban allows one to estimate what the expected mode shares for each route would be given all factors other than cost equal (i.e., road conditions, rail track conditions, security, reliability). This exercise was performed for both the Blantyre-Durban and Lilongwe-Durban OD pairs, and the results are shown in Tables 3.29 and 3.30.

Table 3.29 Expected International Freight Traffic Mode Shares between Blantyre and Durban by Route

Mode(s)	Via	Km Road	Km Rail	Km Sea	Normalized Transport Cost per Ton	Expected Mode Share
Road-Sea	Nacala	950	-	2,200	100	4.0%
"	Beira	803	-	1,500	79	16.1%
"	Dar-es-Salaam	2,039	-	3,100	185	0.1%
Rail-Sea	Nacala	-	996	2,200	79	16.5%
"	Beira	-	857	1,500	63	62.8%
Road-Rail-Sea	Dar-es-Salaam	1,092	697	3,100	154	0.3%
Road Only	-	2,315	-	-	149	0.4%
					Total	100.0%

Note: Estimated transport costs per ton were normalized such that the transport cost per ton from Blantyre to Durban via Nacala port by road and sea has a value of 100.

Source: JICA Study Team.

Table 3.30 Expected International Freight Traffic Mode Shares between Lilongwe and Durban by Route

Mode(s)	Via	Km Road	Km Rail	Km Sea	Normalized Transport Cost per Ton	Expected Mode Share
Road-Sea	Nacala	1,075	-	2,200	108	9.8%
"	Beira	1,008	-	1,500	92	25.0%
"	Dar-es-Salaam	1,674	-	3,100	161	0.9%
Rail-Sea	Nacala	-	1,396	2,200	92	26.0%
"	Beira	-	1,609	1,500	87	35.0%
Road-Rail-Sea	Dar-es-Salaam	781	697	3,100	134	2.7%
Road Only	-	2,626	-	-	169	0.7%
					Total	100.0%

Note: Estimated transport costs per ton were normalized such that the transport cost per ton from Lilongwe to Durban via Nacala port by road and sea has a value of 100.

Source: JICA Study Team.

Interestingly, these estimates indicate that under ideal conditions the Nacala route by road would attract approximately 4% of the total international freight traffic between Blantyre and Durban and approximately 10% of the total international freight traffic between Lilongwe and Durban. If 80% of all international freight traffic travels directly to/from Blantyre and 20% directly to/from Lilongwe, then the Nacala route by road would attract slightly more than 5% of all international freight traffic between Malawi and Durban. This finding is significant.

Although the optimal mode share of international freight traffic on the Nacala route via road is about 5%, due to other factors not included in this analysis, it is conservatively assumed that the Nacala road route will realize only 75% of its potential by the year 2022 (i.e., international freight mode share of 3.75%). Given the international freight volume in 1996 of 1.2 million tons (Table 3.5) and the forecast foreign trade growth rates for Malawi (Table 3.18), the volume of international freight in 2022 can be estimated at 2.7 million tons. However, this figure includes wet and dry cargo, as well as traffic bound for neighboring countries.

Most likely, the Nacala road route will be utilized for dry cargo only and for international freight traffic with origin or destination outside Africa. Considering that 80% of all international freight traffic is dry cargo and 65% of the value of all imports and exports have origins and destinations outside Africa, the volume of international freight in 2022 subject to diversion to the Nacala port can be estimated at 1.4 million tons. Consequently, a 3.75% share would be equal to about 52,000 tons in 2022. It is assumed that most of this freight will be hauled by articulated trucks with an average load of 25 tons. Therefore, the international freight traffic volume on the Nacala route by road would be approximately 2,100 trucks per year or 5.7 trucks per day in 2022. Assuming that this international freight traffic diversion starts to take place in 2002 after rehabilitation of Routes M3 and S131 in Malawi and Route 8 in Mozambique, the international freight traffic volume on the Nacala route by road in 2002 would be approximately 1,100 trucks per year or 3.0 trucks per day.

(7) Normal and Development Traffic

a) Domestic Passenger Traffic Demand

Domestic passenger traffic demand was preliminarily forecast by vehicle based on demand elasticity. Elasticities of vehicular traffic generation with respect to GDRP were determined by vehicle type through an examination of elasticities empirically observed in other developing countries. Future traffic growth rates were then calculated by applying these elasticities to the GDRP estimates. Future traffic OD matrices by vehicle type were subsequently forecast by applying the Fratar method to these zonal traffic growth rates to present year (i.e., 1998) traffic OD matrices by vehicle type constructed from data obtained in the traffic survey of this study.

Since there are no sufficient historical data in Malawi to use for estimating vehicle-km elasticities by vehicle type with respect to GDP, data from other developing countries were used. The elasticities of passenger cars are typically more than 1.0, implying that their traffic growth rate is higher than that of GDP. Heavy buses, on the other hand, tend to have elasticities less than 1.0, implying that the growth rate of bus vehicle-km cannot keep pace with the growth rate of GDP. Bus traffic volumes are often dependent on public transport policy, unlike the situation for passenger cars and less formal means of public transport, such as pickup trucks and minibuses. Although the elasticity of vehicle-km is not conceptually equal to the elasticity of vehicle trips, the latter is substituted for the former in this study.

Because no data on GDRP is available for Malawi, future GDRP estimates were derived following the assumption that Mangochi District will grow 1.5 times faster than the national average (Table 3.31).

Table 3.31 Assumed Future GDRP Growth Rates for Malawi

Item	1998-2002	2002-2012	2012-2022
Mangochi District	6.6%	5.5%	5.2%
Rest of Malawi	4.4%	3.7%	3.5%

Source: JICA Study Team.

The elasticities of vehicle trips with respect to GDP used for the traffic forecasts are shown in Table 3.32. For the forecast of future traffic, the elasticities of vehicle trips with respect to GDP were applied to GDRP. Considering that passenger vehicle trips across the Mangochi Bridge have increased at an average annual rate of 12.7% from 1989 to 1998, these figures seem quite reasonable.

Table 3.32 Assumed Elasticity of Passenger Traffic Demand with Respect to GDP

Passenger Car (PC)	Pickup (PU)	Minibus (LB)	Heavy Bus (HB)
1.5	1.2	1.2	0.8

Source: JICA Study Team.

b) Domestic Freight Traffic Demand

As shown earlier in Table 3.3, domestic road and rail transport have suffered sharp declines in terms of total tonnage hauled since the early 1990s. The total domestic tonnage carried by road fell by an astounding 80% from 1993 to 1994, but since then has been increasing at a rapid rate of 45% per year. This annual growth rate is exceptionally high, and it would be quite speculative to assume that freight hauled by road would increase at this rate in the future. However, it would be reasonable to assume that within the next ten years, the total domestic tonnage hauled by road will at least be equal to the total domestic tonnage hauled by road in 1993. With this assumption, the average annual growth in domestic tonnage carried by road could be estimated at 9.3%, which is still relatively high. If the total domestic tonnage hauled by road in 1993 is not realized again for another, say, twenty years, then the average annual growth in domestic tonnage carried by road could be estimated at 4.6%.

Considering that freight vehicle trips across the Mangochi Bridge have increased at an average annual rate of 9.0% from 1991 to 1998 and an even higher 37.0% from 1996 to 1998, it was assumed that the demand for domestic freight traffic in Mangochi District would grow at an average annual rate of 7.5% from 1998 to 2012, dropping to 5.0% from 2012 to 2022. For the rest of Malawi, the demand for domestic freight traffic was assumed to grow at an average annual rate of 5.0% from 1998 to 2022.

Because the growth in tonnage hauled is not equivalent to the growth in truck trips, the observed empty-truck ratios and observed truck loads from the OD surveys conducted as part of this study were utilized to convert freight traffic demand into vehicle trips. While future changes in the average empty-truck ratio were assumed, changes in average loading were not considered. Also, the share of each truck type was assumed to be the same as the existing share within the forecast period.

Future traffic matrices by vehicle type were forecast by the Fratar method after applying the zonal traffic growth rates to the present year (i.e., 1998) OD matrices by vehicle type constructed from data obtained in the traffic survey of this study.

c) International Passenger Traffic Demand

International passenger traffic is related to the GDPs of origin and destination countries. Therefore, international passenger traffic by road was forecast assuming that traffic grows 1.2 times faster than GDP, resulting in an average annual growth rate of 4.8% on the condition that GDP growth rates in SADC countries are around 4% per annum on average during the forecast period (except for passenger traffic between Malawi and Mozambique's Niassa Province, which is dealt with separately and discussed later). The elasticity of international passenger traffic demand with respect to GDP seems reasonable in light of the experience of other developing countries.

The future modal share between road, rail, and air passenger transport is assumed constant during the forecast period. Therefore, the growth rates of international passenger traffic by road were set equal to those of the total international passenger growth rates for the forecast period. The zoning system in this study was established to reflect this international traffic; future traffic matrices by vehicle type were forecast by the Fratar method after applying the zonal traffic growth rates to present (i.e., 1998) OD matrices by vehicle type.

d) International Freight Traffic Demand

The forecast average annual growth in export and imports, presented earlier in Table 3.18, was used as a basis for forecasting international freight traffic movements between Malawi and other countries (except for freight traffic between Malawi and Mozambique's Niassa Province, which is dealt with separately and discussed later). To simplify the analysis, an average export-import growth rate was calculated from the separate export and import growth rates and applied to all international freight traffic, including Mozambique transit traffic through Malawi. The growth rates applied are summarized in Table 3.33.

Table 3.33 Average Annual Growth Rate for International Freight Traffic

Item	1998-2002	2002-2012	2012-2022
International Freight Traffic Growth Rate	3.9%	3.4%	3.2%

Source: JICA Study Team.

e) Passenger and Freight Development Traffic in Niassa Province, Mozambique

Developments taking place in Niassa Province of Mozambique in the area around Mandimba (across the border from Chiponde) will have a significant effect on the level of passenger and freight traffic on the Mangochi Bridge. In 1996 Mozambique and South Africa signed an agreement whereby South African farmers have already started settling in

Niassa Province, Mozambique's largest and most isolated province. Their mandate is to develop the agricultural potential of this province of Mozambique and also to develop tourist facilities on the eastern side of Lake Malawi. Some 100,000 hectares will be allocated to agricultural production, another 100,000 hectares will be allocated for the development and operation of livestock farming, and 20,000 hectares will be allocated for the development and operation of eco-tourism.

Because Niassa Province is relatively undeveloped, these South African farmers are required to enter Malawi to obtain supplies. They are already very popular as tourists to Malawi, particularly in Mangochi. According to the Kuwait-funded Feasibility Study of the Mangochi-Chiponde Road Project, traffic growth in Niassa Province averaged 15% per year in 1994 and 1995.

For the purposes of this study, an average annual growth rate of 12.5% was selected for passenger and freight traffic between Niassa Province and Malawi for the period 1998-2002, 10.0% for the period 2002-2012, and 7.5% for the period 2012-2022.

(8) Diverted Traffic

The Mangochi Bridge project alone is not expected to promote a diversion of traffic from other modes to road. As presented earlier, diverted international freight traffic to the Nacala port was considered to take place with or without the new bridge project because of the ongoing road improvement projects on Route 8 in Mozambique and on Routes M3 and S131 in Malawi. If the new Mangochi Bridge is not constructed, it is assumed that international freight traffic will travel from Chiponde south via S131 to Blantyre and Lilongwe.

In the case of a new Mangochi Bridge, international freight traffic will most likely choose the M3 route since it significantly shorter than the S131 route (i.e., savings of 25 km for travel to/from Lilongwe and savings of 19 km to/from Blantyre). This form of diverted traffic is determined during the network assignment procedure and does not require exogenous analysis.

No domestic passenger traffic, domestic freight traffic, or international passenger traffic is assumed to divert from other modes to road or from road to other modes. Again, changes in route choice are allowed to take place as this form of diverted traffic is determined during the network assignment procedure.

(9) Induced Traffic

a) Passenger Traffic Demand

Induced traffic arises either because a journey becomes more attractive by virtue of a reduction in cost or time or because of increased development that is brought about by the bridge investment. Induced traffic is difficult to forecast accurately and can be easily overestimated. Induced traffic is likely to be significant only in those cases where the transport infrastructure investment brings about a large reduction in transport costs. A new Mangochi Bridge can be considered to fall under such an investment.

The common approach to forecasting induced traffic is to make use of information about demand elasticities. Evidence from several countries suggests a price elasticity range of –0.6 to –2.0 with an average of –1.0. In general, the elasticity of commodity transport demand with respect to transport cost is smaller than that of passenger transport demand and depends on the proportion of transport cost reflected in commodity prices.

In this study, the following steps were adopted for the estimate of induced passenger traffic: (i) first, the reductions in transport cost due to the provision of a new bridge were estimated for each OD pair; (ii) the changes in transport cost between the with and without new bridge cases were calculated and expressed as percentage changes (e.g., transport cost reduction of 10% from zone x to zone y); and (iii) future induced traffic OD matrices by vehicle type were forecast by applying elasticities with respect to transport cost to the traffic OD matrices by vehicle type. For passenger traffic, a value of –1.0 was adopted as the elasticity (i.e., a 10% decrease in transport cost would result in a 10% increase in passenger traffic volume).

b) Freight Traffic Demand

Induced freight traffic demand was forecast by a method based on the same principles as for the passenger traffic demand forecast. A value of

−0.5 was adopted as the elasticity (i.e., a 10% decrease in transport cost would result in a 5% increase in freight traffic volume).

3.3.3 Results of Traffic Demand Forecast

Forecasts of traffic volumes at the Mangochi Bridge were determined by assigning the traffic matrices by vehicle type to the networks.

(1) Study Cases

Two study cases for the years 2002, 2012, and 2022 were established: a without new bridge case and a with new bridge case. It was assumed that with retrofitting, the existing bridge could be used throughout this period.

Because the existing bridge is a one-lane bridge and is considered unstable for very heavy trucks, it is necessary to take into consideration traffic volume and truck load capacity constraints in the without new bridge case. With respect to traffic capacity, the existing bridge can allow at maximum only three vehicles to cross per minute. According to the traffic count survey results, the peak hour represents 9% of total daily traffic. Therefore, a rough estimate of the traffic volume at which free-flow speeds would still be possible is 2,000 vehicles per day (not including bicycles or motorcycles). When the average daily traffic volume exceeds this level, vehicles will be required to wait prior to crossing the bridge. Therefore, estimates of bridge waiting times were calculated in the without new bridge case.

With respect to truck load capacity constraints, it was assumed that articulated (very heavy) trucks with origins and destinations outside the Mangochi-Chiponde Route M3 corridor would avoid the existing bridge and travel on Route S131 between Liwonde and Chiponde.

(2) Traffic Forecast Results for 2002, 2005, 2012, and 2022

Traffic volumes at the Mangochi Bridge in each case were forecast by assigning the traffic matrices by vehicle type separately to the networks. This method enabled the accurate tracking and reporting of traffic assignments and related statistics (e.g., vehicle-minutes, vehicle-km) by vehicle type.

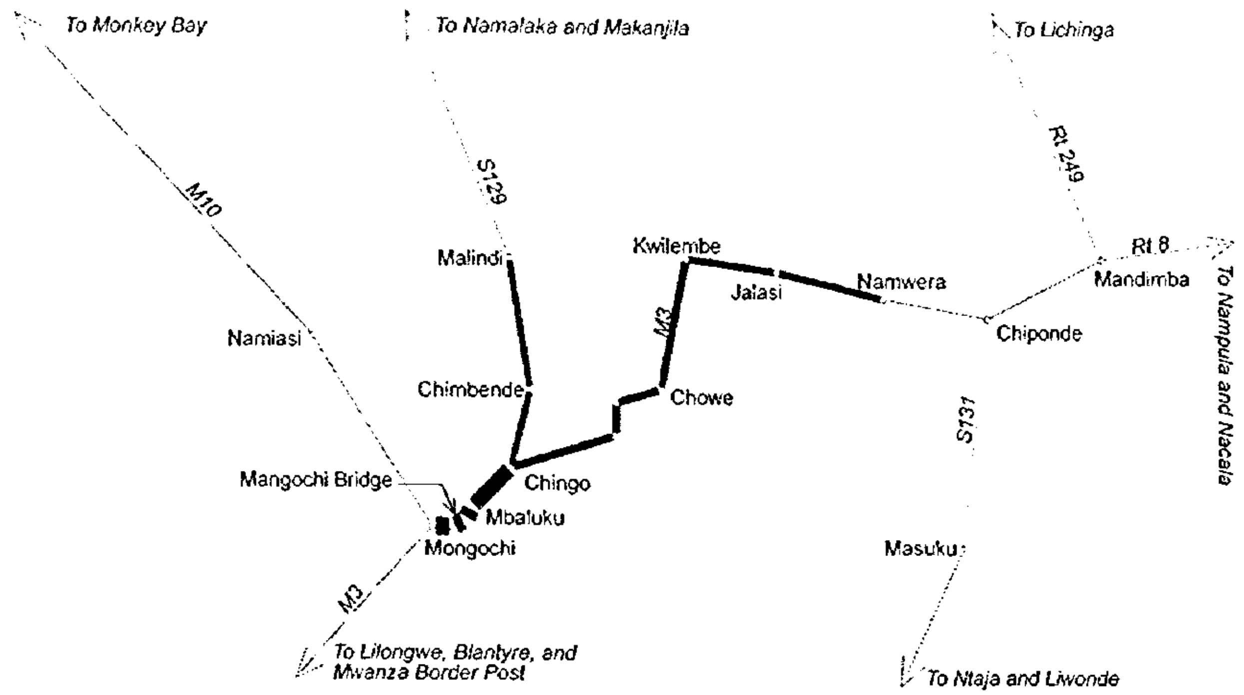
The assignment results for 2002, 2005, 2012, and 2022 are summarized in Table 3.34. Traffic volume bandwidth displays for the with new bridge case in 2002 and 2022 are shown in Figure 3.6. The forecast traffic volume in the without new bridge case is estimated to reach 2,000 vehicle per day by year 2017, after which substantial delays would be incurred in the without new bridge case. At a level of 2,500 vehicles per day (reached in 2021), any additional traffic would divert to another route. This assumption was validated by traffic simulation runs.

Table 3.34 Traffic Assignment Results for the Mangochi Bridge, Vehicles per Day

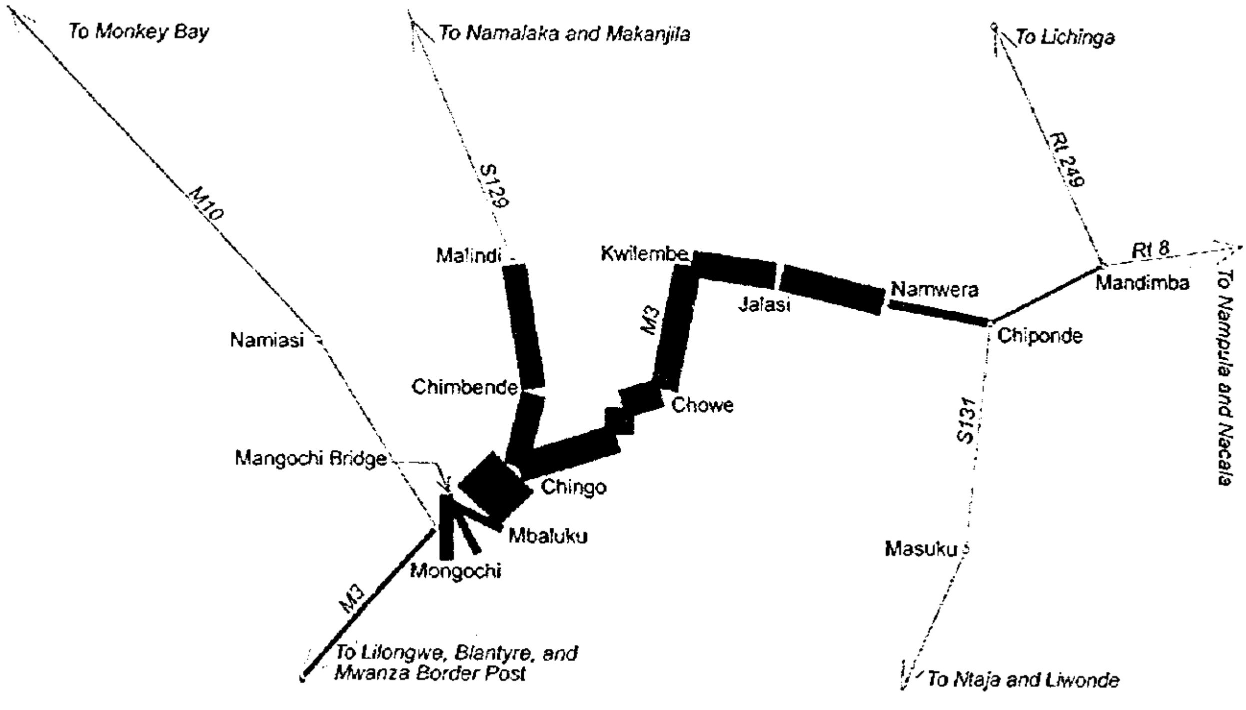
Description	Without New Bridge				With New Bridge			
	2002	2005	2012	2022	2002	2005	2012	2022
Normal & Develop. Traffic								
Passenger Car (PC)	182	229	392	741	187	235	403	836
Pickup Truck (PU)	423	509	786	1,288	424	510	789	1,420
Minibus (LB)	55	66	102	167	56	67	105	192
Heavy Bus (HB)	0	0	0	0	3	3	3	4
Light Truck (LT)	92	112	180	267	103	126	203	341
Medium Truck (MT)	11	13	21	31	14	17	28	51
Heavy Truck (HT)	2	2	4	6	6	7	14	27
Articulated Truck (VHT)	0	0	0	0	6	7	11	17
Subtotal in Vehicles/Day	765	931	1,485	2,500	799	972	1,556	2,888
Induced Traffic								
Passenger Car (PC)	0	0	0	0	12	15	26	55
Pickup Truck (PU)	0	0	0	0	28	33	52	93
Minibus (LB)	0	0	0	0	3	3	6	12
Heavy Bus (HB)	0	0	0	0	0	0	0	0
Light Truck (LT)	0	0	0	0	3	3	6	11
Medium Truck (MT)	0	0	0	0	0	0	0	1
Heavy Truck (HT)	0	0	0	0	0	0	0	0
Articulated Truck (VHT)	0	0	0	0	0	0	0	0
Subtotal in Vehicles/Day	0	0	0	0	46	54	90	172
Total Traffic								
Passenger Car (PC)	182	229	392	741	199	250	429	891
Pickup Truck (PU)	423	509	786	1,288	452	543	841	1,513
Minibus (LB)	55	66	102	167	59	70	111	204
Heavy Bus (HB)	0	0	0	0	3	3	3	4
Light Truck (LT)	92	112	180	267	106	129	209	352
Medium Truck (MT)	11	13	21	31	14	17	28	52
Heavy Truck (HT)	2	2	4	6	6	7	14	27
Articulated Truck (VHT)	0	0	0	0	6	7	11	17
Total in Vehicles/Day	765	931	1,485	2,500	845	1,026	1,646	3,060

Note: Diverted traffic due to a shift in routes (not modes) is included in normal and development traffic.

Source: JICA Study Team.



Year 2002 Forecast Traffic (ADT, With New Bridge Case)



Year 2022 Forecast Traffic (ADT, With New Bridge Case)

The Feasibility Study on the Reconstruction of Mangochi Road Bridge in the Republic of Malawi	Figure 3.6 Volume Bandwidths of Forecast Traffic in 2002 and 2022 for the With New Bridge Case

(Developed by the Study Team using JICA STRADA)

3.4 Evaluation of the Proposed Bridge Reconstruction Project

3.4.1 Benefits

(1) Direct Benefits

a) Introduction

The direct economic benefits of the new bridge are calculated as savings in vehicle operating costs (VOCs) by a "with" and "without" project comparison scenario. While existing bridge maintenance cost savings could also be estimated and applied as a direct benefit, the current situation suggests that very little maintenance is carried out on the existing bridge and any such cost savings would be marginal.

All values used in the economic analysis are expressed in constant prices of March 1998. In order to dissociate the project results from any steep movements in the value of the Kwacha that might render them rapidly out of date, costs and benefits are expressed in United States dollars by applying an exchange rate of US$1.00 equal to MK25.00.

The Terms of Reference for this study initially requested an evaluation period of 20 years after opening. However, for a bridge project of this nature, a longer evaluation period would be appropriate. Consequently, project benefits have been forecast for 50 years after the new Mangochi Bridge is opened with no residual value.

b) Conversion of Financial Prices to Economic Prices

The values used in economic analysis of capital investment should be a reflection of the actual use of natural resources expressed in border prices. Certain adjustments are therefore necessary to express costs and benefits in economic rather than financial prices. To estimate economic prices from market prices, import duties and value added tax have been deducted as these are transfers within the economy and do not represent the real use of resources. An adjustment has also been made to correct for distortions between domestic and international prices. This adjustment has been applied to the local cost component.

i) Calculation of a Standard Conversion Factor for Malawi

In order to convert financial prices to economic prices, a historical Standard Conversion Factor (SCF) is determined from the following formula:

$$SCF = \frac{M + X}{(M + T_m) + (X - T_x)}$$

where	M	=	Border price value of all imports
	X	=	Border price value of all exports
	Tm	=	Revenue from imports duties net of subsidies
	Tx	=	Revenue from exports duties net of subsidies

As shown above, the SCF is a conversion factor for the general distortion between international and domestic prices that is caused by import duties, taxes and tariffs, subsidies, and other price distortions to trade. The SCF is a broad approximation and is generally only applied to local project inputs and outputs that cannot be easily disaggregated into their traded and non-traded components. In this analysis, the SCF will therefore be applied to all local costs and benefits. The SCF for Malawi has been calculated for the years 1990 to 1997 utilizing the latest available statistics as shown in Table 3.35.

Table 3.35 Estimation of a Standard Conversion Factor for Malawi

Item	Year							
	1990	1991	1992	1993	1994	1995	1996	1997
Import Duties	154.7	184.0	234.8	244.6	457.0	746.4	1018.2	954.0
Surtax	310.3	312.9	357.6	435.0	700.0	1239.5	1655.3	2041.0
Export Duties	0.0	0.0	0.0	0.0	0.0	353.7	331.8	170.0
Exports (FOB)	1083.9	1299.3	1400.7	1396.6	2803.3	6189.3	7353.0	9264.1
Imports (CIF)	1584.2	1975.8	2592.0	2184.2	3961.0	6097.6	9118.2	11124.2
SCF	0.90	0.91	0.91	0.89	0.89	0.92	0.92	0.92

Notes: The SCF was estimated assuming 50% of surtax falls on imported goods. Data for 1997 is provisional. Values are in terms of MK million.

Source: Economic Report 1997, Mid-Year Economic Review 1997-1998, Ministry of Economic Planning and Development.

Surtax applies to a wide range of goods and it has not been possible to obtain exact information on the value of this tax collected on imports alone, but it undoubtedly a high proportion of the total. In the estimation of the SCF, the assumption was therefore made that half of the government revenue collected through surtax is collected from imports.

Excise duty is payable on some imports (e.g., passenger cars), but it is mainly levied on domestically produced goods. Excise duty has not been included in the calculation of the SCF because it is not possible to estimate the proportion collected from imported goods. However, this assumption is unlikely to be critical as the total amount of government revenue collected from this tax is relatively small.

The SCF varies little over the period, and distortions are not expected to change significantly in the short to medium term. Some change is evident due to the introduction of export duties in 1995; therefore, the latest estimates of 0.92 for 1995 and 1996 have been applied in the economic analysis. Provisional estimates for 1997 also result in an SCF of 0.92.

ii) Shadow Wage Rates

In an economy marked by vast unemployment and underemployment such as Malawi, the real costs of labor used in the project may be less than the actual wage rate. When this is a widely prevailing condition that is likely to remain for some time, the cost of unskilled labor should be calculated at less than actual wage payments. Therefore, it was considered necessary for this project to use shadow wage conversion factors to adjust financial labor costs into economic costs.

The World Bank recommends that, subject to data limitations, it may be assumed that the economic cost of unskilled labor may be up to 50% lower than actual wages paid. However, because this estimate is not based on any detailed studies, such a low conversion factor should be used with caution and only for projects where the proportion of unskilled labor cost is unusually large, such as a rural road construction project. For the new Mangochi Bridge project, the proportion of the total cost made up by unskilled labor is relatively low; therefore, application of shadow wages will have a minor impact on the economic analysis. Based on discussions with officials of the Ministry of Economic Planning and Development and based on a review of published wage rate data, a shadow price adjustment factor for unskilled labor of 0.60 was adopted.

For domestic skilled labor, the general rule is to take the market domestic rate for such labor and adjust it only by the Standard Conversion Factor. This approach is justified on the grounds that such labor, being scarce, can usually command an equivalent income in other activities, so the market wage reflects its marginal productivity in alternative uses. Foreign skilled labor is, of course, valued at its actual cost (i.e., no conversion factor) since all of such payments are opportunity costs.

iii) Economic Vehicle and Tire Prices

Vehicle operating costs were calculated for the project following a detailed review and updating of a number of recent highway studies performed in Malawi. Similarly, specific vehicles that best represent the fleet of different vehicles actually used in Malawi were selected based on the results of traffic surveys and reviews of previous highway feasibility studies. Ideally, vehicle operating costs would be calculated separately for vehicles used in Malawi versus transit vehicles passing through Malawi or, say, Mozambican vehicles traveling to/from Malawi. However, because fleet and cost data for vehicles originating in other countries are not readily available, only one set of vehicle operating costs by vehicle type were used.

Most vehicles are imported into Malawi completely built as there is virtually no local assembly except for the production of trailers and bus bodies. Imported passenger cars are subject to high rates of import and excise duties. Surtax is also levied on the value of vehicles plus duty. Commercial vehicles are less severely taxed. In fact, no excise duty is applied to goods vehicles, and heavy goods vehicles of gross vehicle weight greater than 10 tons are completely free of all indirect taxes. The objective of this policy is to improve the domestic trucking industry.

Table 3.36 shows how the factors for converting market prices to economic prices have been estimated for different vehicle classes, based on March 1998 data from the Ministry of Finance. The share of import duties and other indirect taxes have been deducted from the market price, and the SCF has been applied to the local component of costs. The proportion of the retail price made up of local distribution costs and the dealers' margin has been estimated from information supplied by local dealers.

In the analysis, the cost of tires has been excluded from vehicle prices as rates of duty and value added tax for tires differ from those for vehicles as does the estimated local content. The conversion factor for deriving economic tire prices from retail prices is also presented in Table 3.36. The economic price of tires is shown to be 68% of the financial price.

Table 3.36 Estimation of Economic Vehicle and Tire Prices, March 1998

Item	Car <2000 cc	Car >2000 cc	Pick-up	4WD	Minibus >10 seats	Large Bus	LT, MT GVW 2.75-10t	HT GVW >10t	Tires
Financial Price	100	100	100	100	100	100	100	100	100
Estimation of Economic Price									
Local Distribution Costs and Dealers' Margin	25	18	15	15	15	15	15	15	20
SCF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Local Cost * SCF	23	17	14	14	14	14	14	14	18
Foreign Cost Inclusive of Duties and Taxes	75	82	85	85	85	85	85	85	80
Rate of Import Duty	35%	35%	20%	35%	35%	35%	10%	0%	35%
Rate of Excise Tax	30%	55%	0%	55%	0%	0%	0%	0%	0%
Rate of Surtax	20%	20%	10%	20%	10%	10%	0%	0%	20%
Foreign Cost Exclusive of Duties and Taxes	36	33	64	34	57	57	77	85	49
Economic Price	59	49	78	48	71	71	91	99	68

Source: JICA Study Team, based on data provided by the Ministry of Finance.

iv) Fuel Prices

A significant proportion of the price of fuel in Malawi represents transfers within the economy rather than real resource costs. Import duty, surtax, and various other levies and taxes have been deducted from the market price of fuel, and the SCF calculated earlier has been applied to the local components of the cost (distribution costs and dealers' margins) to yield the economic price as demonstrated in Table 3.37. The economic prices of petrol and diesel are shown to be 65% and 70% respectively of their retail prices. It should be noted that prior to 3 February 1998 the pump prices of fuel and diesel were respectively MK10.0 and MK8.4 per liter. The current pump prices of fuel and diesel are respectively MK13.0 and MK11.0 per liter.

Table 3.37 Estimation of the Economic Price of Fuel, March 1998
(Tambala per Liter)

Item	Financial Price		Standard Conversion Factor	Economic Price	
	Petrol	Diesel		Petrol	Diesel
CIF Landed Cost in Malawi	638.90	612.14		638.90	612.14
Miscellaneous Levies	227.49	148.66			
Duty	127.78	91.82			
Surtax	76.67	70.40			
Duty Paid Price	1070.84	923.01			
Gross Margin	140.16	101.99	0.92	128.95	93.83
Wholesale Price	1211.00	1025.00		767.85	705.97
Retail Margin	89.00	75.00	0.92	81.88	69.00
Pump Price	1300.00	1100.00		849.73	774.97
Economic/Financial Price				65%	70%

Source: Revised Controlled Petroleum Price Structure, Effective Date 3 February 1998, Department of Energy, Ministry of Energy and Mining.

c) Discount Rate

The economically justified level of investment in new bridge construction will be dependent on the discount rate applied in the economic analysis. The appropriate discount rate, which is the opportunity cost of capital in the public sector, is measured by the marginal rate of return on public sector investments.

Discussions with the Ministry of Economic Planning and Development confirmed that the discount rate to be used for public sector investment appraisal in Malawi is no higher than 12%. This figure, also endorsed by the World Bank, has traditionally been the discount rate applied in Malawi.

Little guidance could be given as to how this rate had been estimated except that it was an approximation of the marginal rate of return on public sector investments. Therefore, in view of the uncertainty attached to the precision of the recommended rate, the effects of using rates of 6%, 8%, 10%, and 12% have been examined. In the analysis of the project's net economic benefit, all project costs and benefits have been discounted back to 1998 to be expressed as present values of that year.

d) Economic Vehicle Operating Costs and Time Costs

i) Economic Vehicle Operating Costs

Vehicle operating costs were divided into the following two main categories: running or variable costs, which are directly related to the operation of the vehicle and include those for fuel, oil, tires, maintenance, depreciation, and capital costs; and fixed costs, which are incurred whether or not vehicles are operated and include drivers' wages and overhead.

In this study, two types of VOCs were estimated: time-related VOCs and distance-related VOCs. Time-related VOCs are made up of passenger time costs, crew costs, and cargo time costs. Distance-related costs are made up of costs for the vehicle, fuel, oil, tires, maintenance, and time-related costs. Time-related costs are included in the distance-related costs in this study for the estimate of changes in VOCs accruing to the alteration of route due to the construction of the new bridge.

For the evaluation, eight vehicle categories were adopted as representative vehicles. The basic vehicle characteristics used an input into the HDM-III VOC3 submodel are summarized in Table 3.38.

Table 3.38 Basic Vehicle Technical Specifications

Item	PC	PU	LB	HB	LT	MT	HT	VHT
Gross Vehicle Weight (kg)	1600	2000	2800	12500	5600	11300	20800	30000
No. of Axles	2	2	2	2	2	2	3	5
No. of Tires	4	4	4	6	6	6	10	22
No. of Passengers	2.3	2.9	13.7	41.7	0	0	0	0
Fuel Type	Petrol	Petrol	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel

Note: No. of passengers does not include the driver or crew members.
Source: JICA Study Team.

Economic costs used in the HDM analysis are presented in Table 3.39. The values obtained were checked with up-to-date information available at the Ministry of Works and Supplies.

Table 3.39 Economic Unit Costs of Vehicles, Tires, and Labor, March 1998 (US$)

Item	PC	PU	LB	HB	LT	MT	HT	VHT
New Vehicle Price	16206	16658	27971	87758	38618	74986	135963	200546
New Tire Price	56	85	64	94	315	356	368	464
Maintenance Labor (per hr)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Driver Crew Cost (per hr)	-	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Other Crew Cost (per hr)	-	0.50	0.50	0.50	0.50	0.50	0.50	0.50

Source: JICA Study Team.

As determined earlier, the economic price of petrol is 849.73 tambala/liter (US$0.340/liter) and the economic price of diesel is 774.97 tambala/liter (US$0.310/liter). The economic price of lubricant was estimated at MK38.9/liter (US$1.556/liter).

Vehicle utilization is a key component of the vehicle depreciation and spare parts consumption calculation in HDM. The assumption of straight line depreciation was made. Utilization also allows conversion between time and distance related costs. The interest rate for loans in United States dollars (8%) was adopted due to the very high interest rate for loans in Malawian Kwacha (30-37%, depending on the loan terms). This assumption is conservative since use of a high interest rate would increase VOCs and thereby increase benefits accruing from VOC savings. Table 3.40 summarizes the values used.

Table 3.40 Vehicle Utilization Data

Item	PC	PU	LB	HB	LT	MT	HT	VHT
Service Life (years)	10	10	8	15	8	10	12	15
Hours Driven per Year	450	1300	2000	2000	1300	2100	2000	1900
Km Driven per Year	18000	30000	60000	80000	50000	65000	70000	80000
Annual Interest Rate	8%	8%	8%	8%	8%	8%	8%	8%

Source: JICA Study Team.

Crew size depends on the vehicle type and the use of the vehicle. It was assumed that car drivers were not generally employed as a driver. Table 3.41 summarizes the figures adopted.

Table 3.41 Crew Size by Vehicle Category

Item	PC	PU	LB	HB	LT	MT	HT	VHT
Driver	-	1	1	1	1	1	1	1
Conductor	-	-	1	1	-	-	-	-
Assistant	-	1	-	1	1	1	1	1
Total	0	2	2	3	2	2	2	2

Source: JICA Study Team.

Roughness of the road pavement is a major factor in the determination of vehicle operating costs. However, because this study is a bridge project and is not concerned with evaluating road improvement alternatives, for the purposes of this economic evaluation it is only necessary to determine a single average vehicle operating cost by vehicle type for the entire study area. Therefore, an average road roughness of IRI 7.0 (i.e., 7 m/km), considered representative of roads in Malawi, was adopted.

ii) Economic Passenger Time Costs

Assuming that the time saved traveling can be put to an alternative and productive use, there will be an economic benefit to be gained from travel time savings. Passengers utilizing motorized vehicles in Malawi, especially passenger cars, are more likely to be higher income earners whose skills are in short supply and whose wage costs are an accurate reflection of the opportunity cost of their labor. Therefore, it is reasonable to place a value on the benefits of time savings accruing to the employers of these workers.

Although of considerably less value than savings in working time, savings in non-working time also has some worth. As a rule of thumb, time savings outside work is generally valued at 25% the savings in working time. This figure is generally supported by willingness to pay surveys.

There is considerable evidence that car ownership is confined to the highest income earning groups. In Malawi, this conclusion has been supported by the results of various household income and expenditure surveys. It is also reasonable to assume that the drivers of cars are generally also the owners; where this is not the case, the owner will often be a passenger. The exceptions to this are the many Malawian Government vehicles on the roads, but these are often carrying higher ranking civil servants.

Few statistics exist on the distribution of earnings in Malawi, making it difficult to produce estimates of the average wage cost for those likely to be traveling by car during working time. Figures on monthly average earnings by sector of activity are available for 1991-1995; however, extrapolation of these figures to 1998 proves difficult in light of the subsequent devaluation of the Malawian Kwacha (from MK15.3 per US$1.00 in 1995 to the current MK25.0 per US$1.00) and high inflation rates in 1995 (83.3%) and 1996 (37.6%). Application of the consumer price index would not be correct, because incomes in Malawi have historically increased at a far lesser rate than the rate of inflation.

Therefore, as a proxy for average annual income, the forecast 1998 GDP per capita of MK5,000 (US$200) was used as a base. Consistent with previous feasibility studies in Malawi, the average income of passenger car drivers was estimated to be 50 times the average GDP per capita, i.e., around MK250,000 (US$10,000) per year, which may still be somewhat low considering the financial cost of a new passenger car exceeds US$20,000 or two times this annual income estimate. As employers will employ labor up to the point where the wage rate equals the marginal revenue product of labor, employer's wage costs, estimated at 25%, were also added. If there are 1,800 productive working hours in a year, the value of working time for a car driver will therefore be MK173.6 per hour (US$6.94 per hour). Non-working time will be valued at MK43.4 per hour (US$1.74 per hour).

Car passengers will probably earn considerably less than car drivers and a figure of one-fourth (MK43.4 per hour or US$1.74 per hour) has been assumed as an average value for their working time. The value of non-working time is therefore MK10.9 per hour (US$0.43 per hour).

Previous surveys of public transport usage have shown that even bus passengers come from higher income brackets. Therefore, consistent with previous feasibility studies conducted in Malawi, a wage rate equal to twice the average GDP per capita was assumed for public transport users. The value of working time for public transport users (including non-crew truck passengers) is then MK5.6 per hour (US$0.22 per hour) and that for non-working time is MK1.4 per hour (US$0.06 per hour).

Assuming that the future increase of passenger cost is in proportion to future increases in GDP per capita, passenger time costs as well as crew and maintenance labor time costs by vehicle type in each forecast year were estimated (Tables 3.42 to 3.45).

Table 3.42 Average Annual Growth Rate of GDP per Capita

Item	1998-2002	2002-2012	2012-2022
Population Growth Rate	2.7%	2.4%	2.4%
Real GDP Growth Rate	4.4%	3.7%	3.5%
Real GDP per Capita Growth Rate	1.7%	1.3%	1.1%

Source: JICA Study Team

Table 3.43 Average Passenger Time Cost by Vehicle Type, 2002 (US$/Hour)

Item	PC	PU	LB	HB	LT	MT	HT	VHT
Crew Time Cost (Driver)	-	0.802	0.802	0.802	0.802	0.802	0.802	0.802
Crew Time Cost (Other)	-	0.535	0.535	0.535	0.535	0.535	0.535	0.535
Crew Size (Persons)	-	2	2	3	2	2	2	2
Hourly Crew Cost	-	1.337	1.337	1.872	1.337	1.337	1.337	1.337
Driver Time Cost (Work)	7.429	-	-	-	-	-	-	-
Driver Time Cost (Non-Wk)	1.857	-	-	-	-	-	-	-
Pass. Time Cost (Work)	1.857	0.238	0.238	0.238	-	-	-	-
Pass. Time Cost (Non-Wk)	0.464	0.059	0.059	0.059	-	-	-	-
Work Trip Rate	35%	35%	25%	25%	-	-	-	-
Avg. Vehicle Occupancy	2.3	2.9	13.7	41.7	-	-	-	-
Hourly Driver Time Cost	3.807	-	-	-	-	-	-	-
Hourly Pass. Time Cost	2.189	0.353	1.421	4.326	-	-	-	-
Total Travel Time Cost	5.996	1.690	2.758	6.198	1.337	1.337	1.337	1.337

Source: JICA Study Team

Table 3.44 Average Passenger Time Cost by Vehicle Type, 2012 (US$/Hour)

Item	PC	PU	LB	HB	LT	MT	HT	VHT
Crew Time Cost (Driver)	-	0.913	0.913	0.913	0.913	0.913	0.913	0.913
Crew Time Cost (Other)	-	0.609	0.609	0.609	0.609	0.609	0.609	0.609
Crew Size (Persons)	-	2	2	3	2	2	2	2
Hourly Crew Cost	-	1.522	1.522	2.131	1.522	1.522	1.522	1.522
Driver Time Cost (Work)	8.453	-	-	-	-	-	-	-
Driver Time Cost (Non-Wk)	2.113	-	-	-	-	-	-	-
Pass. Time Cost (Work)	2.113	0.270	0.270	0.270	-	-	-	-
Pass. Time Cost (Non-Wk)	0.528	0.068	0.068	0.068	-	-	-	-
Work Trip Rate	35%	35%	25%	25%	-	-	-	-
Avg. Vehicle Occupancy	2.3	2.9	13.7	41.7	-	-	-	-
Hourly Driver Time Cost	4.332	-	-	-	-	-	-	-
Hourly Pass. Time Cost	2.490	0.402	1.624	4.942	-	-	-	-
Total Travel Time Cost	6.822	1.924	3.146	7.073	1.522	1.522	1.522	1.522

Source: JICA Study Team.

Table 3.45 Average Passenger Time Cost by Vehicle Type, 2022 (US$/Hour)

Item	PC	PU	LB	HB	LT	MT	HT	VHT
Crew Time Cost (Driver)	-	1.019	1.019	1.019	1.019	1.019	1.019	1.019
Crew Time Cost (Other)	-	0.679	0.679	0.679	0.679	0.679	0.679	0.679
Crew Size (Persons)	-	2	2	3	2	2	2	2
Hourly Crew Cost	-	1.698	1.698	2.377	1.698	1.698	1.698	1.698
Driver Time Cost (Work)	9.430	-	-	-	-	-	-	-
Driver Time Cost (Non-Wk)	2.358	-	-	-	-	-	-	-
Pass. Time Cost (Work)	2.358	0.302	0.302	0.302	-	-	-	-
Pass. Time Cost (Non-Wk)	0.589	0.075	0.075	0.075	-	-	-	-
Work Trip Rate	35%	35%	25%	25%	-	-	-	-
Avg. Vehicle Occupancy	2.3	2.9	13.7	41.7	-	-	-	-
Hourly Driver Time Cost	4.833	-	-	-	-	-	-	-
Hourly Pass. Time Cost	2.779	0.448	1.805	5.494	-	-	-	-
Total Travel Time Cost	7.612	2.146	3.503	7.871	1.698	1.698	1.698	1.698

Source: JICA Study Team.

iii) Economic Cargo Time Costs

For cargo, an average value of US$500 per ton was estimated based on a comprehensive review and analysis of the quantities and values of international and domestic goods transported by road in Malawi. Based on this average value, cargo time costs can be valued according to two different approaches: an inventory time cost approach and a transit time cost approach.

The inventory time cost approach involves applying the prevailing interest rate for foreign loans to the cargo value. At an interest rate of 8% and assuming a working time of 1,800 hours per year, the inventory cost would be US$0.022 per ton-hour (i.e., US$500 per ton times 8% divided by 1,800).

For the second approach, if the turnover time of cargo is estimated to equal one month and infinite demand is assumed, the value of cargo in one hour of transit could be calculated at US$3.333 per ton-hour (i.e., US$500 per ton divided by the number of working hours per month, 150).

The true opportunity cost of cargo should fall somewhere in between the two values. In the Kuwait-funded Economic Feasibility Study of the Mangochi-Chiponde Road Project, a cargo time value of US$1.319 per ton-hour (in 1996 prices) was adopted. However, this value was derived from the cost of transporting tobacco, which is one of the most expensive commodities transported in Malawi. Consider, for example, that the unit price of tobacco is about US$3,000 per ton, six times the average value of cargo. If the tobacco time value used in the Mangochi-Chiponde Road Project Study is adjusted to an average cargo time value, the resulting figure is US$0.231 in 1998 prices. This value, which seems quite reasonable, was adopted for use in this study. Also, the real cargo time value was assumed to increase at an average rate of 2.5% per annum. Considering the average loading on each vehicle type, cargo time costs by vehicle type for each forecast year were estimated (Tables 3.46 through 3.48).

Table 3.46 Average Cargo Time Cost by Vehicle Type, 2002

Item	PC	PU	LB	HB	LT	MT	HT	VHT
Avg. Load on Loaded Veh. (tons)	-	-	-	-	2.4	6.9	15.1	26.9
Cargo Time Cost (US$/ton-hr)	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255
Empty-Truck Ratio	-	-	-	-	0.35	0.20	0.20	0.10
Avg. Cargo Time Cost (US$/hour)	-	-	-	-	0.398	1.408	3.080	6.174

Source: JICA Study Team.

Table 3.47 Average Cargo Time Cost by Vehicle Type, 2012

Item	PC	PU	LB	HB	LT	MT	HT	VHT
Avg. Load on Loaded Veh. (tons)	-	-	-	-	2.4	6.9	15.1	26.9
Cargo Time Cost (US$/ton-hr)	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326
Empty Load Vehicle Ratio	-	-	-	-	0.37	0.22	0.22	0.12
Avg. Cargo Time Cost (US$/hour)	-	-	-	-	0.490	1.746	3.822	7.695

Source: JICA Study Team.

Table 3.48 Average Cargo Time Cost by Vehicle Type, 2022

Item	PC	PU	LB	HB	LT	MT	HT	VHT
Avg. Load on Loaded Veh. (tons)	-	-	-	-	2.4	6.9	15.1	26.9
Cargo Time Cost (US$/ton-hr)	0.418	0.418	0.418	0.418	0.418	0.418	0.418	0.418
Empty Load Vehicle Ratio	-	-	-	-	0.40	0.25	0.25	0.15
Avg. Cargo Time Cost (US$/hour)	-	-	-	-	0.602	2.163	4.734	9.558

Source: JICA Study Team.

iv) Summary

As mentioned earlier, for the estimate of time-related VOCs, passenger time costs, crew costs, and cargo time costs are used. Distance-related costs are composed of the vehicle, fuel, oil, tires, maintenance, and time-related costs. Estimates of distance-related VOCs were carried out utilizing the VOC3 model, a subprogram of the HDM-III model. The resultant figures are shown in Tables 3.49 and 3.50.

Table 3.49 Average Time-Related Vehicle Operating Costs (US$/Hour)

Year	PC	PU	LB	HB	LT	MT	HT	VHT
2002	5.996	1.690	2.758	6.198	1.735	2.745	4.417	7.511
2012	6.822	1.924	3.146	7.073	2.012	3.268	5.344	9.217
2022	7.612	2.146	3.503	7.871	2.300	3.861	6.432	11.256

Source: JICA Study Team.

Table 3.50 Average Distance-Related Vehicle Operating Costs, IRI=7 (US$/1,000 km)

Year	PC	PU	LB	HB	LT	MT	HT	VHT
2002	445.79	203.83	213.44	402.72	347.71	393.73	680.33	1,076.85
2012	507.25	231.93	242.87	458.24	395.65	448.02	774.13	1,225.32
2022	565.90	258.75	270.95	511.22	441.39	499.81	863.63	1,366.98

Source: JICA Study Team.

(2) Indirect Benefits

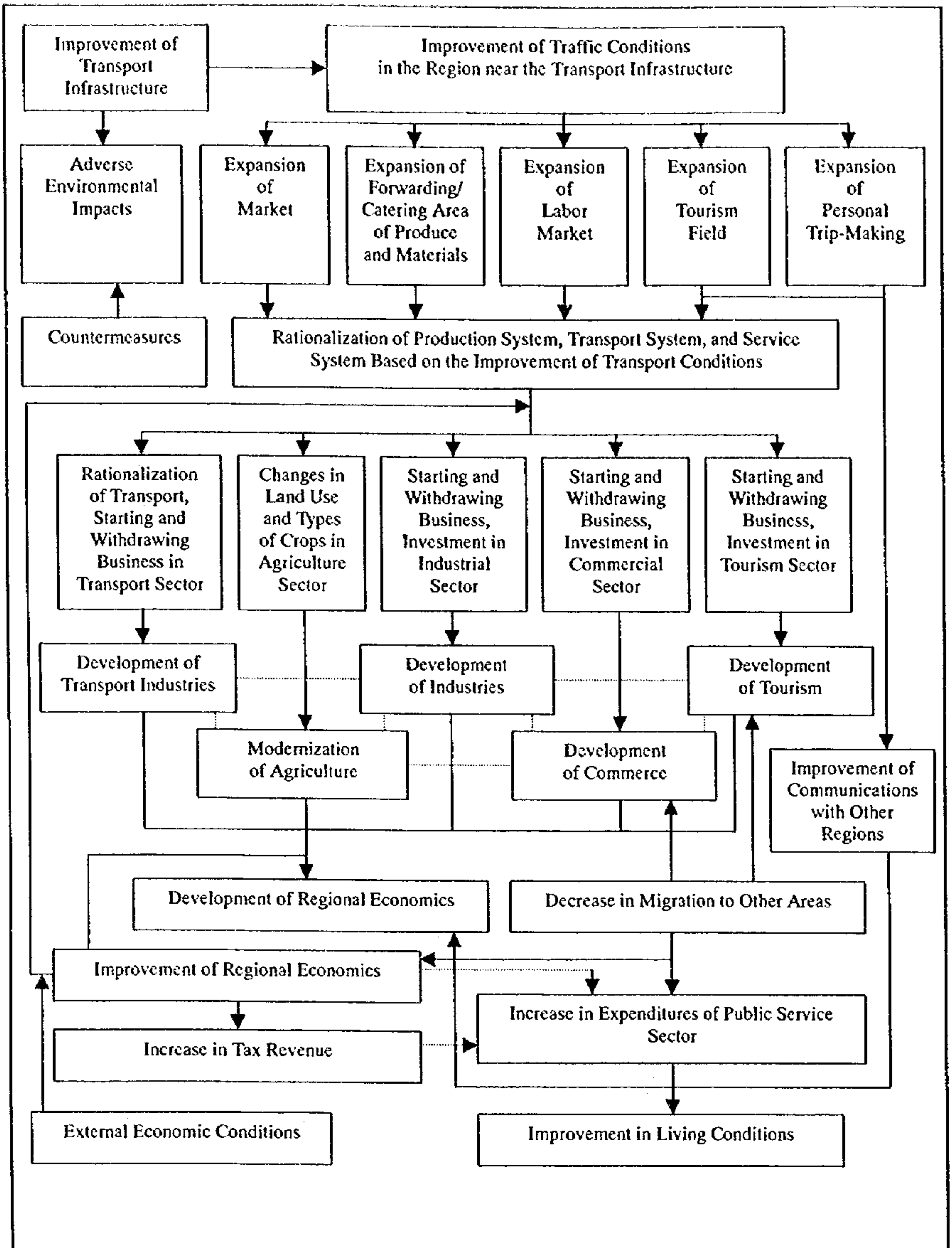
As the functions of the new Mangochi Bridge will be diverse, the effects of the project will be far-reaching but many are difficult to quantify. In general, the project bridge is expected to (i) facilitate exchange and development between Malawi and Mozambique, (ii) reduce transport costs in the project influence area and induce efficient movement of goods and passengers, (iii) support rural development and increase earnings of low-income groups by enhancing the mobility of rural communities, (iv) alleviate poverty and provide employment opportunities along Route M3, and (v) promote tourism in the region. The overall process of indirect benefits that will be brought about by the project bridge is shown in Figure 3.7.

Two main categories of such effects were identified: transport effects and regional development effects. These items are discussed below.

a) Transport Effects

i) Improvement of Traffic Safety

The new Mangochi Bridge would be a modern two-lane facility capable of providing the safe passage and uninterrupted traffic flow of pedestrians, bicyclists, and motorized vehicles as well as safely supporting the loads of heavy and possibly overloaded trucks. The current one-lane bridge is associated with a number of serious traffic safety hazards for all road users. For example, the separated pedestrian walkway is unusable due to missing planks; therefore, pedestrians and bicyclists traverse the bridge in both directions in the single center lane with motor vehicles, which traverse the bridge in only one direction at a time. This situation results in the increased likelihood of collisions between motor vehicles and vulnerable road users. Further, the traffic signals at both ends of the bridge have not been operational since January 1998, thereby increasing the risk of two motor vehicles entering the bridge at opposite ends at the same time and requiring one vehicle to stop and travel in reverse, a rather unsafe maneuver to perform on a narrow bridge filled with pedestrians and bicyclists. Additionally, the current bridge vibrates significantly when being traversed by motor vehicles and may collapse at some point in the next several years, particularly when



The Feasibility Study on the Reconstruction of Mangochi Road Bridge in the Republic of Malawi	Figure 3.7 Illustration of Indirect Benefits of the Project

subjected to heavy axle loads of large container-hauling trucks. The likelihood of collapse is further increased if two or more heavy vehicles travel across the bridge without sufficient spacing between the vehicles.

ii) Strengthening of Malawi's International Road Network

Promotion of an international transport network has been continuously promoted by the Malawian Government for their land-locked country, which relies almost completely on land transport for international trade. The project bridge is strategically situated on Route M3 which runs from the town of Chiponde located on the border with Mozambique to Blantyre, the industrial and commercial center of Malawi. Although the traffic forecasts presented earlier have attempted to capture the diversion of traffic from distant ports to that of Nacala and the new Mangochi Bridge, additional economic benefits will be realized through increased economic cooperation among countries in the region (particularly among Malawi, Mozambique, Zambia, and Zimbabwe) as a result of the project. The cost to Malawi of not having available one of its most direct routes to the sea, that is, via road to Nacala port, is potentially high.

iii) Strengthening of Mozambique's International and Domestic Traffic through Malawi

While the project will have many economic benefits for Malawi, Mozambique will also benefit substantially since the Mangochi Bridge lies along the Tete–Mandimba-Nampula corridor for international traffic to/from eastern Mozambique and particularly for domestic transport between eastern and western Mozambique (yet through Malawi). As revealed during the OD traffic surveys for this study, there is already a substantial flow of Mozambican traffic through Malawi. Because Niassa Province around Mandimba is the primary source of food for Tete Province in western Mozambique, the movement of agricultural produce from Niassa Province through Malawi to Tete Province will greatly benefit from the new Mangochi Bridge.

iv) Improvement of Accessibility to Remote Areas

Improvement of accessibility to remote areas east of Mangochi is considered to have high social and political values. The project bridge, in combination with road improvement projects on Route M3 east of Mangochi, will improve access to the towns of Jalasi, Namwera, and Chiponde. This improved access will enable the better provision of basic necessities, medial aid and supplies, foodstuff, and equipment particularly during emergencies such as floods, earthquakes, and drought. In addition, this improved access will assist in business contacts between business centers and the more remote regions, thereby assisting the development of domestic and foreign trade as well as industrial and commercial activities (discussed later in more detail).

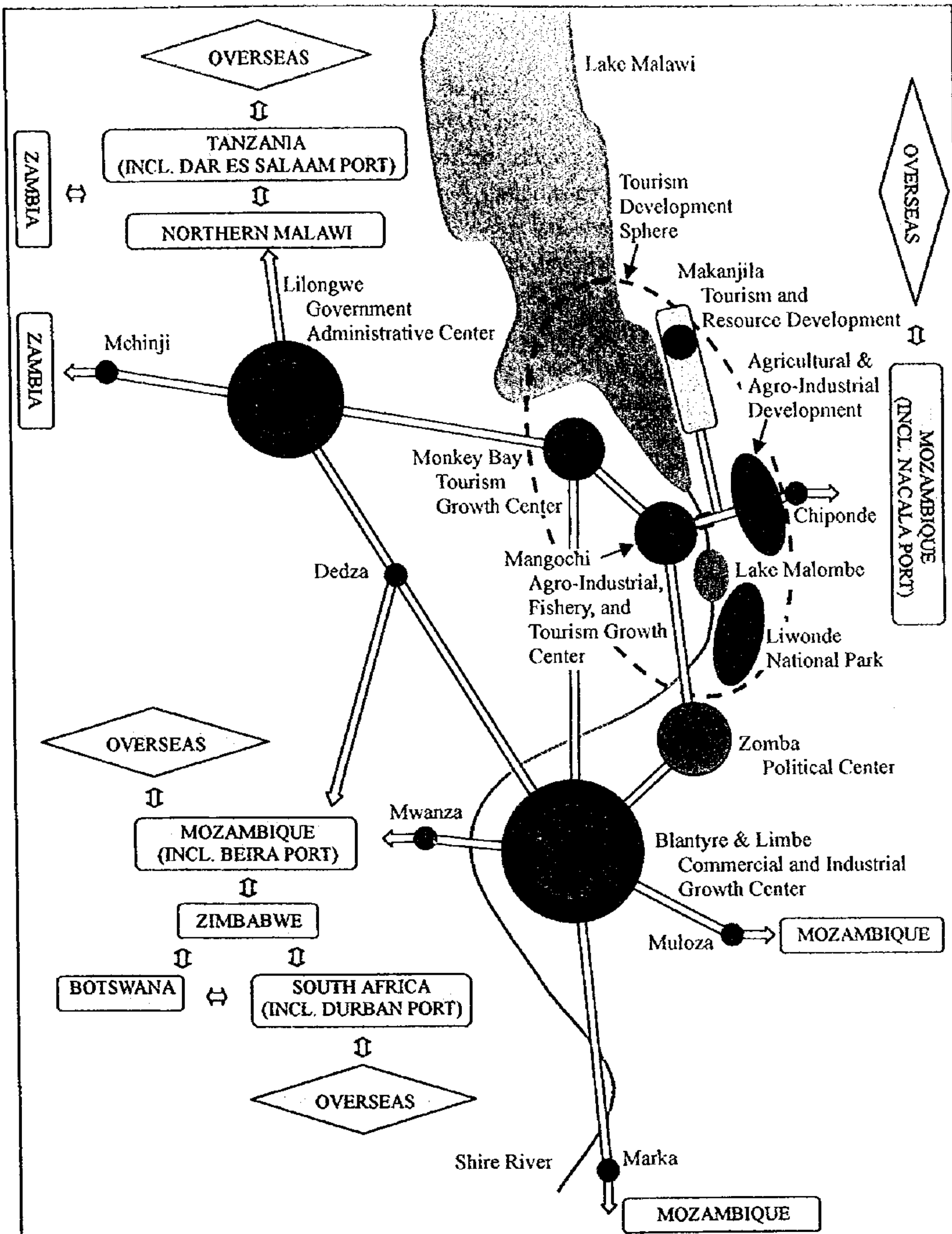
v) Reduced Transport Tariffs and Increased Tax Revenue

The reduction of vehicle operating costs as a direct benefit of the project bridge would initially benefit road transport operators; however, it is expected that transport operators would pass on part of the savings to shippers and passengers, through lower freight tariffs and passenger fares, and to the Government, through payment of taxes on incremental increases in operational profits accruing from the VOC savings.

(b) Regional Development Effects

i) Promotion of Market-Oriented Economy

As discussed earlier, the Government's strategy for achieving sustainable growth is to commit itself to implementing the mechanism of a market economy, which requires the expansion of markets. Already, Malawi is achieving growing success from allowing market forces a greater role in an environment of macroeconomic discipline. An improved transport network can bring about the expansion of diverse markets, such as commercial goods, input, labor, and knowledge. A new Mangochi Bridge is expected to promote a market-oriented economy through the expansion of markets, both domestic and international (Figure 3.8).



The Feasibility Study on the Reconstruction of Mangochi Road Bridge in the Republic of Malawi	Figure 3.8 Illustration of Market-Oriented Economic Development in Central and Southern Malawi

ii) Upgrading of Living Standards in Rural Areas

The standard of living, not only measured by income level, but also by accessibility to income-generating activities (e.g., farming, fishing) and social services (e.g., hospitals, schools), depends on transport conditions. Rural areas in Malawi are disadvantaged in this regard due to poor transport conditions. A new Mangochi Bridge can provide rural areas with good, reliable access to Mangochi, Zomba, Blantyre, and Lilongwe where various income-generating activities and social services are concentrated. A new Mangochi Bridge can also induce the formation of such activities and services.

iii) Modernization of Agriculture

The agricultural sector is likely to remain the mainstay of Malawi's economy. Roads, together with irrigation systems, form the fundamental infrastructure for intensification of agricultural production and expansion of cultivated areas enabling easier input of labor, fertilizer, and machines than before. In eastern areas of the Shire River in Mangochi District there is a good possibility for the intensification of cash crops such as burley tobacco, cotton, spices (e.g., chilies, paprika, turmeric, ginger, pepper, coriander, cardamom, cinnamon), macadamia nuts, and oil seeds (e.g., sunflower, sesame).

Currently, most of the smallholder farmers depend on rain for their agricultural practices, and irrigation is on a limited scale. Yields per hectare are very low, partly a result of the lack of knowledge on how and when to apply inputs. Timely application of inputs is critical to the yields realized per hectare. Further, the cost of poor rural infrastructure is significantly reduced labor productivity and higher production costs, which translates into reduced profits and fewer production incentives. A new Mangochi Bridge, in combination with the Mangochi-Chiponde road improvement project, is expected to provide the base for agricultural intensification, diversification, and modernization.

iv) Promotion of Agro-Industries and Fish-Processing Industries

General

It is well known that maintaining open international trade and participating in technology transfer programs are essential prerequisites for the growth of developing countries. From this point of view, the project bridge will have the potential to play an important role in the industrial and commercial development of Malawi (and Mozambique). Namely, the project bridge will promote international investment and trade, which will foster new industries and businesses in frontier areas. These activities will lead to the accumulation of benefits stemming from acceleration of the regional economies and enhancement of living conditions.

Strengthening and Establishment of Agro-Industrial Zones

The main objectives of improving existing industries are to increase productivity and quality of goods. To attain these objectives, important requirements include the enhancement of research and development capabilities, rapid correspondence to market needs, expansion of market reach through improved distribution means, and formation of efficient production networks. All of these prerequisites are closely related to the features of transport; therefore, the project bridge will contribute to existing and future industries in Malawi (and Mozambique).

The project bridge will ultimately lead to a strengthening of existing agro-industrial zones and give rise to the development of new industrial zones within its area of influence. For example, tobacco and other agro-industries near Mangochi will receive many benefits from access to the project bridge. The project bridge, in combination with road improvement projects on Route M3 between Mangochi and Chiponde, will also improve utilization of industrial resources, labor, and farm produce and establish an international production network within its influence area.

Improvement of Production System

Existing industries will be influenced by the current trends of internationalization, market expansion, and information network formation only if their production systems are improved. These three trends are realized through increased imports; exploitation of foreign markets; development of international, specialized industries; expansion of direct foreign investment; and encouragement of international technology exchange.

The activity level of industries in the study area generally depends on accessibility to major markets. Development of the transport network in recent years has produced new markets for industries and at the same time has facilitated the introduction of new competitors into these markets. As a result, existing industries are forced to improve their production systems if they are to survive.

The industries whose production systems will be most affected by the project bridge are the agricultural and fishery industries. Because freshness is a vital factor for the sale of products such as vegetables, fish, and meat, the project bridge will no doubt stimulate production activities in agriculture and fisheries and promote agro-industrialization in Malawi. Consider, for example, the large disparity in the price of chambo fish among districts in Malawi's Southern and Central Regions. Assuming sustainable fish production in Lake Malawi is achieved, it is envisioned that the project bridge will not only reduce and stabilize the price of fish caught at Lake Malawi, but it will also spur new business opportunities for existing and future fisheries at the Lake.

Likewise, produce-oriented agro-industrial districts will rapidly expand with improved transport service provided by the project bridge. For example, in the case of rice milling, secondary processing industries would evolve, including rice grading and packaging for retail trade and packaging of (pre-cooked) rice in vacuum packs. Because the project bridge will offer quick, safe, and dependable transport of products between Malawi and eastern Mozambique, factories and facilities of business related to secondary processing industries will emerge along Route M3.

v) Promotion of Resource Development

There are limited mining activities in Malawi at present; however, the mining industry is receiving increased attention from the

Government as a viable means to diversify the country's agriculture-dominated economy. According to the Department of Mines, Mangochi District is a potentially rich source of valuable minerals. In the area around Makanjila and along the eastern shore of Lake Malawi, deposits of heavy minerals such as titanium as well as precious metals such as gold have been reported. Mozambique is already reportedly excavating gold in its territory near the eastern shore of Lake Malawi. Kimberlitic rocks, which host diamonds, have also been identified in two areas in Mangochi. Because this resource development basically depends on transport conditions, a new Mangochi Bridge is expected to provide the base for such development.

vi) Tourism Development

Tourism is a very important source of foreign exchange required to build the economy of Malawi. The project bridge is expected to further promote tourism in Mangochi and the surrounding area, which includes Lake Malawi National Park, the Shire River, Lake Malombe, the Mangochi Forest Reserve (containing the ruins of an old colonial fort), the Namizimu Forest Reserve, Makanjila, and Liwonde National Park—considered to be one of Malawi's top tourist attractions with a large population of elephants, hippos, crocodiles, lions, and exotic bird life, as well as two reintroduced black rhinos from South Africa.

vii) Balanced Development of the Region

The increased accessibility of the east bank of the Shire River in Mangochi District, with the corresponding increase in accessibility to goods and services (e.g., schools, markets, medical facilities), will promote balanced development on both sides of the River.

viii) Technology Transfer

Another important benefit will be the strengthened technical skills of domestic labor working on the bridge reconstruction project. In this context, the bridge construction project will contribute to the development of human capital in the region.

3.4.2 Economic Evaluation

(1) Conditions for Economic Evaluation

The basic conditions for the economic evaluation are summarized below.

a) Base Year

The beginning year of the project, 2002, was set as the base year for the economic evaluation.

b) Evaluation Period

Because of the severe budgetary constraints in Malawi, it is not likely that many large bridge projects will be implemented in the country. Therefore, the project life in the economic evaluation should be long. As mentioned earlier, the initial Terms of Reference for this study requested an evaluation period of 20 years after opening. However, for a bridge project of this nature, a longer evaluation period would be appropriate. Consequently, the consultants have adopted a 50-year evaluation period for this study with no residual value. From 2022 to 2052, traffic was assumed to grow at an average annual rate of only 3% per year and real increases in VOCs were assumed to grow at an average annual rate of only 1%.

c) Evaluation Indicators

As evaluation indicators, the economic internal rates of return (EIRRs), net present values (NPVs), and benefit-cost (B/C) ratios were calculated for the evaluation period. The economic internal rate of return is the rate of discount at which cost and benefit streams over the life of the project are equalized. The net present value is the value of the benefits net of costs both discounted at the opportunity cost of capital, and the benefit-cost ratio is a variant of the net present value measure in which both benefits and costs are defined in terms of their present values.

(2) Evaluation Results

With respect to benefits, the average time-related VOCs shown earlier in Table 3.49 were applied to savings in waiting time, and the average distance-related VOCs from Table 3.50 were applied to savings in travel distance. These economic benefits vary by year, increasing from an initial US$135,385 in 2002 to

US$174,231 in 2005 and US$1,450,375 in 2022. With respect to the project cost (see section 6), the taxes and duties component of US$2,543,911 and its portion of contingencies (US$254,391) were subtracted from the total financial cost of US$14,669,700. The annual maintenance cost of US$6,140 was assumed to begin in the first year of operation. The Standard Conversion Factor of 0.92 determined earlier (Table 3.35) was applied to these costs. Based on this procedure, the total economic project cost was determined to be US$10,921,686 in year 2002.

The evaluation results are summarized in Table 3.51 below. As shown, the EIRR of the project is 7.0%, the same as was calculated in the preliminary evaluation.

Table 3.51 Results of the Economic Evaluation

Evaluation Indicator	New Mangochi Bridge Project	Sensitivity Analysis	
		Costs +20%	Benefits -20%
EIRR	7.0%	6.3%	6.1%
NPV @ 6%	2,517,583	773,233	269,716
NPV @ 8%	-1,742,920	-3,358,649	-3,010,065
NPV @ 10%	-3,681,306	-5,180,895	-4,444,633
NPV @ 12%	-4,527,400	-5,921,551	-5,016,071
B/C Ratio @ 6%	1.29	1.07	1.03
B/C Ratio @ 8%	0.78	0.65	0.63
B/C Ratio @ 10%	0.51	0.42	0.41
B/C Ratio @ 12%	0.35	0.29	0.28

Source: JICA Study Team.

The indirect benefits of the project detailed earlier are substantial, and it is the consultant's opinion that these factors remove any doubt concerning the economic viability of the project. The recommendation of the study is that the project should be implemented immediately. The new Mangochi Bridge will be an important asset to the Malawian economy which will safeguard the confidence and security needed to continue the current strong regional and national economic growth.