CHAPTER 6

MASTER PLAN FOR DEVELOPMENT OF THE SENA CORRIDOR

Chapter 6 Master Plan for Development of the Sena Corridor

6.1 Objective of the Master Plan

The objective of the Master Plan for development of the Sena Corridor is to prepare improvement plans for transport sub-sectors, i.e. road, railway and inland waterway sub-sectors, which form the Sena Transport Corridor. The development goals of the Master Plan are sustainable economic growth in Malawi and poverty alleviation in the Study Area. Master Plan programmes are prepared for the short term with a target year of 2015, the medium term with a target year of 2020, and the long term with a target year of 2030.

The Master Plan indicates definite plans for the transport system and its services in the Southern Region of Malawi. The long-term programme has been prepared to achieve the following challenges of the Master Plan: 1) strengthen the SADC transport network, 2) develop an alternative corridor to Beira Port, 3) improve access to ocean ports and international markets, 4) promote exports by agricultural development, 5) secure steady import of fuel and fertiliser, 6) accelerate mobility of people and logistics to/from Blantyre, and 7) improve communication in the Study Area, with appropriate investment in the transport sector.

The long-term programme is also planned to contribute to regional integration in Southeastern Africa under the SADC Treaty.

6.2 Overview for the Development of the Sena Corridor

(1) Viewpoint of Southeastern Africa

a) Current Situation

- The regional infrastructure needs to be developed to accelerate the growth of Africa. Inadequate regional transport infrastructure, however, hinders regional economic and social development. Regarding the activities of Regional Economic Communities (RECs), SADC aims to achieve economic growth, poverty alleviation and improvements in people's living standards through regional integration by regional infrastructure development, and COMESA has a vision of integrating regions with international competitiveness in the trade, custom duty and transport sectors.
- Historically, Malawi, which is a landlocked country, depended strongly on the Sena railway network connecting Beira Port, but services were suspended in 1983 due to the civil war in Mozambique. During the war, the Durban Corridor (road) carried more than 80% of Malawi's international cargo. At present, the ratios of volume transported by corridor are 41% by the Beira Corridor, 18% by the Nacala Corridor, 33% by the Durban Corridor and 8% by the Dar es Salaam Corridor.

b) Major issues

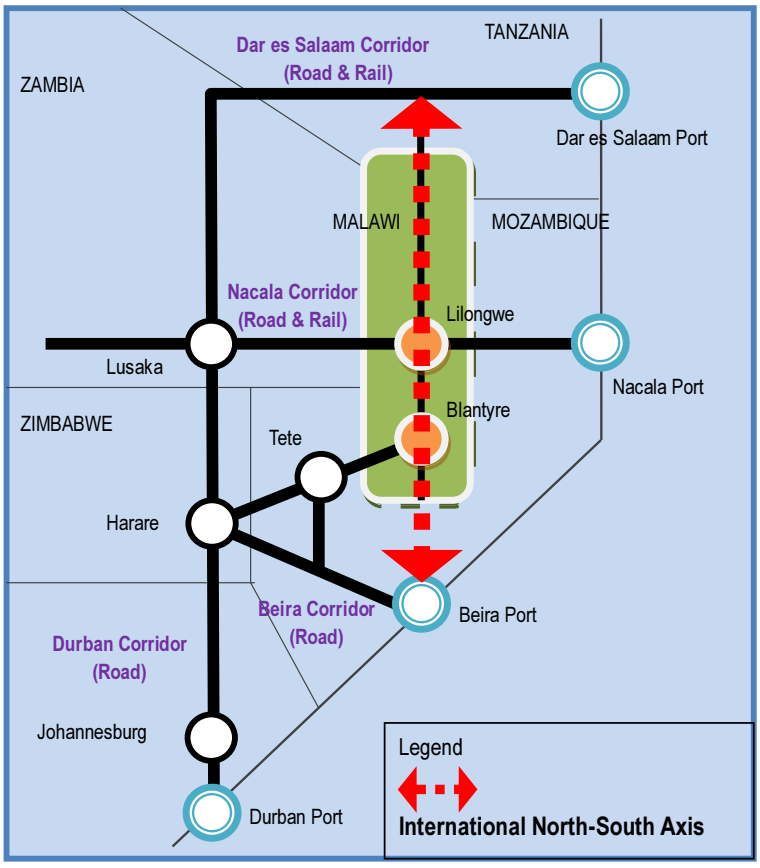
- Huge demand for transporting mineral products to Nacala Port from the Moatize coal mine and Zambia copper mine is expected. The railway transport capacity of Malawi is limited to

2 million tonnes per year. Thus, it could be difficult to secure reliable transport of Malawi's export and import cargo by railway.

- Beira Port accounts for 59% and the Tete Corridor for 62% of Malawi's export and import cargo. The lack of alternative routes accessible to Beira Port may negatively impact Malawi's economy.
- Recently, some critical issues facing the transport sector have become more pronounced, such as the lack of capacity for transporting mineral resources from neighbouring countries and insufficient multiplicity of transport access to the ocean ports. In this regard, forming the regional tansport infrastructure is an urgent issue.

c) Roles and Functions

- The Dar es Salaam Corridor, the Nacala Corridor and the Beira Corridor either cross or pass around Malawi and are arranged in a ladder structure in the east-west direction, owing to development strategies based on access to ocean ports. The development of a north-south international corridor linking these east-west international corridors will create wider, regional, efficient logistics networks integrating the five countries of Malawi, Mozambique, Tanzania, Zambia and Zimbabwe.
- The Sena Corridor (from Blantyre to Beira Port) forms a part of the north-south international axis (see Figure 6-1).



Source: Study Team

Figure 6-1 International North-South Axis

- The international freight volume of both the Nacala and the Beira Corridors will account for 80% of the total in 2030, whereas the Dar es Salaam Corridor will account for only 7%. Based on this future demand, development of the Sena Corridor is of great significance for Malawi since it would supplement and diversify the traffic functions of the Nacala and Beira Corridors.
- The cost of transporting Malawi's export/import cargoes by the Nacala Corridor is about 10 to 15% lower than by the Beira Corridor at present. Also, development programmes for the Nacala Corridor in Malawi and neighbouring countries will be completed by 2015. As a result, the share of the Nacala Corridor will increase. On the other hand, the shares of export/import cargoes related to Malawi handled at Nacala Port and Beira Port are 18% and 41% by volume, respectively. This means that Beira Port is very important for Malawi, particularly after the completion of dredging work and shipping companies' main liners started to call, in order to shift cargo handling from Durban Port to either Beira Port or Nacala Port. As the Beira Corridor currently depends on only the Tete Road Corridor, it is necessary to formulate an alternative corridor to Beira Port in order to secure the sustainable economic growth of Malawi through lower transport costs and transport redundancy. Therefore, the Study Team proposes to develop the Sena Corridor to formulate balanced international transport corridors for export/import in Malawi in the future.

(2) Viewpoint of Malawi

a) Current Situation

- The main targets of the MGDS are sustainable economic growth and poverty alleviation by infrastructure development. The poverty ratio in the southern region of Malawi is higher (64.4%) than in the other regions. Especially, the poverty ratio in the areas that are located far from Blantyre tends to be high, and the poverty ratio of Nsanje District located at the southern border of Malawi is the highest (76.0%).
- The economy and industry of Malawi are heavily dependent on the agriculture sector, and agricultural products are the main exports. The trade deficit of Malawi is tending to increase year by year. According to the MGDS, the strategic sectors are agriculture, transport infrastructure and industry development, and another priority issue is to reduce transport costs by linking producing areas with domestic/international markets.

b) Major issues

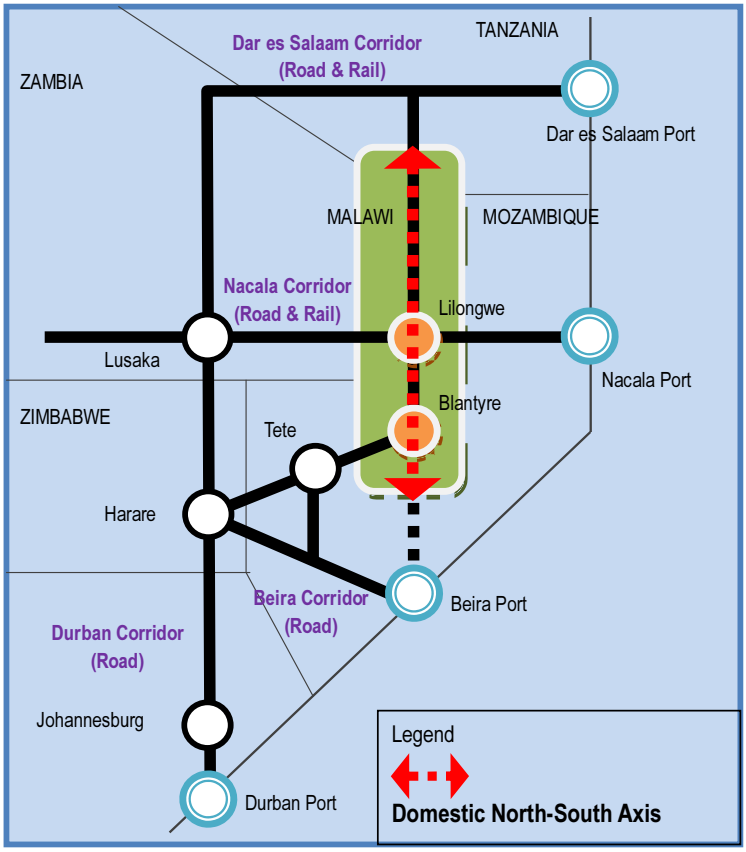
- With the change in business environment of ports, Malawi's cargo handled at Durban Port is expected to shift to both Beira and Nacala Ports. The distance will be about one third, but there is only road access to Beira Port at present.
- Since roads handle 87% of Malawi's international cargo, this could result in higher transport costs and congestion in urban areas. Lack of capacity of the Nacala railway could make the

problems of transport cost and traffic congestion more serious, because of the passive shift in transport from road to railway.

- The development of the Sena Corridor, as part of the national north-south axis, is essential, since the transport system is inefficient and heavily dependent on road transport, as well as inflexible to changes in the business environment of the ports.

c) Roles and Functions

- The development of the north-south axis through the nation will strengthen the links among cities and improve access to Lilongwe and/or Blantyre as well. In addition, the development of the road and railway infrastructure in the Southern Region, especially in the area to the south of Blantyre which has poor traffic functions, will help integrate the logistics network of the Southern Region into the national network.
- For Malawi, the Sena Corridor (borders from Blantyre) is part of the national north-south axis (see Figure 6-2). The development of the Sena Corridor is expected to contribute to the balanced development of the country since the southern region serves as the gateway to Beira Port with the shortest route, and will strengthen access to the Nacala Corridor.



Source: Study Team

Figure 6-2 Domestic North-South Axis

(3) Viewpoint of the Study Area

a) Current Situation

- A large part of the Study Area is in low-lying land, whereas all operating Border Posts (Mwanza BP, Dedza BP, Songwe BP, Mchinji BP and Muloza BP, which account for 99.6% of the total international cargo) are located at an altitude of more than 1,000 m. Transport costs tend to be high due to this large difference in altitude.
- The ratio of paved arterial roads in the Study Area is 4.5 points lower than the national average, and railway services are not operating. Moreover, the loss of part of the road and railway transport functions due to the Chiromo washaway reduced the railway transport capacity to/from Blantyre as well as foreign investment in plantations. The problems in the transport infrastructure also resulted in worsening access to markets as well as medical and education services.

b) Major issues

- The development of the Sena Corridor in the Study Area is needed to eliminate traffic congestion and to reduce transport costs. In particular, the poverty ratio in the Study Area is high.

c) Roles and Functions

- The Sena Corridor is an arterial transport network in the Study Area. Once the traffic functions are enhanced by developing the Corridor, it is expected to improve access to/from Blantyre as well as from the poverty areas to the arterial traffic network. It is also expected to reduce transport costs for international freight because the short distance between Beira Port and the Study Area.
- Major cash crops in Malawi are tobacco, sugar, tea, pigeon peas, and cotton. Especially, it is estimated that the amounts of cotton and sugar will increase around four times over the next 20 years. The main export destinations are Europe (30% of total volume), Asia (9%) and some neighbouring countries such as Zimbabwe (14%), Zambia (7%) and Mozambique (7%) at present. To sustain Malawi's economic growth, it is important to improve transport networks' access to outer ports and markets in neighbouring countries while reducing the cost of transporting cash crops. Major crops produced in the southern region of Malawi are pulses including pigeon peas (42% of total volume), sugar (59%), tea (80%), cotton (40%), and sesame (66%) for cash crops, and maize (13%) and sweet potatoes (33%) for food crops. Since the study area accounts for a high share of national production, it is necessary to improve the transport sector in the southern region.

6.3 Assumptions of External Factors for the Master Plan

a) Definition of Assumptions

In this Master Plan, the development of transport infrastructure in Mozambique is defined as an external factor. External factors to be considered are the section from the border between

Malawi and Mozambique to Beira Port for both the road and railway. Regarding the inland waterway, the AfDB is carrying out a feasibility study on developing the Shire Zambezi Inland Waterway, and waterway services will start operation by 2015.

- **External Factors for the Road Sub-sector:** Upgrading of the unpaved road section from *Vila Nova de Frontela* to the N1 road in Mozambique. The length of the section is about 140 km and the implementing agency is the National Road Administration (ANE).
- **External Factors for the Railway Sub-sector:** Rehabilitation of the existing railway section from the international border (*Vila Nova de Frontela*) to *Dona Ana* in Mozambique. The length of the section is about 44 km and the operator is CFM.

b) Proposed Assumptions

There are three proposed assumptions for the Master Plan:

- **Assumption 1:** Both the road and railway will be developed up to 2030.
- **Assumption 2:** Only the railway will be developed up to 2030.
- **Assumption 3:** Only the road will be developed up to 2030.

c) Evaluation of Assumptions

The proposed evaluation items are "Transport Reliability" for Malawi and "Qualitative Benefit" for Mozambique. As a result of evaluating the assumptions for the Master Plan, Assumption 1 is evaluated to be the most advantageous for both Malawi and Mozambique. For Mozambique, the road and railway are expected to bring qualitative benefits, as shown in Table 6-1. Therefore, **Assumption 1** is proposed for the Master Plan.

d) Benefits for Mozambique

Considering the study method, it is difficult to measure the proper, quantitative benefits for Mozambique. However, since the following qualitative benefits are expected, the development of the Sena Corridor could be beneficial for Mozambique.

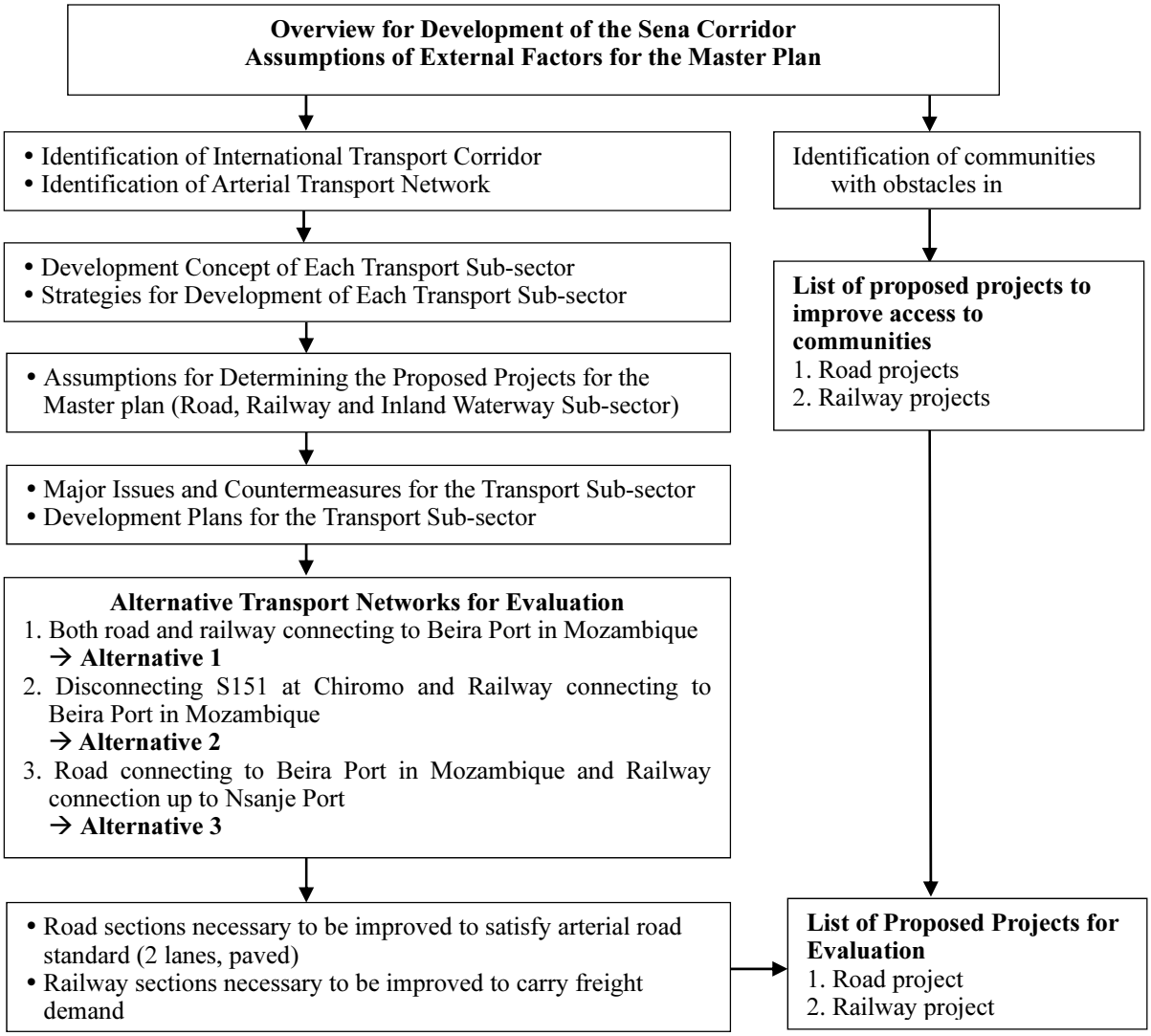
Table 6-1 Benefits for Mozambique

Item	Road Sub-sector	Railway Sub-sector
Shared	• Creating jobs during the construction stage • Increasing Malawi's and Zambia's cargo handled at Beira Port • Improving traffic conditions on the Tete Corridor owing to shifting to the Sena Corridor • Increasing the efficiency of utilization of the Nacala railway	
Specific	• Improving accessibility to the Sena region • Promoting economic revitalization and alleviating poverty in the Sena region	• Increasing freight fare • Creating jobs in the railway sector • Reducing CO2 emissions owing to the modal shift

Source: Study Team

6.4 Strategies for Development of Each Transport Sub-sector

Figure 6-3 shows the process to prepare proposed projects for the Master Plan in the Study based on the overview for development of the Sena Corridor and assumptions of External Factors for the Master Plan.



Source: Study Team

Figure 6-3 Process to Prepare Proposed Projects for Evaluation

6.4.1 Formulation of Alternative Transport Networks based on the Development Scenarios

The Study Team has considered possible alternative networks to meet the future projected traffic for each transport network by assigning freight volume and vehicular traffic volume. These alternative transport networks have been evaluated for the Master Plan, in order to fulfil the basic concepts proposed in the Study.

(1) Formulation of Alternative Transport Network

a) Breakdown of Basic Concept for Southeastern Africa into the Study Area

The proposed basic concept for Southeastern Africa is "Development of infrastructure network to support economic integration in Southeastern Africa" by addressing the challenges of: 1) Strengthening the SADC transport network, and 2) Providing an alternative corridor to Beira Port.

To address these challenges, the breakdown of the basic concept for Southeastern Africa can be considered from the viewpoint of "Improvement of International Transport Corridor in the Study Area", because all aspects of the concept and challenges are related to the development of the international transport network in Malawi.

There are five main roads connecting to international borders at present, namely: 1) M1 through Marka Border Post, 2) M2 and M4 through Muloza Border Post, 3) M6 through Mwanza Border Post (Tete Corridor) and 4) M3 towards Chiponde Border Post (Nacala Road Corridor), while only one railway line, the Nacala Railway through Nayuchi Border Post, is functioning at present.

The following two transport routes can be added as international transport routes by considering functional classification as well as possible improvement works up to the border in the near future:

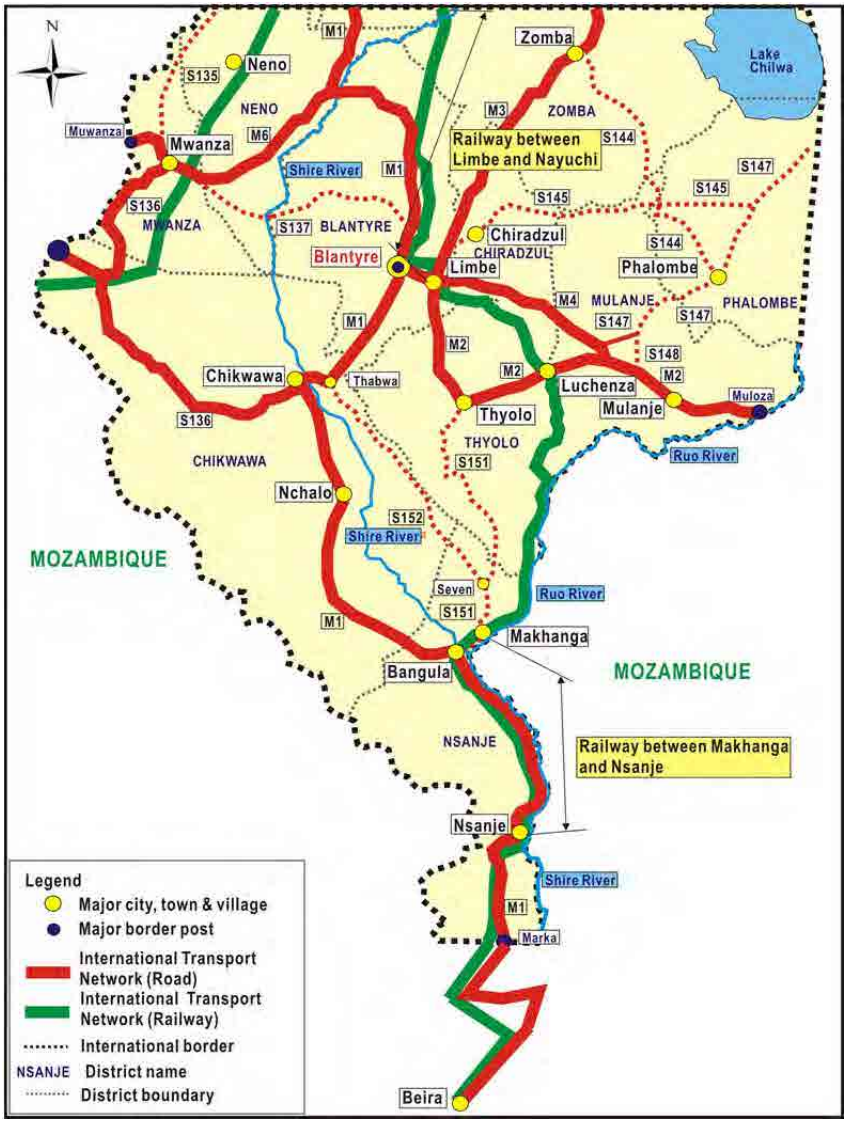
- S136 between Chikwawa and Mwanza, with an additional short-cut link to Mozambique (new border post)
- Reconstruction of the railway line between Makhanga and Border Station

Figure 6-4 shows the proposed international transport corridor in the Study Area.

b) Breakdown of Basic Concept for Malawi into the Study Area

The proposed basic concept for Malawi is "Formulation of arterial transport network to support efficient export and import" by addressing the challenges of: 1) Improving access to ocean ports and international markets, 2) Promoting exports by agricultural development and 3) Securing steady import of fuel and fertilizer.

To consider these challenges, the breakdown of the basic concept for Malawi can be considered from the viewpoint of "Improvement of Arterial Transport Network in the Study Area", because all aspects of the concept and challenges are related to the development of the arterial transport network.



Source: Study Team

Figure 6-4 Proposed International Transport Corridors in the Study Area

There are five main roads and three secondary roads which can be classified as arterial roads at present, namely: 1) M1, 2) M2, 3) M3, 4) M4, 5) M6, 6) S136, 7) S151, and 8) S152, while only one railway line between Limbe and Nayuchi border via Liwonde is functioning as an arterial transport route at present.

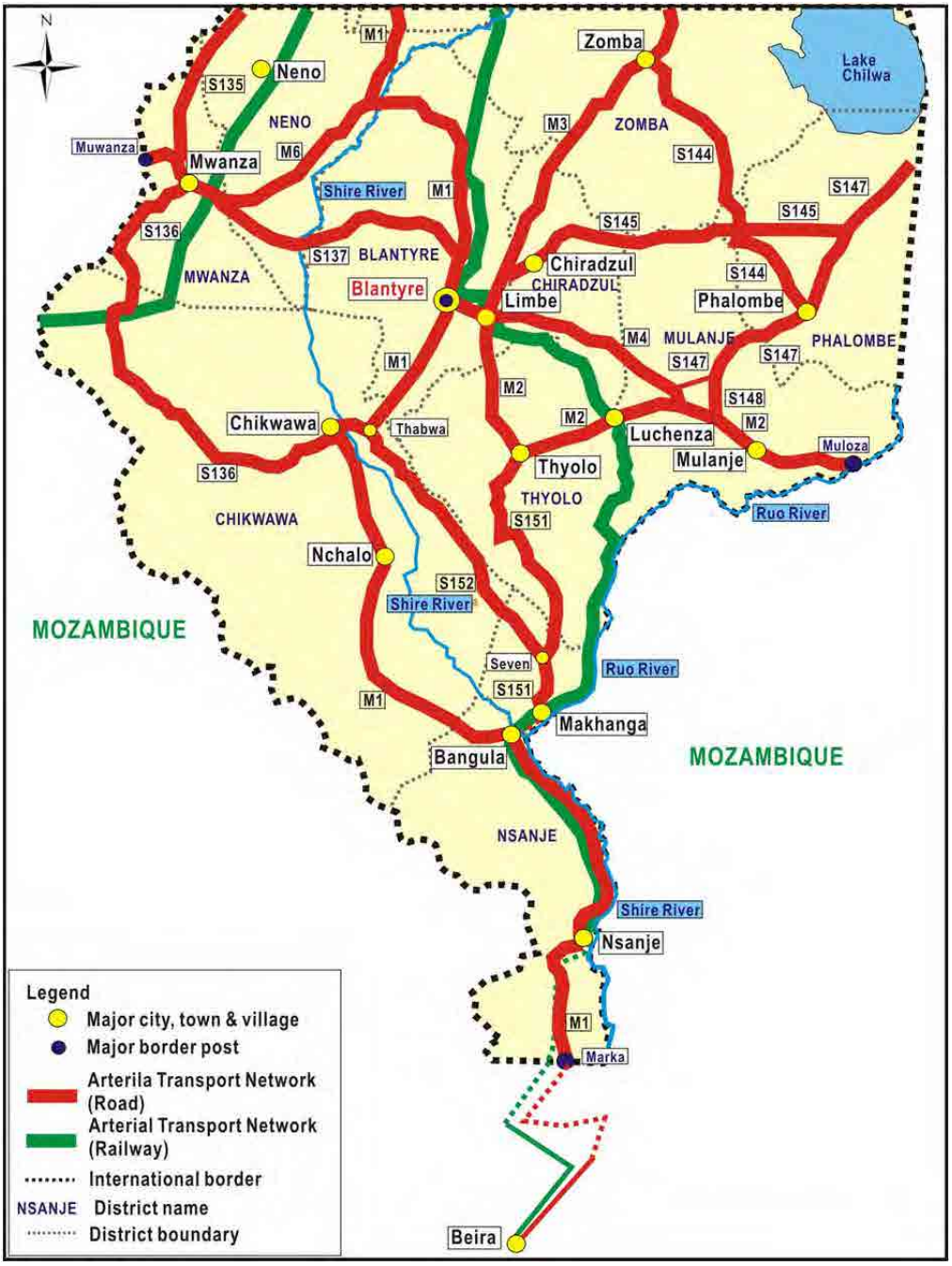
The following transport route can be added as an arterial transport route by considering functional classification as well as possible improvement works in the near future:

- Reconstruction of the railway line between Makhanga and Nsanje

Figure 6-5 shows the proposed arterial transport routes in the Study Area.

c) Breakdown of Basic Concept for the Study Area

The proposed basic concept for the Study Area is "Formulation of transport network to alleviate poverty" by addressing the challenges of: 1) Accelerating mobility of people and logistics to/from Blantyre, and 2) Improving communication in the Study Area.

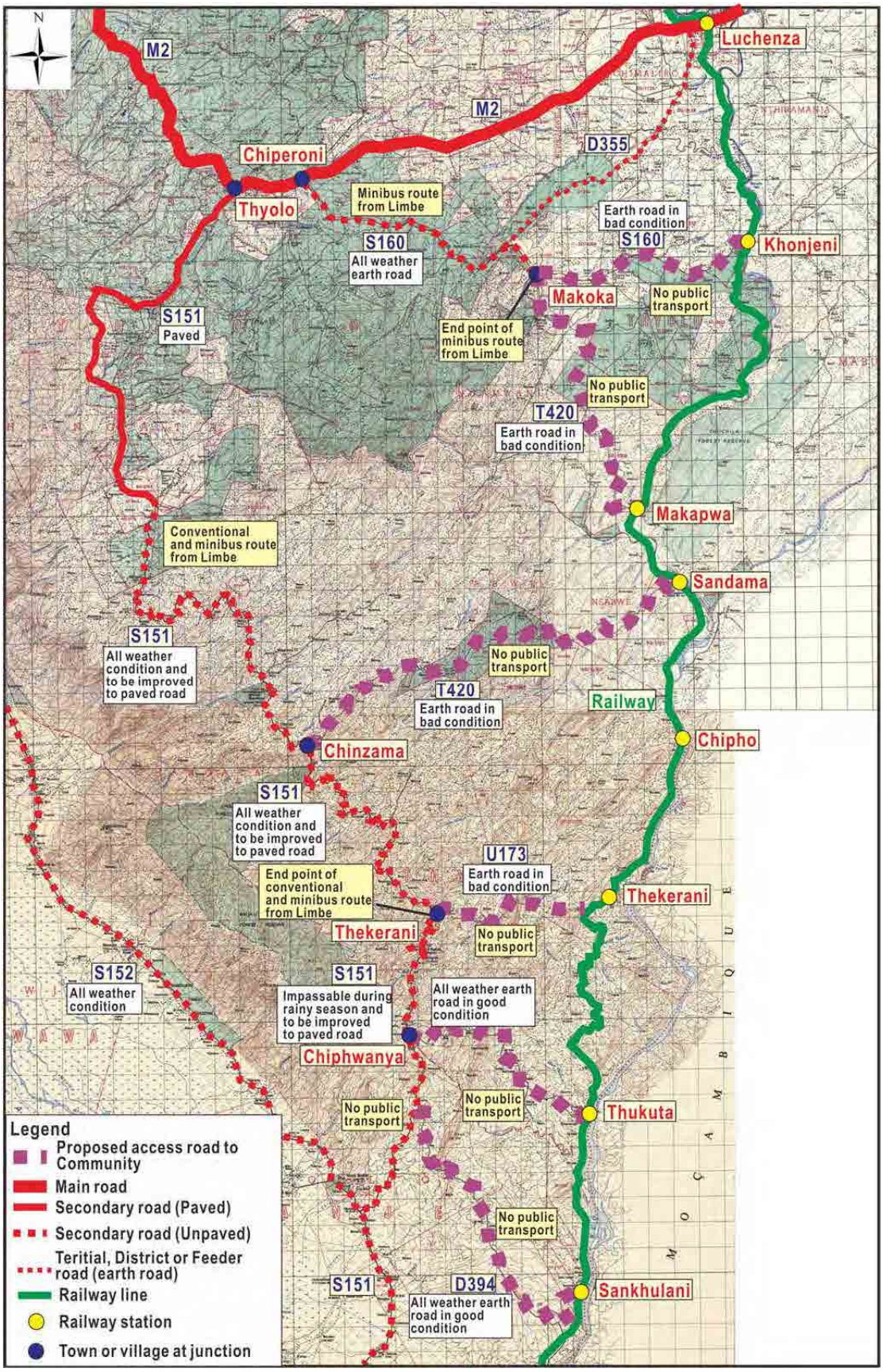


Source: Study Team

Figure 6-5 Proposed Arterial Transport Routes in the Study Area

To address these challenges the breakdown of the basic concept for the Study Area can be considered from the viewpoint of "Improvement of Access to Communities in the Study Area", because all aspects of the concept and challenges are related to improvement of access to communities where there are difficulties in accessing a market.

There are one secondary road (S160), one tertiary road (T420), one district road (D394) and two undesignated roads which can be classified as access roads to those communities, while an increase in the train operation frequency between Limbe and Makhanga will improve access to communities. Figure 6-6 shows the proposed access route to communities in the Study Area.



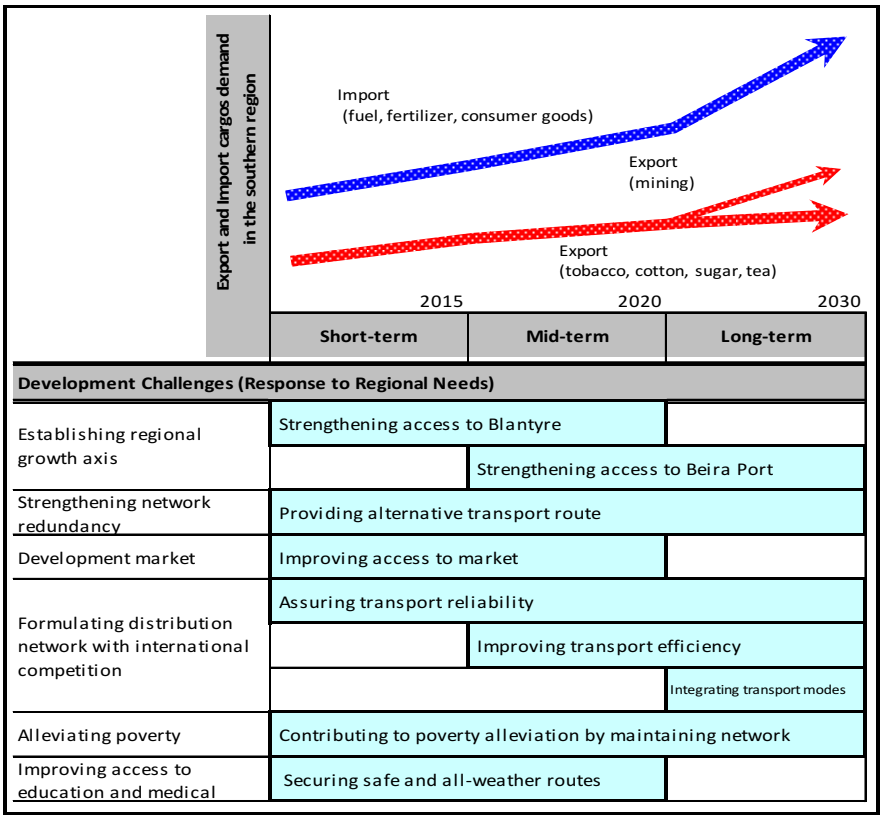
Source: Study Team

Figure 6-6 Proposed Access Route to Communities

6.4.2 Development Concept of Each Transport Sub-sector

The development concept for the Sena Corridor in the southern region of Malawi is to fully address the proposed six development challenges shown below corresponding to the basic concept for developing the Sena Corridor, including regional development issues and potentials. The concept of developing the Sena Corridor is to strengthen and improve the traffic functions of the three modes, i.e. roads, railway and inland waterway, which constitute the corridor in terms of national and regional axes which should support efficient physical distribution and traffic flows. A conceptual diagram of the development concept for the Sena Corridor in the Study Area is shown in Figure 6-7.

- Establishing regional growth axes by strengthening access to Blantyre and Beira Port
- Strengthening transport network redundancy by providing alternative transport routes
- Developing markets by improving access to markets at both the rural and international levels
- Formulating a distribution network with international competitive by assuring transport reliability, improving transport efficiency and integrating transport modes in a step-by-step approach
- Contributing to poverty alleviation by maintaining the transport network
- Improving access to education and medical services by securing safe, all-weather roads



Source: Study Team

Figure 6-7 Basic Concept of developing the Sena Corridor in the Study Area

On the other hand, road and railway have their own characteristics and advantages. Thus, it is important to recognize and maintain a mutually complementary relationship between road and railway transport. For instance, road transport has some merits in aspects of door to door transport, limitation of operating time, accident response and change of cargo volume. Railway transport also has some merits in aspects of long haul cost, adjustment of delivery date, Carbon Dioxide (CO_2) emissions, bulk transport and punctuality. Table 6-2 summarizes the merits of road and railway transport.

Table 6-2 Comparison of Characteristics and Advantages of Road and Railway Transport

Merits of Road Transport		
Item	**Road**	**Railway**
Door to door transport	Possible	Not possible, cargo handling takes more than one hour at both ends of transport
Limitation of operating time	No limitation if using detour routes	Maintenance time required (6 hours during night time)
Accident response	High risk, but alternative transport possible	Low risk, but alternative transport not possible
Change of cargo volume	Relatively easy by using more vehicles	Difficult in case of limit of loading capacity
Merits of Railway Transport		
Item	**Road**	**Railway**
Long haul cost	Disadvantage if distance≥500 km	Advantage if distance ≥500 km
Adjustment of delivery date	Difficult	Possible to use terminal as stock yard
CO_2 emissions	Higher than railway transport	Lower than road transport
Bulk transport	Not suitable	Suitable for fuel, coal and cement, etc.
Punctuality	Influence of traffic accidents and congestion	Possible

Source: Study Team

6.4.3 Strategies for Development of Each Transport Sub-sector

(1) Road Sub-sector

The long-term development strategies for the road sub-sector are summarized in Table 6-3 below. The development objectives and strategies are divided into four areas: Operation and Management, Infrastructure Development, Institutional Capacity and Funding.

It is proposed that arterial road networks in the Study Area can be classified into three functions in terms of road network characteristics. The three proposed functional classifications are: 1) National North-South Axis, 2) Access to International Corridor and 3) Links among Regional Centres. To achieve the targets[6] of developing the Sena Corridor, it is essential to form comprehensive links among regional centres under a long-term approach. Thus, the strategy for improving the road network is to integrate the proper level of network considering regional development issues and potentials in the Study Area.

[6] [**Level of Southeastern Africa**] Sustainable economic growth and strengthen redundancy of transport network, [**Level of Malawi**] Sustainable economic growth, improve international competitiveness of export products, and strengthen redundancy of transport network, [**Level of the Study Area**] Sustainable economic growth, poverty alleviation, and improve living conditions in the Study Area

Table 6-3 Development Objectives and Strategies for the Road Sub-sector

Area	Objectives	Strategies
Operation and Management	• Maintenance of infrastructure • Road safety • Minimum accessibility for the poor	• Preparation of road maintenance programme based on the road sector programme • Implementation of road safety measures based on national road safety master plan • Implementation of appropriate road user charges to cover road maintenance
Infrastructure Development	• Establishment of efficient national and regional axes • Development of reliable and adequate arterial road network • Improvement of accessibility to key corridors and transport nodes	• Provision of the minimum standard for Main Roads: a paved carriageway at least two lanes wide • Improvement of arterial road network to secure the minimum standard including all-weather condition • Extension and upgrading of road network to improve accessibility, particularly in rural areas
Institutional Capacity	• Strengthening of road administration capacity • Maximum utilization of road database • Promotion of user-oriented and environment-friendly services	• Provision of education and training for road planning and maintenance systems and contract management • Improvement of data management capacity and business skills • Implementation of on-going road and bridge condition surveys and traffic counts
Funding	• Establishment of sustainable funding maintenance and development	• Funding of road maintenance from the government development budget and recurrent budget funded by the Roads Fund • Application of funds to development partners • Development of own fund sources including the private sector

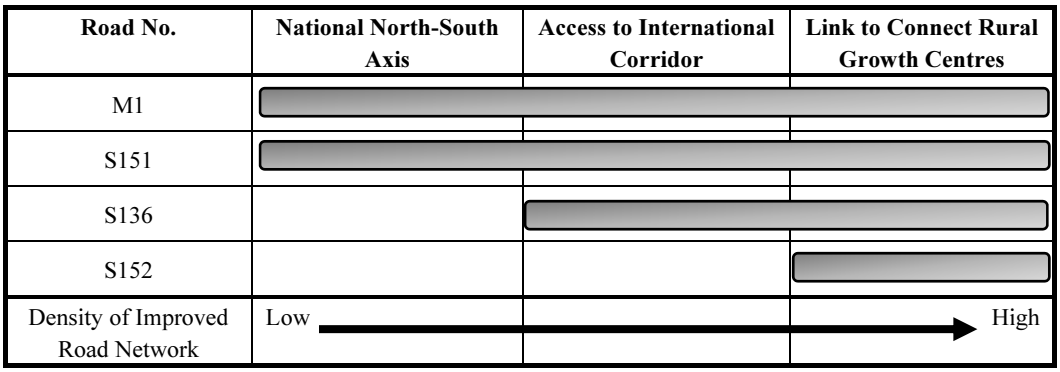
Source: Study Team

The development target for the **National North-South Axis** composed of M1 and S151 is to comply with international standards and to develop alternatives to the M1 route. The development target for **Access to International Corridor** composed of M1, S136 and S151 is to strengthen access to Beira Port and Nacala Port and to strengthen access to Beira Corridor. The development target for **Links among Regional Centres** composed of M1, S136, S151 and S152 is to develop the national axis and strengthen access to it. The functional classifications and development targets are summarized in Table 6-4 and Figure 6-8.

Table 6-4 Functional Classification of Road Network in the Study Area

Functional Classification	Composition	Target
National North-South Axis	M1, S151	Complying with International Standards (M1)
		Developing alternatives to M1 route (S151)
Access to International Corridor	M1, S136, S151	Strengthening access to Beira and Nacala Corridors (M1 and S151)
		Strengthening access to Beira Corridor (S136)
Links among Regional Centres	M1, S136, S151, S152	Developing national axis composed of M1 and S151
		Strengthening access to national axis (S136 and S152)

Source: Study Team



Source: Study Team

Figure 6-8 Density of Improved Road Network in the Study Area

(2) Railway Sub-sector

The long-term development strategies for the railway sub-sector are summarized in Table 6-5 below. The development objectives and strategies are divided into four areas: Operation and Management, Infrastructure Development, Institutional Capacity and Funding.

Table 6-5 Development Objectives and Strategies for the Railway Sub-sector

Area	Objectives	Strategies
Operation and Management	• Maintenance of infrastructure • Maintenance and procurement of rolling stock • Security of safe and stable transport service	• Execution of emergency rehabilitation between Limbe and Makhanga • Execution of complete rehabilitation and procurement of new rolling stock • Introduction of periodical maintenance system for infrastructure and rolling stock to secure safe and stable operation
Infrastructure Development	• Establishment of efficient international corridor (connection to Beira Port) • Development of reliable and adequate railway network	• Establishment of railway construction standards • Resolution of disconnection of the railway at Chiromo • Improvement of railway network based on freight demand • Bilateral agreement on international freight transport
Institutional Capacity	• Strengthening of managerial capability • Strengthening of commercialization and market-oriented development of railway market • Strengthening of competitiveness of railway sub-sector in the transport sectors	• Establishment of Railway Act • Establishment of management system (Strengthening of railway administration department in MoTPI) • Development of human resources (application to JICA training courses, etc.)
Funding	• Promotion of financial autonomy on railway operation	• Revision of concession agreement to clarify rights and duties of each party and to enhance operation productivity • Establishment of long-term investment plan for railway network • Introduction of ODA • Development of self-sponsored funds
Market Development	• Market development (strengthening of container transport, ore transport, etc.) • Establishment of safe and stable freight transport	• Establishment of marketing division and realistic business plan for railway transport service • Improvement of infrastructure and development of human resources • Promotion of commercialization of railway business by unbundling peripheral business

Source: Study Team

To achieve the targets of developing the Sena Corridor, it is essential to reconstruct comprehensive links with Beira Port under a long-term approach. Thus, strategies for improving the railway network are to extend operating lines in stages toward Beira Port after the emergency rehabilitation. Simultaneously, the institutional capacity of MoTPI should be developed by establishing a Railway Act.

(3) Inland Waterway Sub-sector

Even though the F/S on the Shire–Zambezi Waterway Project has not yet commenced according to MoTPI, the Study Team assumed that the Waterway will start operation before 2015. This would realize intermodal freight transport encompassing road, rail and waterway, thus reducing transport cost and time.

6.4.4 Assumptions for Determining the Proposed Projects for the Master Plan

The followings assumptions are used to determine proposed projects for the Master Plan by sub-sector.

(1) Road Sub-sector

a) Ongoing, Committed and Planned Projects by the GoM

There are several ongoing, committed[7] and planned[8] road projects by the GoM in the Study Area, as shown in Chapter 3. These projects are planned to be completed by 2015 and so are selected as high-priority projects in the Master Plan for implementation in the short term.

Since the GoM budget for these projects is or will be allocated under the PSIP with the target year of 2015, these projects are selected in the project list, but are excluded from the evaluation process.

b) Minimum Design Standard for Planned Roads

Minimum design standards for planned arterial roads and bridges are determined so as to satisfy the requirements of arterial roads with two-lane paved carriageway. The minimum design standard for planned tertiary/district roads are determined so as to satisfy the requirements of all-weather earth road.

c) Improvement of Road Section between *Vila Nova de Frontela* and Caia via Mutarara

The road section between Vila Nova and Caia via Mutarara is one of the proposed projects to form a direct road link from Blantyre to Beira Port. The present condition of this road section is not clear, except for the *Vila Nova de Frontela*–Mutarara section where the Study Team observed the condition in November 2011. In addition, there is a ferry crossing at the Shire River and a bridge needs to be built.

Therefore, the improvement plan and construction cost of this section are prepared based on the same standard for improving of road sections in Malawi, and the construction of a 190 m span bridge is included in the improvement plan and cost estimation.

[7] Committed project means that the GoM has already allocated budget for construction works by fiscal 2011.
[8] Planned project means that the GoM has decided to allocate budget for construction works in the following years.

The whole section between Caia and Beira Port has already been improved to a two-lane paved road.

(2) Railway Sub-sector

a) New Railway Construction and Rehabilitation of Existing Nacala Railway by Vale

Based on the MoU signed in April between the GoM and Vale, Vale is going to construct a new railway line between Chikwawa District and Nkaya Junction in Balaka District, and rehabilitate the existing railway line between Nkaya Junction and Nayuchi Station (border). Even though the details of these construction and rehabilitation plans have not yet been disclosed by Vale, the works are planned to be completed by 2014. Therefore, this project is considered as a committed project in the Master Plan, but excluded from the evaluation.

b) Improvement of Railway Line between Limbe and Liwonde

Improvement of the railway line between Limbe and Liwonde is essential for transporting freight to/from Nacala Port using the Nacala Railway. Even though the investment required for improving this section is not clear, this project is excluded from the Master Plan because this line crosses the boundary of the Study Area.

c) Capacity of Nacala Railway for General Freight Transportation

Vale plans to transport 12 to 18 million tonnes of coal from Moatize Coal Mine to Nacala-a-Velha Port after building the new line and rehabilitating the existing Nacala Railway line with 12 round-trip trains running every 24 hours. As a result, the operation of general freight trains will be limited, but transportation allowances for general freight trains have not been announced to either MoTPI or CEAR. In making traffic projection as well as preparing the Master Plan, the Study Team assumed that there is no limitation on transporting general freight on the Nacala Railway.

d) Reconstruction of the Branch Line of the Sena Railway between *Vila Nova de Frontela* and *Dona Ana*

The railway section between *Vila Nova de Frontela* and *Dona Ana* is a part of the former branch line of the Sena Railway and is one of the proposed projects for forming a direct railway link from Blantyre to Beira Port. The present condition of this railway line is fair on the flat terrain according to the observation by the Study Team in November 2011.

The reconstruction plan and construction cost for this section, therefore, are prepared based on the same standard for reconstructing railway sections on flat terrain in Malawi.

(3) Inland Waterway Sub-sector

Since the F/S of the Shire-Zambezi Waterway Project has not commenced yet, no information related to the F/S is available to the Study Team, other than TOR for the study. The Study Team has therefore assumed that the Shire-Zambezi Waterway will commence operation by 2015, but the destination will be Beira Port, the same as transportation of sugar from Marromeu Sugar Mill to Beira Port, because the GoMZ has no plan to develop a port at Chinde Port.

6.5 Preparation of Development Plan for the Transport Sub-sectors

6.5.1 Road Sub-sector

(1) Functions of the Road Sub-sector for the Sena Corridor

The Sena Corridor is recognized as a part of the Beira Corridor and it has both international and domestic transportation functions. Regarding international transportation for Malawi as a landlocked country, it offers important access to ocean ports and neighbouring countries. However, the efficiency of road networks and accessibility to other international corridors of the Sena Corridor need to be improved. In addition, accessibility to international border posts and good mobility among regional capitals and main centres are indispensable for domestic transportation. High-speed and mass-transit arterial roads are required. The Main and Secondary road based on the hierarchical classification in the road sub-sector have a key role to play in international and domestic transportation, and the Main and the Secondary road form the Sena Corridor in the Study Area.

(2) Major Issues of the Road Network in the Study Area

a) Poor Condition of the Road Network

1) Present Condition

The total length of the country's arterial road network is 6,482 km, of which 50.2% is paved. In the south of the Study Area including Thyolo, Chikwawa and Nsanje Districts and part of Blantyre and Mwanza Districts, the length of the arterial road network is 528 km, of which 45.7% is paved, 4.5 points lower than the national level (See Table 6-6).

Table 6-6 Paved Ratio of Arterial Road Network in the Study Area

Route	Section		Length km	Present Condition	On-going & Committed (Short-term)
M1	Blantyre	Nsanje	180.0	Paved	Paved
M1	Nsanje	Marka	26.9	Unpaved	Unpaved
M2	Blantyre	Luchenza	61.1	Paved	Paved
S136	Mwanza	Chikwawa	106.4	Unpaved	Unpaved
S151	Thyolo	Bangula	94.2	Unpaved	Paved *1
S152	Thabwa	Seven	59.1	Unpaved	Unpaved
Total				**527.7**	**527.7**
Paved				241.1	335.3
Unpaved				286.6	192.4
% of Paved				45.7%	63.5%
% of Unpaved				54.3%	36.5%

Note: *1 The Makhanga - Thyolo section is not committed
Source: Study Team

2) Short-term Condition

Regarding upgrading of unpaved roads, a future challenge for the road sub-sector is to upgrade around 870 km of unpaved roads over the five-year period up to 2015. The projected ratio of paved roads in 2015 is 63.6% in line with this government policy. When the committed unpaved roads such as M1 (section between Nsanje and Marka) and S151 in the Study Area are

upgraded, the ratio of paved roads will be 63.5%, which is almost the same as the national level.

b) Poor Mobility in the Study Area

1) Roads impassable during the rainy season

The arterial roads in the Study Area lie near or among steep mountainous terrain as well as the Lower Shire River, and so are prone to flooding caused by regular torrential rainfall. There are many drainage facilities such as bridges, culvert pipes, drifts and vented drifts on the roads because of the number of rivers, streams and wadi crossing the roads. During the rainy season, especially December and January, S151, S152 and M1 (unpaved section between Nsanje and Marka) become unreliable due to flash flooding.

2) Sections impassable across the rivers

The large-scale washaway in 1997 resulted in the complete loss of S151's traffic function as an arterial road network. The only means of crossing the river is by small passenger boats operated by local residents throughout the year. The section crossing the Mwanza River on S136 was also washed away and is impassable during the rainy season.

i) Major Washaway at Chiromo (between Makhanga and Bangula)

The banks of the railway and road were washed away by the deluge in 1997, and neither the railway nor the road has been operation ever since. The bank of the railway was washed away for the length of approximately 360 m, and that of the road for approximately 80 m. Since villagers, goods, bicycles, etc. cross by boat at present, a solution such as a permanent bridge, temporary bridge or ferry is required (see Figure 6-9).

ii) Means to cross the river

- Ferryboat

  This is a means to cross the river by a power-driven ferryboat instead of the hand-powered boat used at present. Since the ferryboat would be larger than the present boat and be power-driven, it could carry many people safely and quickly. However, since a power-driven ferryboat would incur the purchase cost, fuel costs and maintenance costs, the toll for one trip is expected to rise from MWK 100 at present to several hundred kwacha. Since even the MWK 100 toll at present is quite expensive for villagers, a toll of several hundred kwacha would be a heavy burden for them. Since this may run counter to poverty alleviation, a power-driven ferryboat to cross the river is not appropriate.

- Temporary bridge

  This means to construct a temporary Bailey bridge or jetty. The maximum span of a Bailey bridge is generally approximately 30 m. Since the river width at the Chiromo washaway is approximately 80–90 m, at least two bridge piers are needed in order to construct a Bailey bridge. Since the depth of the New Shire River which flows through the Chiromo washaway is as deep as 5–10 m and its flow velocity is also fast at 1.5–3 m/sec, it is very difficult to construct bridge piers in the river.

Source: Study Team

Figure 6-9 Present Condition of Chiromo Washaway

Since the construction of bridge piers in a deep, fast river requires a very large-scale, expensive project, such a bridge would have to be permanent, not temporary. Hence, a temporary bridge such as a Bailey bridge or jetty is not a suitable means to cross the major washaway.

- Permanent bridge

By constructing a permanent bridge at the Chiromo washaway, the following two matters would become certain:

- ✓ Villagers would be able to cross the New Shire River free of charge, thus the bridge would help to alleviate their poverty.
- ✓ It is not necessary to construct bridge piers in the river by constructing a permanent bridge with a span of 80 to 90 m.

Hence, it is most desirable to construct a permanent bridge as a means of crossing the New Shire River.

3) Bottlenecks in terms of steep geography

M1 (part of the section between Blantyre and Chikwawa), S136 and S151 lie in the Rift Valley which varies in altitude by approximately 800 m, so these roads have some steep sections. These steep sections cause bottlenecks for industry and transport logistics.

c) Poor Accessibility to Ocean Ports and Neighbouring Countries

The international border posts operating at present are the Mwanza Border Post (BP) and the Muloza BP. The Mwanza BP, which accounts for 38% of Malawi's total international cargo volume is a crucial access point to the ocean ports and neighbouring countries. The economic growth of Malawi depends on export and import trading, mainly through Beira/Durban Port, with South Africa and other countries via the Mwanza BP links with the Tete Corridor. The Muloza BP is part of an alternative route of the Nacala Corridor as well as offering access to the Beira Port.

The distance from Blantyre to the Mwanza BP is 112 km and the distance to the Muloza BP is 114 km. Thus, Blantyre is located at mid-way between the two border posts. However, the distance from Nsanje, Chikwawa and Thyolo Districts to these two international border posts is 1.4 to 2.6 times that from Blantyre, except that the distance from Thyolo District to the Muloza BP is shorter than from Blantyre to the BP (see Table 6-7).

Table 6-7 Distance from Main Centre to International BP

Regional Capital/ Main Centre	Beira Port		Nacala Port	
	To/From Mwanza BP		To/From Muloza BP	
	km	Ratio	km	Ratio
Blantyre	112	1.00 (base)	114	1.00 (base)
Nsanje	292	2.60	294	2.58
Bangula	192	1.71	246	2.16
Chikwawa	157	1.40	159	1.40
Thyolo	153	1.36	73	0.64

Source: Study Team

Access road from the Marka BP to the Beira Port in Mozambican territory only provides a local transport service at present. Upgrading this Mozambican section will enable Nsanje, Chikwawa and Thyolo districts to improve the access to the Beira Port significantly.

d) Poor Road Network in terms of International Connectivity

In terms of international connectivity, the current arterial road network is summarized below.

- The distance from Nsanje District to the Mwanza BP is 292 km and to the Muloza BP is 294 km.
- S136 will shorten the distance from Bangula and Chikwawa to the Mwanza BP by 51 km compared with M1 route. However, S136 cannot be used for inter-regional transport at present due to its narrow width, unpaved surface which is prone to torrential rainfall, and impassable section at the Mwanza River.
- S151 will shorten the distance from Nsanje and Bangula to the Muloza BP by 79 km compared with the M1 route. However, S151 cannot be used for inter-regional transport at present due to its narrow width, unpaved surface which is prone to torrential rainfall, and impassable section at Chiromo.

(3) Considerations for Improving the Arterial Road Network

a) Road Improvement Strategy

The goal of Malawi's NTP is to provide adequate, safe, reliable, efficient and economical road transportation services in order to meet the country's current and future road transport as a key priority of the MGDS, which is to provide an adequate network of roads based on appropriate standards through the rehabilitation and upgrading of all-weather roads to meet sub-regional agreed standards. Followed by the MGDS and the NTP, the RA Five-Year Business and Strategic Plan which is to be reviewed in line with the RSP, was developed with the following main objectives.

- Ensure accessibility on all designated roads by implementing annual routine maintenance programmes.
- Systematically rehabilitate bitumen roads which have outlived their design life with the aim of reducing maintenance costs.
- Connect district centres with bitumen roads.
- Implement regular periodic maintenance to prevent further deterioration of roads.
- Construct new roads based on priorities of the GoM as approved by MoFDP.
- Reduce the unpaved road network by gradually upgrading some unpaved roads to bitumen standard through the "low volume sealed roads" concept,
- Gradually replace timber-deck bridges with concrete decks to reduce maintenance costs and environmental degradation.

b) Role of the Key National Corridors

Transport infrastructure development would improve mobility and accessibility for the people and goods to key road corridors within and outside of Malawi and would facilitate continued development of the country's rural areas according to the growth and development framework of the MGDS. Consequently, it is important to maintain the M1 route, which is the south-north corridor of the country, to assist of economic growth and alleviate regional economic disparity.

c) Role of Export Routes

Export-led growth of Malawi's economy is crucial for sustainable economic growth of the country through increasing the number of businesses with access to international markets for their products in line with the MGDS. With respect to increasing business opportunities and improving access to international markets, the characteristics of the present road network in the Study Area are summarised in Table 6-8.

d) All-weather Road with Fundamental Flooding Measures

Based on the results of the inventory survey conducted by the Study Team, the number of drainage facilities for M1 (Nsanje to Marka), S151 (Makhanga to Bangula) and S152 (Thabwa to Seven) are 62 (per 26.9 km), 11 (per 9.7 km) and 175 (per 59.1 km), respectively. Thus the number of drainage facilities per kilometre of road length for M1, S151 and S152 is 0.43, 0.88 and 0.34, respectively, and 0.55 on average.

Table 6-8 Characteristics of the Road Network in terms of Export Routes

Criterion	M1	S151	S152	S136
Function of primary road network	High	High*1	Low	Medium
Connectivity to international borders/corridors	High	Medium	Low	High*3
Accessibility to railways	High	High*2	Medium	Low
Accessibility to inland waterway	High	Medium	Low	Low
Accessibility to regional potential development	High	High	High	Medium
Need for foreign investment and assistance	High	High	Medium	Medium

Note: *1: This secondary road is the only alternative to M1 which connects the Study Area with the provincial centre.
*2: Makhanga Station and Luchenza Station considered
*3: Mwanza Border Post considered
Source: Study Team

If the unpaved roads are upgraded to the paved standard in the Study Area, drainage facilities must be installed every 0.55 km on average, and some bridges may need to be built instead of culverts to secure an appropriate cross-sectional area of water flow. These fundamental flood measures to ensure proper service as all-weather roads for road users would increase the construction cost compared with works in normal terrain.

e) Road Safety Measures

According to the National Road Safety Council of Malawi, traffic accidents are mainly caused by vehicle speeding with pedestrians being killed or injured, as shown in Table 6-9. The relation between accidents types and road conditions shows that more than 95% of all road accidents occur on roads in good or fair condition. Road safety is one of the most important government policies, so when improving the arterial road network, measures for road accidents are to be taken in consideration of the main centres, local markets, social service centres, traffic volume of vehicles, pedestrians and bicycles, and steep gradient.

Table 6-9 Major Causes of Traffic Accident

Accident Types	Road Condition					
	Good/Fair	Corrugated	Potholes	Slippery	N/A	Total
Fatal	3,688	43	132	21	29	3,913
Serious injury	3,050	31	108	30	14	3,233
Slight/Minor injury	7,144	76	237	66	34	7,557
Damages only	7,267	40	149	51	40	7,547
Animal only	139	1	7	1		148
Total	21,288	191	633	169	117	22,398

Source: National Road Safety Council of Malawi

(4) Development Plans for the Road Sub-sector

a) Criteria for Identifying Road Projects

The proposed strategic criteria for identifying road improvement projects for the Master Plan are as follows.

- To strengthen international linkages of the arterial road network with the Nacala Corridor and the Beira/Durban Corridors as well as improve accessibility to ocean ports and neighbouring countries.
- To implement road projects in line with the standard of all-weather roads for the arterial road network as a part of the Sena Corridor.
- To formulate a reliable inter-regional transport network with lower transportation costs by upgrading unpaved roads to the bitumen standard.
- To overcome the geological disadvantages and difficult natural conditions through appropriate investment.
- To strengthen the traffic function of the Sena Corridor, and to improve access to rural areas through introducing the multimodal transport concept.
- To fully consider not only economic and social evaluations, but also a comprehensive evaluation of the investment in the road-sub sector.
- To consider and harmonise investments in the road and railway sectors.

b) Project Types

Project types are defined as follows.

- Rehabilitation works aim at restoring the original condition of target roads through relatively extensive works including pavement layer reconstruction, milling and replacing existing materials, reshaping of the road cross-section, reconstruction of shoulders, drainage works and resealing/overlays.
- Upgrading works aim to improve the level of service of the target roads from the existing level. This requires paving earth (unpaved) roads.
- New construction works involve constructing new roads and bridges where these have been found to be economically sound.

c) Road Design Standard

1) Road Class

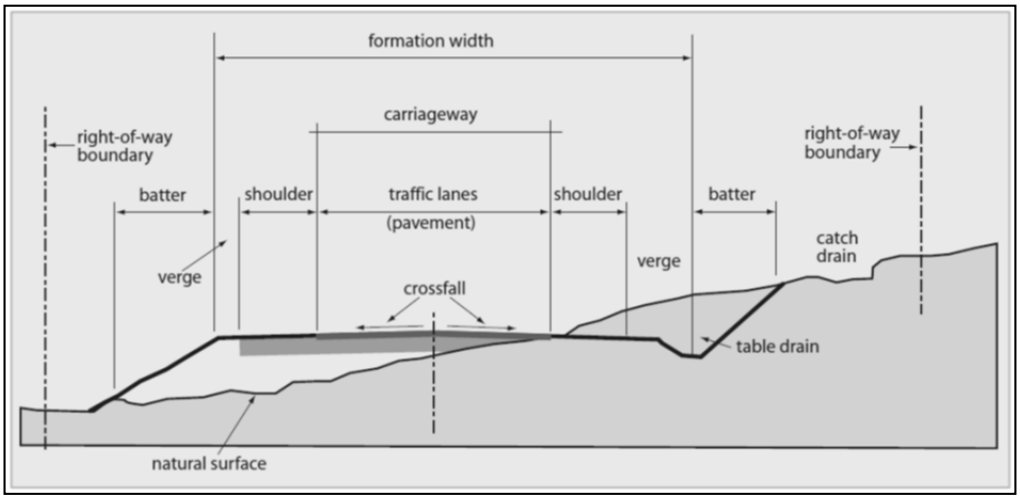
The Highway Design Manual, Ministry of Works and Supplies, 1978, describes two classes of road, Class I and Class II. The choice of class normally depends on existing and projected traffic flows and on the status of the road within the Malawi highway network. Typical sections through the roads show that all basic sectional dimensions are the same: only the width of surfacing is different between the classes (see Table 6-10 and Figure 6-10). This is to allow roads to be upgraded from Class II to Class I when conditions warrant. Similarly, the desirable and minimum design speeds in normal terrain of the two classes, and hence all geometric standards, are the same. Design speeds have been varied only in mountainous terrain.

Table 6-10 Cross-sectional Dimension

(Unit: m)

Class	Total	Shoulder (Left)	Carriageway	Shoulder (Right)
Class I	9.7	1.5	6.7	1.5
Class II	9.7	2.1	5.5	2.1

Source: Malawi Highway Design Manual



Source: Southern Africa Transport and Communications Commission (SATCC)

Figure 6-10 Typical Road Cross-section Elements

2) Design Speed

The design speeds to be used according to the class of road, are given below. (Table 6-11) Minimum design values should only be used when the desirable values cannot be attained economically.

Table 6-11 Design Speed

(Unit: km/h)

Class	Normal Terrain		Mountainous Terrain	
	Desirable	Minimum	Desirable	Minimum
Class I	100	80	80	65
Class II	100	80	65	50

Note: Minimum design values should only be used when the desirable values cannot be attained economically
Source: Malawi Highway Design Manual

3) Right of Way

The Right of Way (ROW) for Main roads, Secondary roads and Tertiary roads passing through an urban area is 60 m, 36 m and 36 m, respectively, as shown in Table 6-12. The ROW for roads in rural areas is the same as in urban areas.

Table 6-12 Right of Way

Road Type	Urban area	Rural area
Main road	60 m (2@30 m)	60 m (2@30 m)
Secondary road	36 m (2@18m)	36 m (2@18m)
Tertiary road	36 m (2@18m)	36 m (2@18m)

Note: ROW for urban area depends on the condition along the road
Source: MoTPI

d) Traffic Capacity

1) Capacity and Level of Service

The concept of Level of Service (LoS) is a qualitative measure describing operational conditions within a traffic stream and their perception by drivers and/or passengers. A Level of Service definition generally describes these conditions in terms of such factors as speed and travel time, freedom to manoeuvre, traffic interruptions, comfort, convenience and safety. Six levels are defined for each type of facility ranging from LoS A, which is the highest level to LoS F which is the lowest and subject to instability and total breakdown of flow. The capacity of a road is defined as the volume of traffic associated with Level of Service E. Level of Service B is usually selected for design purposes, as shown in Table 6-13.

LoS A represents free flow whereby individual road users are virtually unaffected by the presence of others in the traffic stream. LoS B to D are described as representing stable flow but with increasing influence from other road users in the traffic stream on the freedom to manoeuvre. As stated above, LoS E is considered to represent capacity conditions for a two-lane two-way road with approximately 2,800 passenger cars per hour in both directions.

Table 6-13 Design Factors for Two-lane Two-way Roads

(Unit: passenger cars per hour, both directions)

K Factor	Level of service				
	A	B	C	D	E
Flat terrain					
0.10	2 400	4 800	7 900	13 500	22 900
0.11	2 200	4 400	7 200	12 200	20 800
0.12	2 000	4 000	6 600	11 200	19 000
0.13	1 900	3 700	6 100	10 400	17 600
0.14	1 700	3 400	5 700	9 600	16 300
0.15	1 600	3 200	5 300	9 000	15 200
Rolling terrain					
0.10	1 100	2 800	5 200	8 000	14 800
0.11	1 000	2 500	4 700	7 200	13 500
0.12	900	2 300	4 400	6 600	12 300
0.13	900	2 100	4 000	6 100	11 400
0.14	800	2 000	3 700	5 700	10 600
0.15	700	1 800	3 500	5 300	9 900
Mountainous terrain					
0.10	500	1 300	2 400	3 700	8 100
0.11	400	1 200	2 200	3 400	7 300
0.12	400	1 100	2 000	3 120	6 700
0.13	400	1 000	1 800	2 900	6 200
0.14	300	900	1 700	2 700	5 800
0.15	300	900	1 600	2 500	5 400

Source: SATCC

2) Design Hourly Traffic Volume

On rural roads the design hourly volume is frequently assumed to be the 30th highest hourly volume of the future year chosen for the design, i.e. the hourly volume exceeded during only 29 hours of that year. The design hourly volume, as a percentage of the average dairy traffic (ADT), is referred to as the K-Factor and typically varies between 12 and 18 %. A value of 15 % is thus normally assumed unless actual traffic counts suggest another value. On an annual basis, the

directional split on most rural roads is approximately 50:50 (see Table 6-14).

Table 6-14 Capacity of Two-lane and Two-way Roads (Flat Terrain)

(Unit: passenger cars per hour, both directions)

Directional Split	Basic Traffic Capacity
50:50	2,800
60:40	2,630
70:30	2,490
80:20	2,320
90:20	2,100
100:10	1,990

Source: SATCC

3) Future Daily Traffic Volume

The future daily traffic volume in 2030 by vehicle type in the Study Area is shown in Table 6-15 for full network of road and railway modes. Of the relevant sections, the section of M1 (Blantyre to Chikwawa) has the highest traffic volume at 5,051 vehicles per day. Some parts of this section have a steep gradient due to the Rift Valley Escarpment topography. A steep road gradient reduces the traffic capacity depending on the number of large vehicles. The passenger car unit (PCU) per hour for the steep section is assumed to be 1,143 (792 PCU per hour would be assumed for flat terrain). This means that the LoS of the steep section goes down compared with the flat/rolling section between Blantyre and Chikwawa.

Table 6-15 Future Traffic Volume (2030)

Route	Section		Traffic Volume (vehicles/day)					
	To	From	Total	Passenger. cars	Minibus	Buses	Small Tracks	Large Tracks
M1	Blantyre	Chikwawa	5,051	2,756	1,049	67	1,012	167
	Chikwawa	Bangula	4,203	1,966	923	59	1,077	178
	Bangula	Nsanje	953	206	88	6	560	93
	Nsanje	Marka	547	16	0	0	456	75
S151	Thyolo	Seven	208	137	44	3	21	3
	Seven	Makhanga	1,395	927	381	24	54	9
	Makhanga	Bangula	1,606	1,076	467	30	28	5
S152	Thabwa	Seven	1,188	790	337	21	34	6
S136	Chikwawa	Mwanza	461	0	211	13	203	34

Note: Values in the table are full network case

Source: Study Team

e) Development Plans for the Road Sub-sector

There are seven major issues for the road sub-sector as follows. The countermeasures for the major issues identified in the analyses of the present condition of the road sub-sector are considered based on the policy for improvement as shown in Table 6-16.

1. Formulation of reliable arterial road network
2. Development of road network as international transport corridor
3. Reduction of transport cost
4. Upgrading of undeveloped road section
5. Development of road network to support regional development

6. Improvement of large scale washaway sections
7. Sustainable operation and maintenance system

Development plans for the road sub-sector have been prepared by considering engineering considerations, investment situation and development priorities, and are summarised in Table 6-17 and Figure 6-11.

- Building all-weather roads, Upgrading to paved roads and Maintaining roads linking residential areas with trading centres are common countermeasures for the arterial road network (M1, S136, S151 and S152) in the Study Area. Considering the development concept for the Sena Corridor and the functional classification of the road network in the Study Area, higher priority is given to countermeasures for the M1 and S151 routes. These two routes have a wide range of traffic functions such as serving as the national north-south axis, access to international corridors, and linking of rural growth centres, followed by the S136 and S152. On the other hand, since the GoM has already decided to allocate funds and will finalize for upgrading both the M1 and S136 roads by 2015, additional investments are required for the section from Makhanga to Bangula of the S151 (L = 9 km) and the whole of the S152 (L = 59 km).
- The timing of implementation of Connecting S151 at Chiromo as an alternative north-south axis and Reconstructing the washed-away Mwanza Bridge on S136 should be considered in line with upgrading of the S151 and S136, respectively. These countermeasures would contribute not only to formulating efficient logistics routes but also to increasing the living standards of local people by connecting large-scale washed-away sections.
- Widening the existing Shire Rail/Road Bridge and Widening at steep-gradient sections for assuring traffic service level are considered as countermeasures in the medium and long term because of the forecasted increase in traffic demand.
- Creating shortcut to Tete road and Beira Port and Upgrading the section between *Vila Nova de Frontela* and Caia in Mozambique should be started in the long term.
- Maintaining access roads to railway stations is the countermeasure for community roads such as the T420 and U173. Maintenance of these community roads will be implemented in the railway rehabilitation works from Limbe to Makhanga because they could be transportation routes for the railway rehabilitation works.
- The road maintenance programme is formulated in line with the Road Sector Programme which is revised every five years and the budget for the routine and periodic road maintenance should be secured annually based on field surveys and inspections. The budgeting and management system for road maintenance are working at present. Therefore, priority is given to routine maintenance for unpaved roads in the short term. However, because the length of paved roads in the Study Area will increase in the medium and long term, it is necessary to provide education and training for the paved road maintenance

system and contract management as well as to secure budget for periodic and pothole patching.

Table 6-16 Major Issues and Countermeasures for the Road Sub-sector

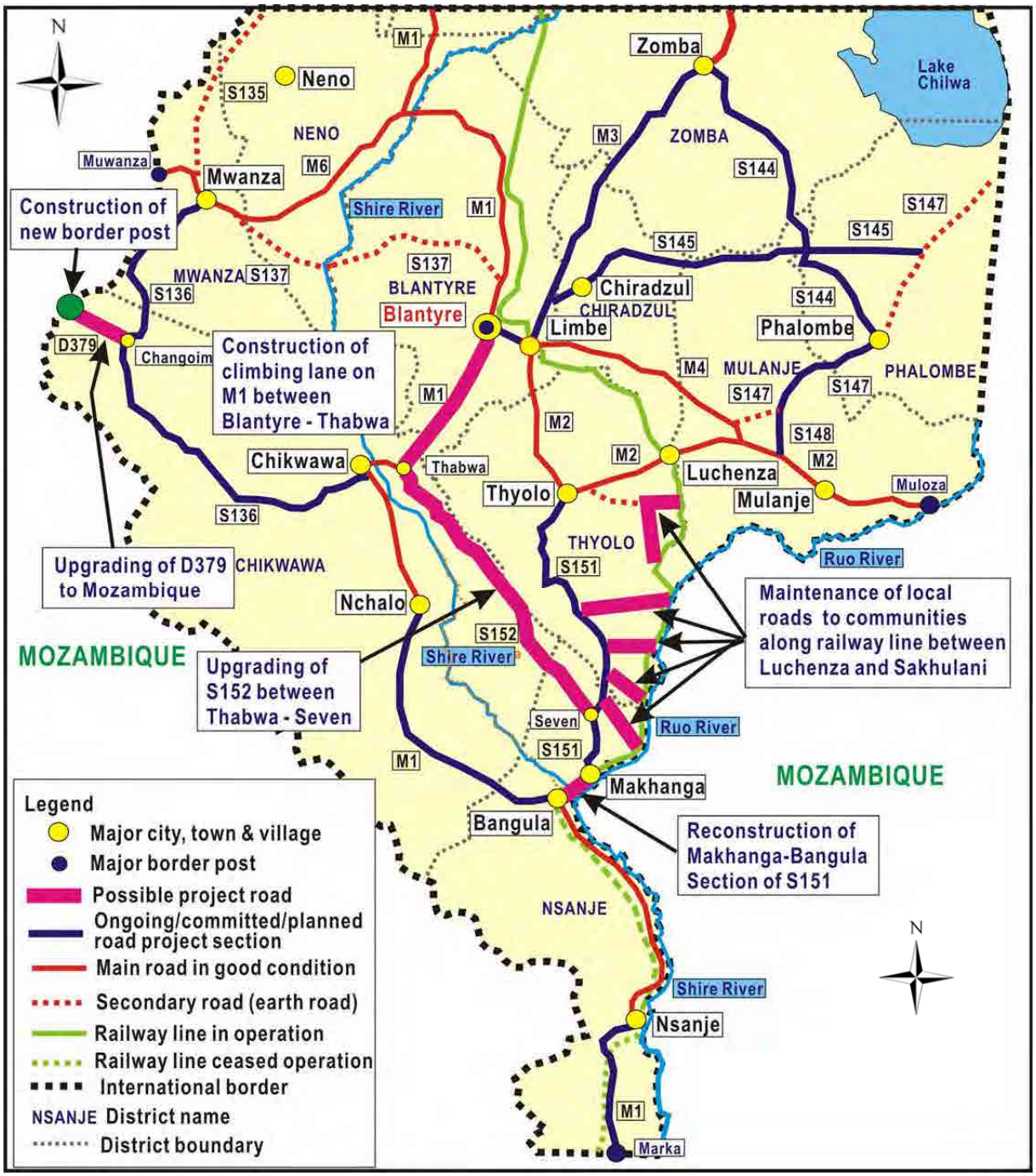
Major Issue	Policy for Improvement	Countermeasures
1. Formulation of reliable arterial road network	Proper arterial road functions	• Building all-weather roads • Upgrading to paved roads • Upgrading section between *Vila Nova de Frontela* and Caia in Mozambique • Widening at steep-gradient sections for assuring traffic service level • Widening the existing Shire Rail/Road Bridge, considering road design standards for road width • Creating shortcut to Tete road and Beira Port • Maintaining roads linking residential areas with trading centres • Maintaining access roads to railway stations
2. Development of road network as international transport corridor	Proper international road functions	
3. Reduction of transport cost	Cheaper transport route	
4. Upgrading of undeveloped road section	Appropriate road structures and facilities	
5. Development of road network to support regional development	Growth of regional economy and rising living standards of local people	
6. Improvement of large scale washaway section	Passable throughout the year	• Connecting S151 at Chiromo washaway for an alternative north-south axis • Reconstructing the washed away Mwanza Bridge
7. Sustainable operation and maintenance system	Efficient road maintenance	• Securing fund for routine and periodic maintenance from the Road Fund Administration • Improving maintenance planning and management

Source: Study Team

Table 6-17 Development Plans for the Road Sub-sector

Major Issue	Short Term (2015)	Medium Term (2020)	Long Term (2030)
1. Formulation of reliable arterial road network	1. Upgrading of M1 Chikwawa–Bangula (on-going) 2. Upgrading of M1 Nsanje–Marka (planned) 3. Upgrading of S136 Mwanza–Chikwawa (planned) 4. Upgrading of S151 Thyolo–Makhanga (committed) 5. Reconstruction of S151 Makhanga–Bangula	1. Upgrading of S152 Thabwa–Seven	-
2. Development of road network as international transport corridor		1. M1 Bangula–Thabwa (climbing lanes)	1. Improvement of *Vila Nova de Frontela*–Caia section (Mozambique)
3. Reduction of transport cost		-	1. Upgrading of D379 New access road to Mozambique 2. Improvement of *Vila Nova de Frontela*–Caia section (Mozambique)
4. Upgrading of undeveloped road section		-	-
5. Development of road network to support regional development	6. Maintenance of local roads to access rural communities	1. Upgrading of S152 Thabwa–Seven	-
6. Improvement of large scale washaway section	1. S151 Makhanga– Bangula 2. Reconstruction of Mwanza River Bridge on S136	-	-
7. Sustainable operation and maintenance system	1. Secure sufficient fund for routine maintenance	1. Secure sufficient fund for routine and periodic maintenance	1. Secure sufficient fund for routine and periodic maintenance

Source: Study Team



Source: Study Team

Figure 6-11 Development Plans for the Road Sub-sector

f) Description of Road Improvement Projects for the Master Plan

Descriptions of proposed road improvement projects for the Master Plan are shown in Table 6-18.

Table 6-18 Description of Road Improvement Projects for the Master Plan

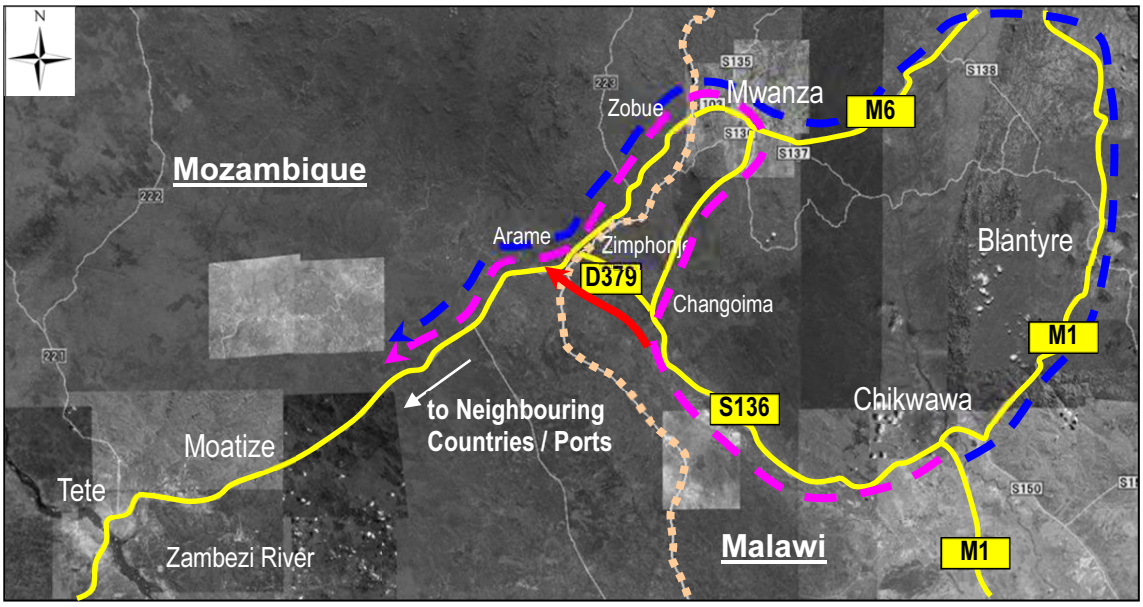
Route	Project	Description
M1	Chikwawa - Bangula	Rehabilitation work for the 50 km section between Chikwawa and Nchalo was completed in 2011 by the 9th EDF, except for the 30 km section between Nchalo and Bangula funded by the GoM which is ongoing.
M1	Bangula - Nsanje	Upgrading work for this 48.2 km section was completed in 2011, funded by the GoM.
M1	Nsanje - Marka	Upgrading work for this 26.9 km section is planned by the GoM and is expected to be completed by 2015. The detailed engineering review was done in 2002. At present RA is considering a second detailed engineering review for the tender procedure for detailed design and construction works. The concept of the road design standard for the section is the same as for the road between Bangula and Nsanje.
M1	Climbing lane for steep section	Widening of the steep section of M1 near Thabwa is proposed in the Master Plan in order to maintain the traffic service level considering the future traffic demand for this section. The concept of the long term project is to widen some sections to add a climbing lane to improve the traffic flow for passenger cars, which are seriously affected by slow trucks and trailers. The length to be widened is 5 km, in order to minimize the topographical change and construction cost.
S136	Mwanza - Chikwawa	Upgrading work for this 106.4 km section is planned by the GoM. The government budget for the detailed engineering design was allocated in 2011/12 financial year. The allocated budget for the section includes the construction of the Mwanza Bridge to improve the crossing over the river because the bridge was washed away by flooding.
S151	Thyolo - Makhanga	The funding for upgrading works the 84.5 km section between Thyolo and Makhanga is committed. The funding sources are the Kuwait Fund, OPEC, BADEA and GoM. The original expected completion year was 2010, but the work is behind schedule. The design concept for S151 is the paved standard with two lanes. A design report for S151 between Thyolo and Bangula was prepared in 2004.
S151	Makhanga - Bangula	The 9.7 km section between Makhanga and Bangula is part of S151 between Thyolo and Bangula. The design standard for this section is basically the same as for the ongoing section between Thyolo and Makhanga. There is a steel truss bridge accommodate both road and single railway line over the Shire River. At the Chiromo washway where the embankment was washed away by flooding in 1997, the only way to cross the river is by small boats operated by local people.
S152	Thabwa - Seven	Upgrading work for this 59.1 km section is planned by the GoM. The detailed engineering design was done in 2009. The entire section between Thabwa and Seven lies along the Rift Valley Escarpment and so is highly prone to flash flooding. The cost of upgrading this section is high even if the road runs through flat terrain. The road is constantly in use by pedestrians and bicycles because runs through areas of high population density and socio-economic activity.
T420	Chinzama - Sandama Rail station	Reconstruction work of T420 is proposed in the Master Plan in order to secure transportation at the stage of rehabilitating the railway line between Luchenza and Bangula and at the rail operation stage for maintenance and emergency purposes as well. The section length is 20 km. After rehabilitation of the railway line, the road will provide proper access to the arterial road (S151) from the Sandama trading centre and Sandama Railway Station as well as for the local people.
U173	Thekerani - Thekerani rail station	Reconstruction work of U173 is proposed in the Master Plan in order to secure transportation at the stage of rehabilitating works for the railway line between Luchenza and Bangula and at the railway operation stage for maintenance and emergency purposes as well. The section length is 7 km. After rehabilitation of the railway line, the road will provide proper access to the arterial road (S151) from Gombe school and Thekerani Railway Station as well as for local people.
D379	New access road to Mozambique from S136	Upgrading work of D379 is proposed in the Master Plan in order to improve accessibility to the Tete Corridor from the Southern Region in Malawi. S136 will bisect the road at Changoima, one direction toward Mwanza on S136 and the other toward Arame on the Tete Corridor. The length of the new access road to Mozambique from S136 is 12.7 km. The design concept of upgrading is the same as for the upgrading of S136. This project is required to establish a new international border post.
Mozambique	N1-*Dona Ana-Vila Nova de Frontela*	Upgrading work of the unpaved road between N1 (Mozambican national highway), *Dona Ana* and *Vila Nova de Frontela* in Mozambique territory is proposed in the Master Plan in order to form and strengthen the Sena Corridor road network. The length of the section is 140 km. The existing road is missing where it crosses the Shire River.

Source: Study Team

1) D379: New access road to Mozambique from S136 (proposed)

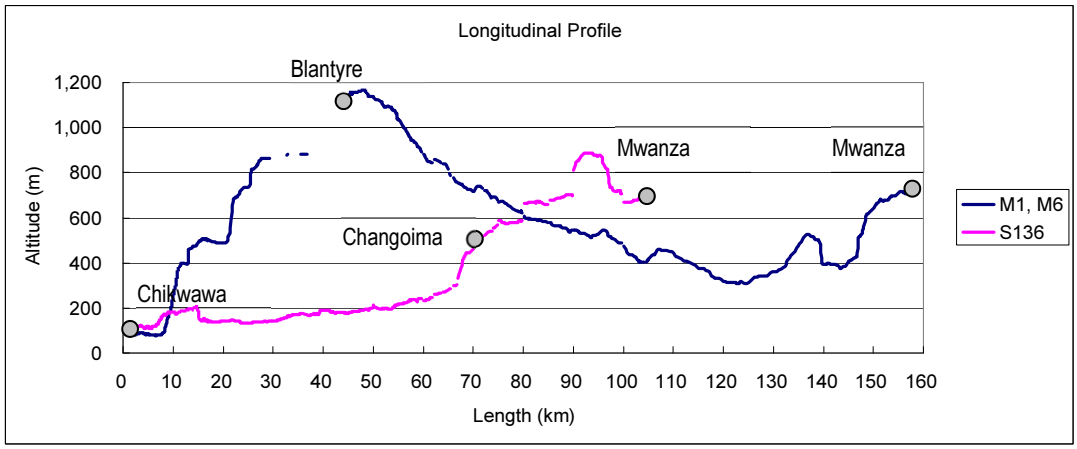
The only access road to the Muwanza International BP from Chikwawa is only M1/M6 route via Blantyre at present. This access road is about 160 km long and varies in altitude difference

between 100 m and 1,200 m above sea level. On the other hand, the existing S136 is unpaved and cannot be used for inter-regional traffic because it is not possible to cross the Mwanza River during the rainy season. The GoM has decided to build a bridge across the Muwanza River and is planning to upgrade S136 to a paved road. The length between Chikwawa and the Mwanza BP through S136 is 110 km, which is 50 km shorter than the M1/M6 route and the altitude variation of 100 m to 900 m is also easier (see Figures 6-12 and 6-13).



Source: Study Team

Figure 6-12 Route Map of New Access Road to Mozambique from S136



Source: Study Team

Figure 6-13 Comparison of Longitudinal Profile M1/M6 and S136

Regarding international accessibility, however, the problems of long transportation distance and high fuel consumption remain even if S136 is upgraded. To improve international accessibility in future, a new access road to Mozambique from S136 is proposed by upgrading D379 which bisects S136 at Changoima toward Arame on the Tete Corridor in Mozambican territory. The altitude between Chikwawa and Arame ranges between 100 m and 500 m, and the

distance is 80 km. Thus, compared with the 200 km from Chikwawa to Arame on the M1/M6 route, the new access road would be 120 km shorter.

2) M1: Climbing Lane for Steep Section (Proposed)

As previously mentioned in the section on Road Traffic Capacity, there will be problems with slower-moving vehicles due to the steep gradient on M1 when traffic demand increase in the future, so a climbing lane for the steep section is proposed in the Master Plan.

Photo by the Study Team, February 2011

Photos 6-1 Traffic Condition and Width of Road Bed on the Steep Section of M1

A climbing lane is an auxiliary lane added on the outside of the through lanes and reduces congestion by removing slower-moving vehicles from the traffic flow. A climbing lane is usually used to match the level of service on the rising grade to that prevailing on the level sections of the route.

Climbing lanes help maintain an acceptable level of service on sections of a route. They also enhance safety by reducing the speed differential in the through lane. Therefore, climbing lanes may be warranted depending on both the speed and volume of the traffic.

From observation at the site, the Study Team considers that a climbing lane should be built within 5 km from Thabwa in consideration of the horizontal and vertical alignments, traffic conditions, topography and sufficient width of the existing road bed for adding a climbing lane without requiring large-scale cutting and filling. Within this 5 km section, the critical length that causes the design truck speed to be reduced by 20 km/h is considered (see Table 6-19),

Table 6-19 Critical Length of Gradient

Gradient (%)	Length of Grade (m)
3%	500
4%	350
5%	250
6%	200
7%	175
8%	150

Source: Malawi Highway Design Manual; SATCC

3) Outline of Bridge Improvement Plan

The plan for improving each major issue related to bridges is shown in Table 6-20.

Table 6-20 Outline of Bridge Improvement Plan

Major Issue	Site	Present Condition	Improvement Plan
(1) Major Disconnection	1) Chiromo washaway	・Washaway of the bank of road (L=80m) ・Washaway of the bank of railway (L=360m) ・Villagers, goods, bicycles, etc. cross the washaway by boat (accidents happen).	Connecting road by construction of a new bridge (L=80 - 230m) is required.
	2) Shire River (at the downstream side of the existing Kumuzu Truss Bridge in Malawi)	・Existing Kumuzu Truss Bridge is a single line railway bridge (L=180m). ・Vehicles cross the existing Kumuzu Truss Bridge.	A connecting road by constructing a new road bridge (L=190m) at the down stream side of the existing Kumuzu Truss Bridge is required. The existing Kumuzu Truss Bridge can be used as a railway bridge.
	3) Shire River (on N322 in Mozambique)	・Width of Shire River is 150 m. ・Cargo vessels will be scheduled to use the river.	Connecting the N322 road by constructing a new bridge (L=190 m) is required.
	4) Mwanza River (on S136)	・Washaway the bridge (L=100m)	Connecting the S136 road by constructing a new bridge (L=100 m) is required.
(2) Bottleneck of the Roads	M1 (Nsanje-Marka Road)	・There is one existing bridge (single lane)	Reconstruction of the bridge is required.
		・There are some vast wadi.	Four new road bridges for the wadi need to be built.
	S152 (Thabwa-Seven Road)	・There are three existing bridges (single lane)	Reconstruction of the three bridges is required.
		・There are some vast wadi.	12 road bridges for the wadi need to be built
	S136 (Chikwawa-Mwanza Road)	・There are 17 existing bridges including timber deck bridges (single lane).	Reconstruction of nine bridges is required. The construction of culvert and small existing bridges must be considered.
		・There are some vast wadi.	Three new road bridges for the wadi and washaway (excluding Mwanza River Washaway) must be considered.

Source: Study Team

(5) Maintenance Plan of Roads

a) Routine Maintenance

This programme will target the entire road network with prioritization based on the road network ranking list. The programme will involve conducting maintenance activities that need to be carried out at least once a year so that the roads can continue to function as designed. Activities under this programme will include, but are not limited to:

- Cleaning and opening drains
- Spot reshaping/grading of carriageway on unpaved roads
- Filling potholes and gullies on unpaved roads
- Repairing drainage structures
- Removing of foreign materials from road carriageways
- Spot trimming/filling shoulders on paved roads
- Temporarily filling potholes on paved roads

- Cutting grass and shrubs
- Pruning trees on the road reserve
- Planting erosion-control vegetation

b) Grading and Reshaping

This programme is for grading and reshaping (labour-based) unpaved roads that are in good to fair condition. An annual implementation of this programme translates into grading and reshaping (labour-based) unpaved roads once every two to three years with the aim of sustaining their designed functionality. Under normal circumstances, grading is applicable to main, secondary and tertiary roads, whereas reshaping is usually applicable to district roads as they are narrower and grading operations are impossible.

c) Sectional Periodic and Rehabilitation of Paved Roads

This programme aims to restore the original design condition of relatively short sections of paved roads that are characterised by excessive loss of surface materials, deformation and potholing due to factors such as ageing, traffic action and environmental damage, thereby rendering lesser intervention measures inappropriate. The programme will ensure a reasonable level of service within the affected sections. The works under this programme which are relatively complex in nature will include re-construction of the pavement layer and surfacing. This programme is suitable for road sections that are in poor to bad condition based on the road network ranking list.

d) Pothole Patching on Paved Roads

This programme will target all paved roads to ensure the safety of road users throughout the year and also to prevent damage to the pavement layer from rain-water ingress. Implementation will focus on high-ranking roads in the road network ranking list.

e) Road Centre and Edge Lines Marking

This programme aims to improve safety on selected paved roads through improved road marking using retro-reflective paint or other approved road marking products. This is a routine maintenance activity, and so the programme will continue being executed annually based on the existing road marking condition. Since there is a backlog to be cleared, the approach being taken is to start with the roads that are in good condition based on the network ranking list.

f) Improvement of Accident Spots

This programme aims to improve safety at accident-prone sections of paved roads by carrying out spot improvements such as widening and sealing the shoulders, constructing traffic separation features, constructing speed humps, laying rumble strips, installing road signs, and applying pavement marking. Target sections will be identified in liaison with the National Road Safety Council of Malawi and the Traffic Police.

g) Replacement of Road Signs

This programme aims to enhance road safety and provide general information to road users by installing road signs and maintaining damage/defaced ones, starting with paved roads. The

programme is based on the network ranking list.

h) Spot Repair Interventions

Since routine maintenance works are to be carried out continuously as needed on the ground and targeting the entire road network with resources spread over one full year, any single-event intervention that would quickly deplete the routine maintenance resources, thereby preventing the rest of the road network from benefiting, will be considered under this programme. This programme shall therefore include, but not be limited to:

- Road surface repairs
- Embankment formation/repairs
- Bridge guard/handrail repairs and re-installation
- Edge marker posts repairs and re-installation
- Guardrail repairs and re-installation
- Bridge repairs
- Drainage repairs including scouring protection and river training
- Localized gravelling
- Construction of missing structures on designated roads

6.5.2 Railway Sub-sector

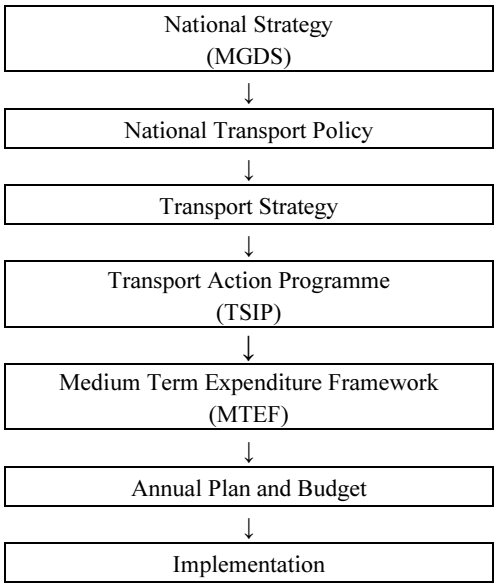
(1) Major Issues for Improvement of Railway Sub-sector

The major issues for improving the railway sub-sector are described below.

a) Consistency with the Master Plan

The improvement of the railway sub-sector should be consistent with national or regional plans such as Malawi's development plans, land use plans in the target area, road improvement plans, and so forth. It is also necessary to be consistent with on-going or planned projects which will be implemented. The implementation process of transport sector projects in Malawi is shown in Figure 6-14. In the National Transport Strategy, road development and maintenance have been a top political priority, and have been allocated 95% of the budget. In contrast, the operation and maintenance of railway and inland waterway transport have been consigned to the private sector. However, these private consignments have often failed due to the signing of inadequate contracts regarding responsibilities for maintenance and rehabilitation of degraded infrastructure. In particular, expected results have not been obtained in the railway sub-sector due to lack of adequate regulation and oversight by the MoTPI.

In recent years, the national strategy and national transport policy which influence the railway sub-sector have had to respond to the rapid development of railways in neighbouring countries. Specifically, there is a project for transporting large amounts of coal from the Moatize Coal Mine to Vale's newly developing *Nacala-á-Velha* Port using part of Malawi's railway line. Major investment in maintaining Malawi's railway line will be done without Malawi having to invest itself, and so Malawi will benefit from the project to transport rail freight to Nacala Port.



Source: "Transport Sector Investment Programme (TSIP)" Draft Final, January 2011, MoTPI

Figure 6-14 Hierarchy of Investment Process in the Transport Sector

However, the target route of the Study will require separate rehabilitation because it is not covered by the coal transport project.

TSIP for the railway sub-sector is shown in Table 6-21 and the completion year and the cost of the railway network rehabilitation and renewal is shown in Table 6-22. However, the budget has not been appropriated and the rehabilitation plan for the 44 km between Dona Ana and Vila Nova in Mozambique is not clear.

Table 6-21 TSIP for the Railway Sub-sector

Item	Completion Year
Railway Line Rehabilitation	
Mchinji–Lilongwe (Kanengo)	2016
Lilongwe (Kanengo)–Salima	2015
Salima–Nkaya	2016
Limbe–Nkaya	2013
Nkaya–Nayuchi	2016
Limbe–Makhanga	2015
Blantyre–Limbe	2015
Bridge and Culvert Repairs	
Mchinji–Lilongwe (Kanengo)	2013
Lilongwe (Kanengo–Salima	2012
Salima–Nkaya	2013
Limbe–Nkaya	2013
Nkaya–Nayuchi	2016
Limbe–Makhanga	2014
Blantyre–Limbe	2015

Source: "Transport Sector Investment Programme (TSIP)" Final Draft Report, July 2011, MoTPI

Table 6-22 Cost of Railway Network Rehabilitation and Renewal

Work Category		Cost (US$ million)	% of Total
Track rehabilitation		75.82	14.4%
Track renewal		219.50	41.5%
Sub-total		295.32	55.9%
Bridge rehabilitation		9.67	1.8%
Bridge renewal		214.23	40.5%
Sub-total		223.90	42.4%
Others		9.12	1.7%
Total cost		528.34	100.0%
Section			
1	Mchinji–Kanengo (Lilongwe)	35.51	6.7%
2	Kanengo (Lilongwe)–Salima	34.62	6.6%
3	Salima–Nkaya	91.73	17.4%
5	Limbe–Nkaya	43.95	8.3%
4	Nkaya–Liwonde–Nayuchi (border)	13.74	2.6%
Sub-total for Nacala Corridor		219.55	41.6%
6a	Limbe–Bangula	208.38	39.4%
6b	Bangula–Border (Marka)	96.67	18.3%
Sub-total for Sena Corridor		305.05	57.7%
	Signalling equipment unallocated to individual sections	3.75	0.7%
Grand Total		528.35	100.0%

Source: "Technical Assistance to Rail Sector Development" Draft Final Report (May 2009, GOPA)

b) Integration of Transportation Modes

The integration of transport systems should be encouraged through linking rail and other transport modes (road, river and lake transport). In the Study Area, the river transport from Nsanje International Port is available, and so the loading and unloading of freight at Nsanje International Port is considered. However, integration with air transport is not considered as railway transport is suitable for bulk commodities.

c) Related Areas Utilising the Characteristics of the Railway

For the route to be competitive with other transport modes, investment in related areas (bulk transport, container transport, fuel transport, etc.) should be encouraged utilising the characteristics of the railway. Railway transport should sever as an important infrastructure to support the social and economic development of Malawi.

On the target route, railway transport is superior for the bulk transport of fertilizers, etc., container transport of general cargoes, and fuel transport.

d) Rehabilitation Considering the Functions and Characteristics of Each Railway Line

As to securing safe and reliable railway transportation, the priority issue is to rehabilitate infrastructures such as deteriorated tracks, substructures and bridges. It is also necessary to rehabilitate deteriorated freight station facilities before the Sena Railway branch line can be reopened. The rehabilitation plan should be established considering the functions and characteristics of each line.

e) Reliable Freight Transport

To improve the efficiency of operation, freight transport should be made safe and reliable. This requires the rehabilitation of tracks including the installation of heavy rails, replacement of bridges and introduction of new signalling and telecommunication facilities.

f) Appropriate Investment Scale for Malawi

Considering the scale of Malawi's economy and investment in the transport sector, a feasible plan for the railway sub-sector with an appropriate investment scale should be formulated. Therefore, the target route should be rehabilitated in phases.

g) Consideration of Local Procurement

The rehabilitation plan encourages local procurement wherever possible and reduces foreign currency expenses. Therefore, the rehabilitation of civil works including embankments and culverts except long bridges should be planned according to Malawi's current level of construction techniques.

h) Environmental Considerations

The rehabilitation plan should consider environmental plans, regional development plans, etc. in addition to the rationalisation of railway operations.

i) Diversification of methods for securing funds

For securing funds, it is necessary to consider using the build, operation and transfer (BOT) scheme and returning development profits. The section between Nkaya and Nayuchi, which is part of the Nacala Corridor, will be rehabilitated by Vale, without investment by Malawi.

j) Balanced Investment for Each Department

Investment plans should also be balanced for each department such as rolling stock and transport, not only for facility rehabilitation.

(2) Major Issues for the Rehabilitation of Railway Infrastructure

The major issues for the rehabilitation of railway infrastructure are as follows.

1) Rehabilitation of Dilapidated Facilities

Rehabilitation should be carried out for facilities such as tracks, substructures, and bridges that are the foundation for safe and reliable railway transportation. The railways infrastructures in Malawi are generally dilapidated, resulting in train speed restrictions and reduced transportation capacity caused by frequent derailment; as a result railway transport cannot satisfy the freight demand.

These infrastructure facilities must be rehabilitated to achieve safe and reliable railway transportation that customers can relay on. The specific benefits of rehabilitation will include fewer derailments, faster train speed and resulting shorter transportation times, less out-of-service time (resulting in shorter operating and transportation times) for recovering from derailments, lower derailment recovery work, and reduced compensation for damaged freight. The shorter transportation time and improved in the rolling stock operating rates will directly improve transportation efficiency and boost freight demand. In addition, lower unit

transportation cost will improve railway management.

2) Elimination of Rolling Stock Problems

In addition to procuring newly manufactured and reconditioned rolling stock, it is essential to repair rolling stock that has broken down and become inoperable. Many railways, not only in CEAR but also in CDN, have reduced transportation capacities due to insufficient trains in operation, and cannot meet demand. To alleviate this problem, it is necessary to increase the rolling stock by procuring newly manufactured and reconditioned rolling stock. In addition, spare parts for maintaining broken-down rolling stock will need to be replenished. There is also an urgent need to enhance the efficiency of rolling stock maintenance to improve the rolling stock operating rate. Increasing the amount of rolling stock will support greater freight demand and reduce unit transportation costs.

3) Reinforcement of Track

The track infrastructure should be enhanced, including replacing heavy rails, increasing the ballast depth, increasing the number of sleepers and changing to PC sleepers. Existing rails in Malawi are as light as 40 kg/m or less, and dilapidated rails that have exceeded their lifetimes and are still being used. The track load-bearing capacity is also inadequate, due to factors such as the insufficient ballast depth and inadequate number of sleepers. It is necessary to upgrade rails to heavy rails, secure sufficient ballast depth, and use good-quality sleepers in addition to laying sufficient number of sleepers. These efforts will reduce maintenance costs.

4) Improvement of Signalling and Communication Facilities

It is necessary to improve the operation safety and management efficiency by planning to modernise and reintroduce the signalling system. In Malawi, the signalling system is an old type and is not maintained, so train operations are basically carried out without signalling. A reliable signalling communication system is essential for train safety.

5) Improvement of Container Transportation

It is necessary to increase dedicated container cars, prepare container handling stations, and install and improve dedicated lines and loading/unloading facilities. In recent years, the percentage of Malawi's railway freight taken up by containers has been rapidly increasing, and the importance of container transportation is likely to increase further. However, although block trains are being effectively used, containers are sometimes mixed with general freight wagons. It is necessary to improve the container transportation capacity by increasing the container cars, providing fully equipped loading/unloading facilities, and establishing and expanding the handling depot.

6) Improvement of Employee' Skills

In Malawi, railway employees generally lack sufficient skills and operational efficiency in the areas of management, track maintenance, maintenance of railway roadbeds and bridges, rolling stock maintenance, signal maintenance, and container handling. As the repair of rolling stock requires higher technical skills than workers possess, maintenance is not carried out, It is

important to improve their ability to maintain rolling stocks. Regarding improvement measures, in the short term the skills of railway employees can be raised by dispatching specialists and using a training system. In the longer term, railway staff training centres need to be established locally to improve employees' technical skills.

7) Improvement of Concession Agreement

The current concession agreement involves problems including an inadequate legal system, insufficient agreement articles, evasion of responsibility by the government, insufficient investment funding, and non-payment of compensation. As the concessionaire cannot provide sufficient support, the possibility of improving the concession should be considered. However, the WB has been working on introducing a railway Public Private Partnership (PPP) in Africa since the 1990s, and cooperation with the WB is one solution.

8) Modernization of Depot and Workshop

It is necessary to modernise the workshop in the depot for inspecting and repairing the rolling stock to achieve efficient maintenance work. Although the workshop in Malawi has facilities for daily inspection/maintenance and overhaul of rolling stock, the facilities are old and efficient maintenance is difficult. The major issues in the workshop are:

- Lack of spare parts
- Modernization of the workshop
- Improvement of the utilisation rate of rolling stock
- Skills training for the maintenance staff

Regarding the lack of spare parts, parts for repair are cannibalized from other damaged rolling stock which causes a vicious circle and ever-decreasing number of available rolling stock.

(3) Development Plans for the Railway Sub-sector

There are eight major issues for the railway sub-sector as follows. The countermeasures for the major issues identified in the analyses of the present condition of the railway sub-sector are considered based on the policy for improvement as shown in Table 6-23.

1) Construction of bridge at the Chiromo washaway section
2) Rehabilitation/ reconstruction of existing railway facilities and strengthening of railway tracks
3) Inadequate rolling stock
4) Improvement of signal and telecommunication system
5) International freight transport
6) Capacity development of MoTPI and CEAR personnel
7) Improvement of concession agreement
8) Strengthening of transport capacity

Development plans for the railway sub-sector have been prepared by considering engineering considerations, investment situation and development priorities, and are summarised in Table

6-24 and Figure 6-15.

Table 6-23 Major Issues and Countermeasures for the Railway Sub-sector

Major Issue	Policy for Improvement	Countermeasures
1. Construction of bridge at washaway section	Resolution of disconnection of the railway at Chiromo	* Construction of new bridge at the Chiromo washaway section
2. Rehabilitation/ reconstruction of existing railway facilities and strengthening of railway tracks	Restoration of railway transportation	* Rehabilitation of Limbe–Makhanga section (replacement of ballast, sleepers and rails, and rehabilitation of bridges) * Reconstruction of Makhanga–Border (Marka) section
3. Inadequate rolling stock	Resolution of lack of available rolling stock	* Procurement of rolling stock (diesel locomotives, wagons and passenger coaches) to meet traffic demand
4. Improvement of signal and telecommunication system	Securing safe and stable railway operation	* Installation of new signal and telecommunication system
5. International freight transport	Promotion of international rail freight transport through Malawi	* Arrangement of bi-lateral agreement with GoMZ by transporting freight through Beira Port by railway
6. Capacity development of MoTPI and CEAR personnel	Enhancement of supervision and management capability for railway operation	* JICA training * Institutional reform of Railway Division of MoTPI and CEAR * Revision of Railway Act
7. Improvement of concession agreement	Resolution of ambiguous issues in concession agreement	* Improvement of concession agreement between GoM and CEAR.
8. Strengthening of transport capacity	Enhancement of railway transport capacity	* Rehabilitation/reconstruction of Limbe–Border–Dona Ana section.

Source: Study Team

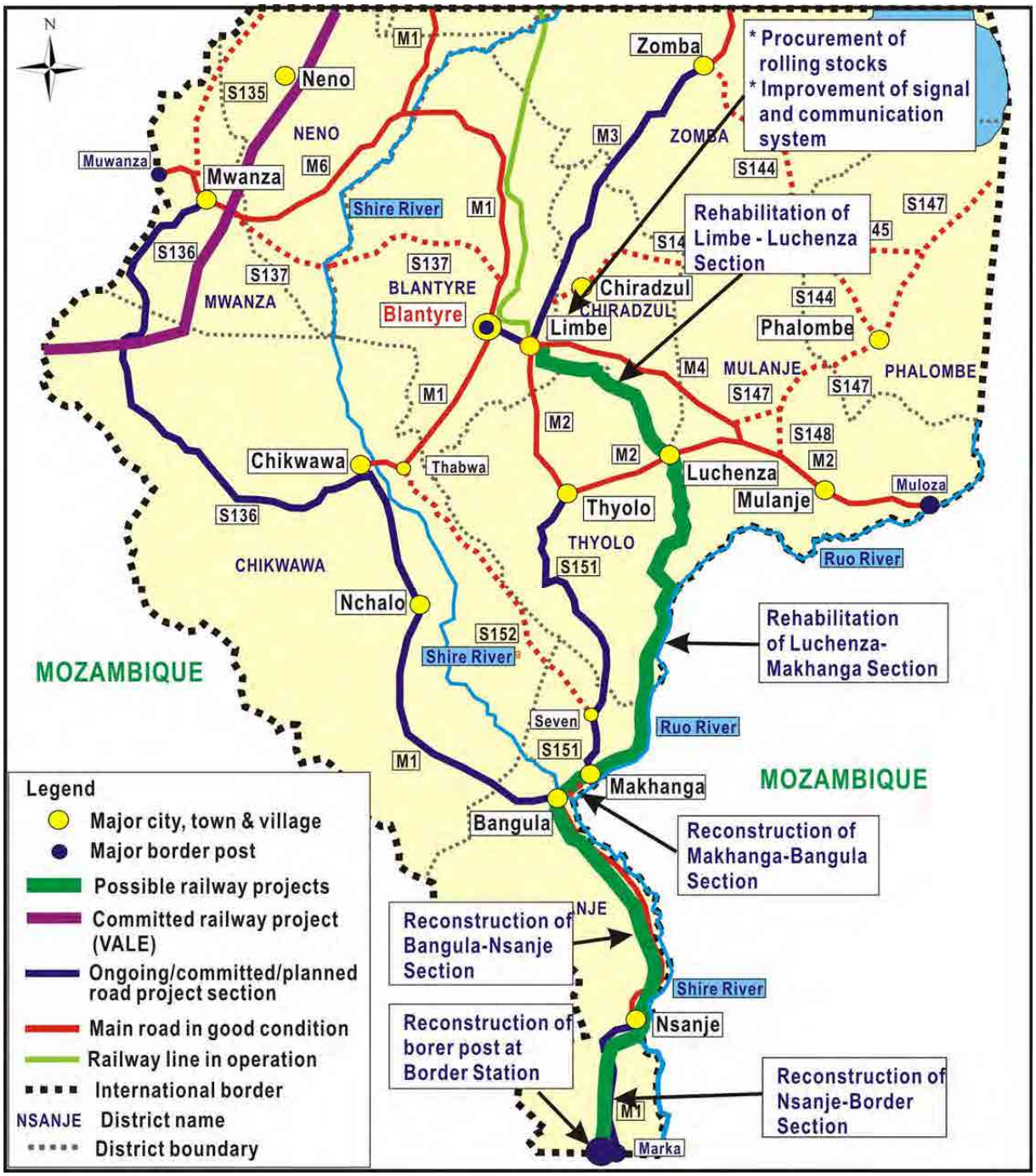
Table 6-24 Development Plans for the Railway Sub-sector

Major Issue	Short Term (2015)	Medium Term (2020)	Long Term (2030)
1. Construction of bridge at Chiromo washaway section	-	1. Reconstruction of Makhanga–Bangula	-
2. Rehabilitation/ reconstruction of existing railway facilities and strengthening railway tracks	1. Emergency rehabilitation of Limbe–Makhanga (GoM)	1. Rehabilitation of Limbe– Makhanga	1. Reconstruction of Bangula–Border
3. Inadequate rolling stock	-	1. Procurement of rolling stock	1. Procurement of rolling stock
4. Improvement of signal and telecommunication system	-	1. Installation of signal and telecommunication system for Limbe–Bangula	1. Installation of signal and telecommunication system for Bangula–Border (Marka)
5. International freight transport	-	-	1. Bilateral treaty with Mozambique for international freight transport
6. Capacity development of MoTPI and CEAR personnel	1. JICA training 2. Institutional arrangements of Railway Division of MoTPI and CEAR	-	-
7. Improvement of concession agreement	1. Improvement of concession agreement between GoM and CEAR	-	-
8. Strengthening of transport capacity	-	-	1. Reconstruction of V*ila Nova de Frontela–Dona Ana* (GoMZ) 2. Installation and signal and telecommunication system for *Vila Nova de Frontela–Dona Ana* (GoMZ)

Source: Study Team

- Construction of new bridge at the Chiromo washaway section: Regarding the development of the railway corridor to connect ocean ports based on the concept for developing the Sena Corridor, the construction of a new bridge is one of the key issues. The bridge should be constructed in the medium term after completing the rehabilitation between Limbe and Makhanga.
- Rehabilitation of Limbe–Makhanga section and Reconstruction of Makhanga–Border (Marka) section should be carried out for facilities such as tracks, substructures, and bridges that are the foundation for safe and reliable railway transportation. Because the railway infrastructure in Malawi is generally dilapidated, resulting in train speed restrictions and reduced transportation capacity caused by frequent derailment, railway transport cannot satisfy the freight demand. Rehabilitation/reconstruction should be executed in the medium and long term.
- Procurement of rolling stock to meet traffic demand: Many railways, not only in CEAR but also in CDN, have reduced transportation capacities due to insufficient trains in operation and cannot meet demand. To alleviate this problem, it is necessary to increase the rolling stock by procuring newly manufactured and reconditioned rolling stock. In addition, spare parts for maintaining broken-down rolling stock will need to be replenished. The procurement should be executed in the medium and long term.
- Installation of new signal and telecommunication system: It is necessary to improve the operation safety and management efficiency by planning to modernise and reintroduce the signalling system. In Malawi, the signalling system is an old type and is not maintained, so train operations are basically carried out without signalling. A reliable signalling communication system is essential for train safety. The installation should be executed in the medium and long term.
- Arrangement of bi-lateral agreement with GoMZ by transporting freight through Beira Port by railway: For the route to be competitive with other transport modes, investment in related areas (bulk transport, container transport, fuel transport, etc.) should be encouraged utilising the characteristics of the railway. To resume international freight transport to Beira Port, arrangements on a bilateral agreement with GoMZ should be started, and actual international freight train operation should be started in the long term.
- JICA training, institutional reform of the Railway Division of MoTPI and CEAR, and revision of the Railway Act: Among the major issues identified in the analyses of the present condition of the railway sub-sector, capacity development programmes for the railway sub-sector should be prepared based on engineering considerations and the investment situation. In addition, institutional arrangements for MoTPI and CEAR, and revision of the Railway Act are urgent matters. The capacity development should be started immediately.

- Improvement of concession agreement between GoM and CEAR: The current concession agreement involves problems including an inadequate legal system, insufficient agreement articles, evasion of responsibility by the government, insufficient investment funding, and non-payment of compensation. As the concessionaire cannot provide sufficient support, the discussion on the improvement of the concession agreement should be started immediately.
- Rehabilitation/reconstruction of Limbe–Border–*Dona Ana* section: To improve the efficiency of operation, freight transport should be made safe and reliable. This requires the rehabilitation of tracks including the installation of heavy rails, replacement of bridges and introduction of new signalling and telecommunication facilities. The rehabilitation/ reconstruction should be executed in the medium and long term except the emergency repair between Limbe and Makhanga, which should be executed in the short term.



Source: Study Team

Figure 6-15 Development Plans for the Railway Sub-sector

(4) Description of Railway Rehabilitation Projects for the Master Plan

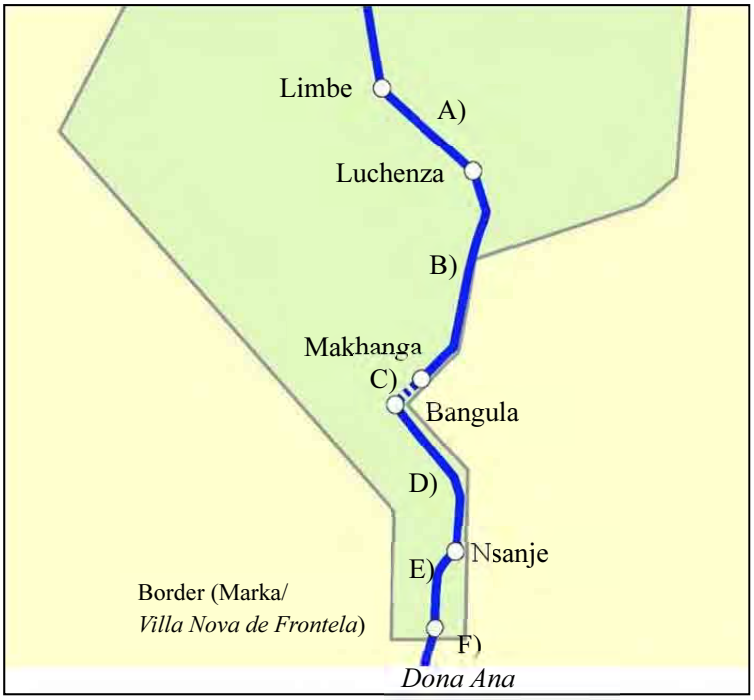
Descriptions of proposed railway rehabilitation projects for the Master Plan are shown in Table 6-25.

Table 6-25 Description of Railway Rehabilitation Projects for the Master Plan

Sec.	Project	Description
A	Rehabilitation of Limbe–Luchenza Section	Rehabilitation work for the 44.0km section has not been planned except emergency rehabilitation work. There are 16 bridges (span ≥ 5m) in this section. The key issue in this section is the dilapidated bridges. The vertical alignment is steepest along the whole line. All steel bridges and tracks should be replaced. The section will be rehabilitated by preparing parallel construction roads. Major findings of the survey are as follows: No major landslides on the embankment are found. The track condition is bad and it must be replaced. Wooden sleepers on the bridges are badly rotten and must be replaced urgently. One bridge has been repaired with trough girders, but the bearing capacity of the piers seems to be inadequate.
B	Rehabilitation of Luchenza–Makhanga Section	Rehabilitation work for the 76.6km section has not been planned except emergency rehabilitation work. There are 24 bridges (span ≥ 5m) in this section. The key issue in this section is the dilapidated bridges. The vertical alignment is relatively steep, but the section between Makanga and Sankhulani is flat. Half of the steel bridges and tracks should be replaced. The section will be rehabilitated by using the one-way construction method, because construction roads for rehabilitation works cannot be built. Major findings of the survey are as follows: The embankment has collapsed in parts. The track condition is fair to bad. Wooden sleepers on the bridges are badly rotten and must be replaced urgently. Some sections without drainage have flooded. There is an area susceptible to flooding between Sankhulani and Osiyani stations, of length 2.3 km from Km 86.7 to Km 89.0. This section must be improved by constructing embankments or elevated structures. Many bushes were found, which must be cut down properly.
C	Reconstruction of Makhanga–Bangula Section	Reconstruction work for the 8.7km section has not been planned. There are three bridges (span ≥ 5m) in this section. The key issue in this section is the disconnection by the washaway in 1997. There have been some minor collapses on the 3m high embankment. The alignment near the Chiromo washaway is very close to the New Shire River. When the new Chiromo Railway Bridge is constructed, it should be located further from the river. The section can be reconstructed by preparing parallel construction roads. Major findings of the survey are as follows: There are minor landslides on the embankment. The track condition is bad and it must be replaced. The length of the Chiromo washaway section is 380 m. It is not recommended to construct a railway bridge on the existing alignment. The toes of the embankments are encroached upon by the river at many sections. There are seven pipe culverts with insufficient cross-sectional area to handle inundation.
D	Reconstruction of Bangula–Nsanje Section	Reconstruction work for the 45.4 km section has not been planned. There are 30 bridges (span ≥ 5m) in this section. There are no major dilapidated structures. The vertical alignment is almost flat. Drainage is insufficient. The embankment shoulder has collapsed in parts. The section will be reconstructed by preparing parallel construction roads on the adjacent cultivated land. Major findings of the survey are as follows: The shoulder of the embankment has collapsed in parts, but the height is only about 2 m. The track condition is fair. There is no washaway part in this section, however, minor collapse of embankments was found at 19 locations. As almost all sections are installed parallel to M1, the reconstruction work would be easy.
E	Reconstruction of Nsanje–Border (Marka) Section	Reconstruction work for the 25.6km section has not been planned. There are 19 bridges (span ≥ 5m) in this section, and many bridges are trough girders. The key issue in this section is the 60 m-wide wadi at 4 km from the border. The vertical alignment is almost flat. The section will be reconstructed by preparing parallel construction roads. Major findings of the survey are as follows: The track is thickly covered with trees. The shoulder of the embankment has collapsed in parts, but the height is only about 2 m. The track condition is fair to bad. Eight washaway sections were found, the section with a 60 m-wide wadi must be reconstructed by reinforced concrete (RC) bridges or plate girders, and other sections by embankments and culverts.
F	Reconstruction of *Vila Nova de Frontela–Dona Ana* Section	Reconstruction work for the 44.0 km section has not been planned. The vertical alignment is almost flat. Some sections of track need rehabilitation due to deformation of the rails, etc. The section will be reconstructed by preparing parallel construction roads, but the rehabilitation cost will depend on whether bridges are reconstructed and other conditions. Major findings of the survey are as follows: There are not many embankment sections with minor collapse. The track condition is fair to bad.

Source: Study Team

Note: Additional information on the above cost estimations is found in Chapter 6.5.2 and Appendix-5. A comparison of costs by GOPA (Table 6-22) and the Study Team is also shown in Appendix-5.



Source: Study Team

Figure 6-16 Locations of Proposed Railway Projects

(3) Basic Transportation Plan

a) Freight and Passenger Transportation Improvement Plan

Based on the demand forecasts estimated from the transportation service conditions that were set for the future road network, the plan to improve freight transportation is premised on meeting customer needs and reducing transportation costs.

The transportation of bulk freight should be standardized and container transportation plans with clear arrival dates and times of freight should be established.

- Regarding general cargo, by shifting to container transportation as the main system and adopting door-to-door intermodal transportation, the plan should aim to reduce the transportation time and create a system with known arrival dates and times.
- Bulk freight transportation should be stabilized by using block trains.
- In combination with improving the transportation system, the arrangements and functions of the freight yards should be reviewed.
- For passenger transportation, local transportation in the regions with insufficient transport modes should be improved.

b) Train Operating System and Basic Conditions for Operation Planning

The train operation system will consist of the following.

1) Traction Power System

The traction power system includes electric locomotive, electric car, diesel locomotive, and diesel car systems. Electrification of the railway will improve the efficiency of the energy used, and changing the trains to high-speed operation will also be much easier than when using

internal combustion engines. However, in order to realize electrification, a large investment is required for the construction and maintenance of facilities, and there may be restrictions due to various conditions. Generally, sections with larger transportation volumes will receive greater benefit from electrification because the operating costs will fall. On the other hand, the demand for railway freight transportation in Malawi is not so large. A diesel locomotive system should be continued as in the existing system.

2) Block System

As shown in Table 6-26, block systems are broadly divided into systems in which a token is carried by the driver as a permit to secure the block and allow the train to pass through the block section, and token-less systems in which the tokens are omitted and a response is made to the block completion signal of the starting signal equipment, meaning that the driver does not have to carry anything.

In Malawi, a semi-automatic block system for single track is appropriate since it does not require the installation of track circuits between stations.

Table 6-26 Block System

Block System	Type
Token System	Staff Block System, Staff and Ticket Block System, Tablet Block System (Single Track)
Token-less System	Interlocking Block System, Controlled Manual Block System, Semi-automatic Block System (Single Track)
	Automatic Block System, Cab Signal Block System (Single Track, Double Track)

Source: Study Team

(4) Train Operation Plan

a) Freight Train

1) Future Freight Demand

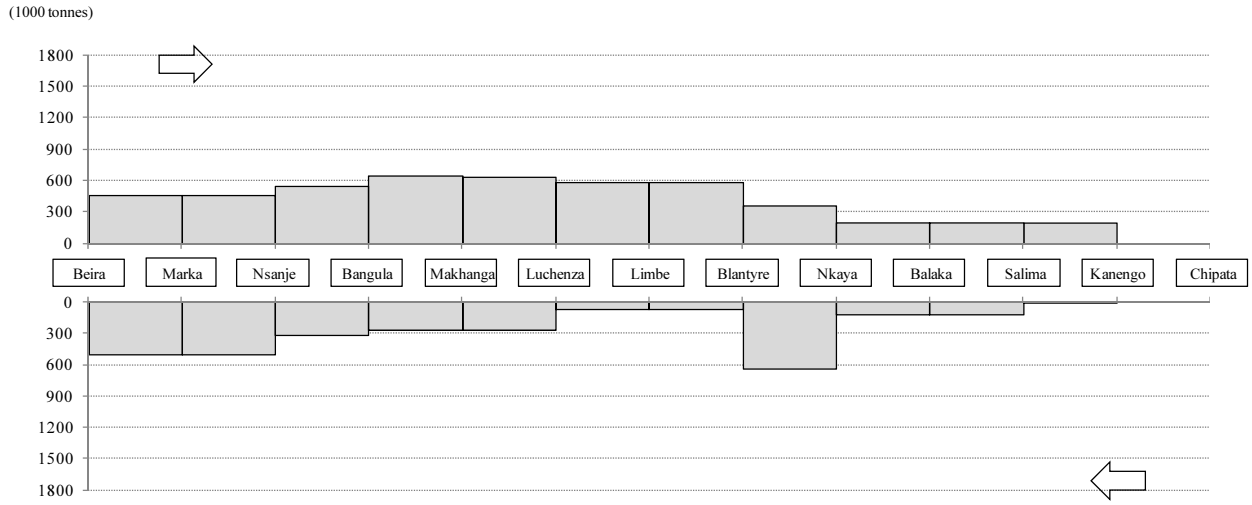
According to the demand forecasts, the freight traffic flow assuming that the Sena Corridor has been linked to Beira Port is as shown in Figure 6-17.

In 2030, the largest section on the Sena Corridor will be 643 thousand tonnes/direction/year between Makhanga and Luchenza, while the corresponding value on the Nacala Corridor will be 1,296 thousand tonnes/direction/year between Liwonde and Nayuchi excluding coal transported by Vale. Of this amount, 1,125 thousand tonnes will consist of the transportation of nickel and other ores, so the amount of exported freight will be only 171 thousand tonnes.

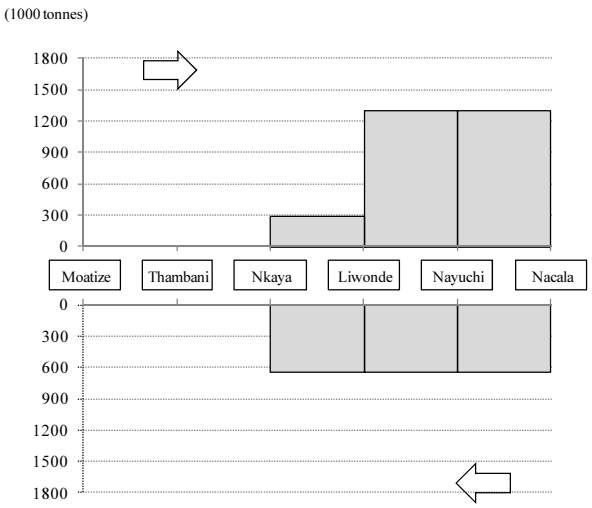
When planning train operations, it is necessary to calculate the running time between stations for each type of train. The following three calculation methods are available.

i) Using a train operations diagram based on vehicle performance, train weight, and line conditions.

Beira-Chipata (Year2030)



Moatize-Nakala (Year2030)



Source: Study Team

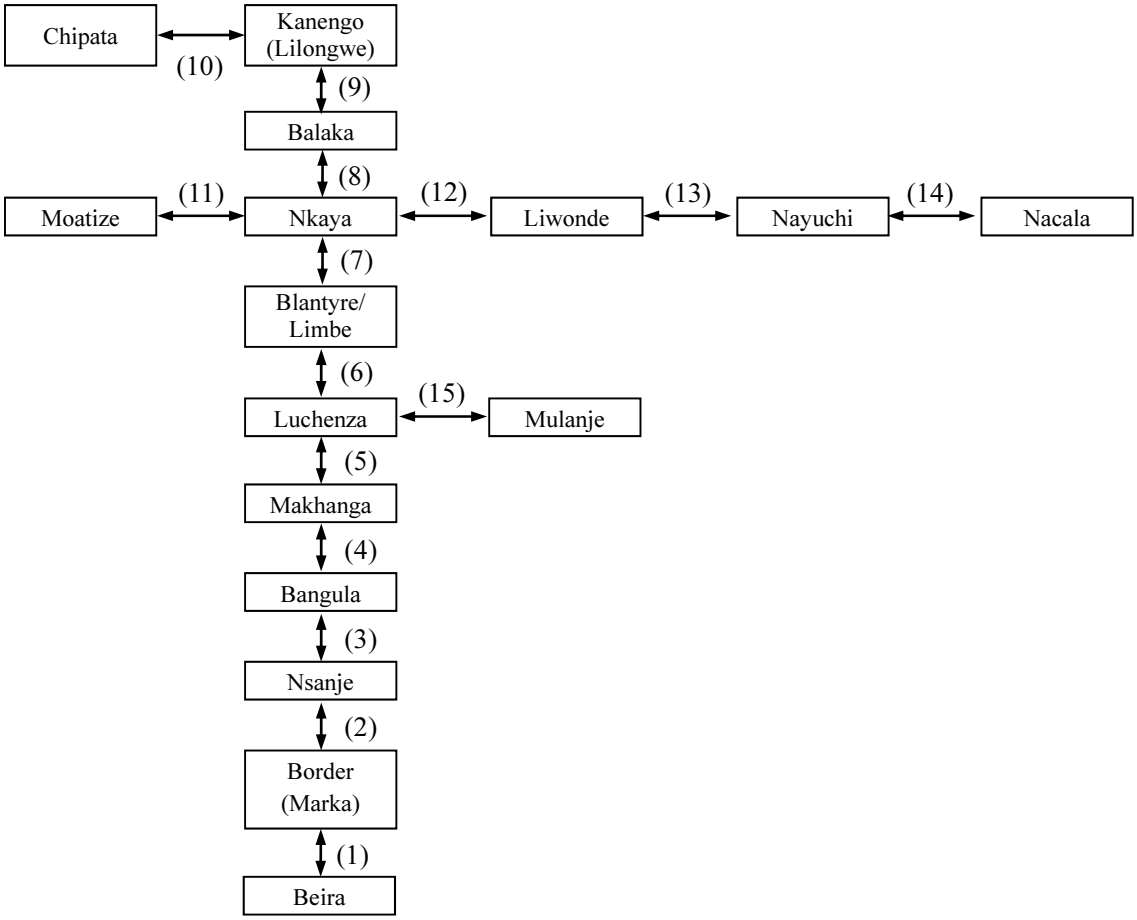
Figure 6-17 Freight Traffic Flow Diagram

ii) Using the average train speed.

iii) Using the current train timetable.

In the Study, method ii) was selected and the following conditions were set:

- The average speed for freight trains after the rehabilitation is assumed to be 40 km/h.
- At stations with freight yards, stop-over times of 2 hours are anticipated for train formation changing, locomotive exchange, and crew changeover. Border (Marka) and Nayuchi have such stations on the target railway line in the Study.



Source: Study Team

Figure 6-18 Operating Section

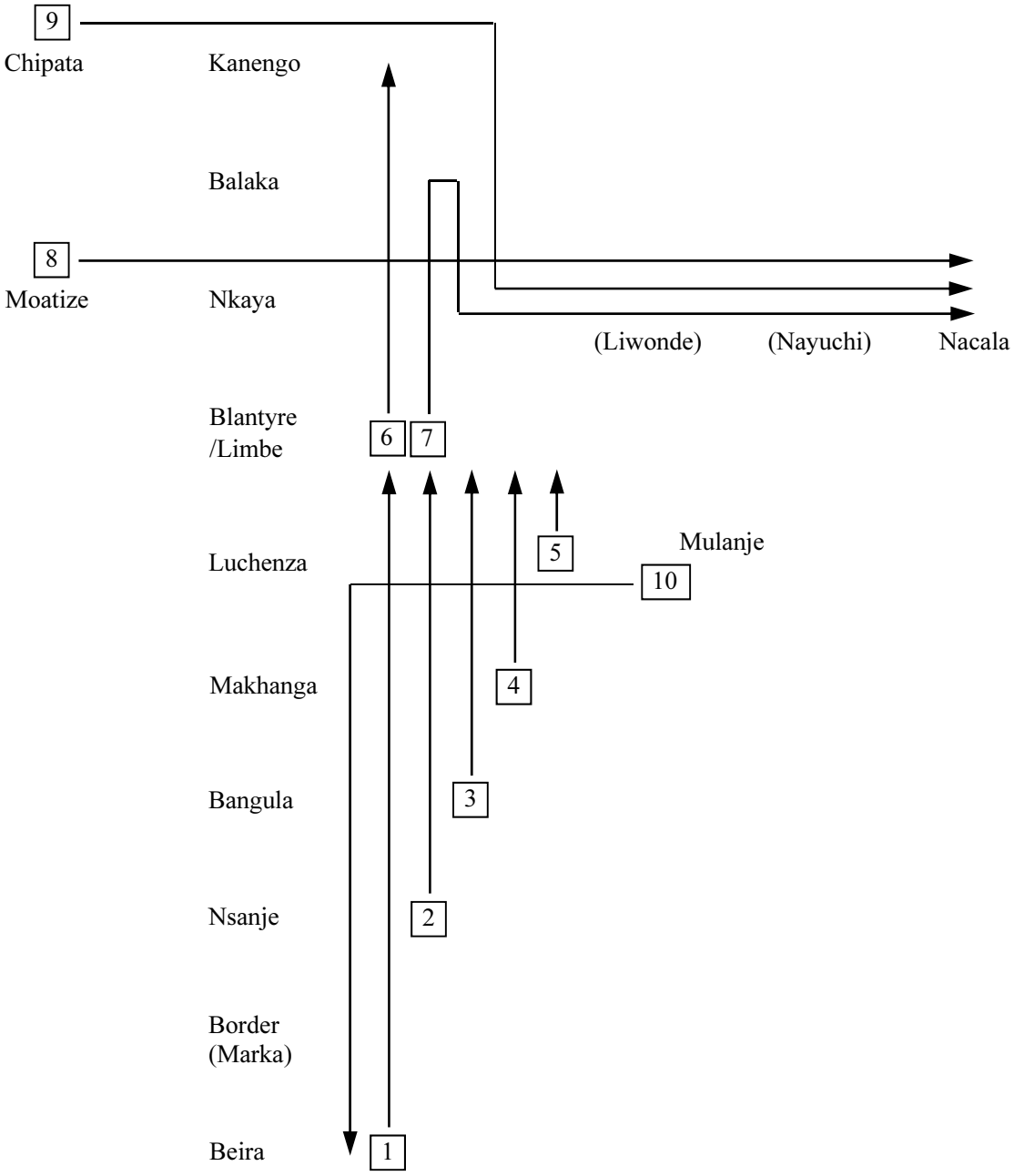
Table 6-27 Running Time by Section

No.	Section		Distance (km)	Running Time (hour)	Running Time (min.)	Remarks
(1)	Beira	Border (Marka)	373	9	20	Rounded up to 10 minute
(2)	Border (Marka)	Nsanje	25	0	40	Ditto
(3)	Nsanje	Bangula	46	1	10	Ditto
(4)	Bangula	Makhanga	8	0	20	Ditto
(5)	Makhanga	Luchenza	77	2	00	Ditto
(6)	Luchenza	Blantyre/Limbe	52	1	20	Ditto
(7)	Blantyre/Limbe	Nkaya	88	2	20	Ditto
(8)	Nkaya	Balaka	16	0	30	Ditto
(9)	Balaka	Kanengo (Lilongwe)	261	6	40	Ditto
(10)	Kanengo (Lilongwe)	Chipata	137	3	30	Ditto
(11)	Moatize	Nkaya	218	5	30	Ditto
(12)	Nkaya	Liwonde	26	0	40	Ditto
(13)	Liwonde	Nayuchi	73	1	50	Ditto
(14)	Nayuchi	Nacala	614	15	30	Ditto
(15)	Luchenza	Mulanje	30	0	50	Ditto
(Ma)	Border (Marka) Stop-over Time		-	2	00	
(Na)	Nayuchi Stop-over Time		-	2	00	

Source: Study Team

2) Operating Routes

The operating route based on the demand forecast are shown in Figure 6-19.



Source: Study Team

Note: The operating route between Mulanje and Beira shown in dashed line is optional.

Figure 6-19 Operating Routes

In this figure, the running times are calculated for each route by matching the section numbers along the routes. The results are shown in Table 6-28.

Table 6-28 Operating Routes and Running Times

No.	Operating Route		Operating Section No.	Running Time
1	Beira	Blantyre/Limbe	(1)+(Ma)+(2)+(3)+(4)+(5)+(6)	16:50
2	Nsanje	Blantyre/Limbe	(3)+(4)+(5)+(6)	04:50
3	Bangula	Blantyre/Limbe	(4)+(5)+(6)	03:40
4	Makhanga	Blantyre/Limbe	(5)+(6)	03:20
5	Luchenza	Blantyre/Limbe	(6)	01:20
6	Blantyre/Limbe	Kanengo	(7)+(8)+(9)	09:30
7	Blantyre/Limbe	Nacala	(7)+(8)+(8)'+(12)+(13)+(Na)+(14)	23:20
8	Moatize	Nacala	(11)+(12)+(13)+(Na)+(14)	25:30
9	Chipata	Nacala	(10)+(9)+(8)+(12)+(13)+(Na)+(14)	29:40
10	Mulanje	Beira	(15)+(5)+(4)+(3)+(2) +(Ma)+(1)	16:20

Source: Study Team

3) Train Formations and Number of Train Sets

Regarding the train formations, the CEAR's standard locomotives with an output of 1,500 hp and standard 60-tonnes (load: 40 tonnes, tare weight: 20 tonnes) freight wagons (including hopper wagons and tank cars) are assumed, and the train formations shown below are set assuming the maximum gradient of 2.27% on the target route railway divisions.

Locomotive + Max. 30 wagons (Net=1,100 tonnes, Gross=1,800 tonnes)

Locomotive + Locomotive + Max. 30 wagons (Net=1,100 tonnes, Gross=1,900 tonnes)

Conditions of the calculation:

Considering the effective lengths of sidings at each station, 2 locomotives + 30 freight wagons are taken as the maximum train formation. In the CEAR, one 1,500 hp. locomotive can haul a maximum of 1,100 tonnes for each 1 locomotive on a 1.0% gradient. In this calculation, only standard freight wagons are assumed, and the maximum allowable tonnage for each locomotive is set as 1,100 tonnes.

The required numbers of rolling stock for each route are calculated as follows:

- The annual transportation volume obtained in the demand forecast is divided by 300 days excluding Sundays and national holidays to calculate the average daily transportation volume.
- This average daily transportation volume is multiplied by 1.2 as a fluctuation rate to obtain the value of the daily transportation volume.
- The daily transportation volume is divided by 40 tonnes for general freight and fuel for each freight wagon to calculate the required total number of freight wagons and tank wagons for each day.
- Regarding each of the allocated train formations, the number of effective operating units required to run one train each day on the supported target routes is multiplied to obtain the number of rolling stock required.

Table 6-29 Allowable Tonnage at Each Section by One Diesel Locomotive

Section		Load (tonnes)	Wagons (No.)	Max. Gradient
From	To			
Vila Nova	Sankhulani	1,088	30	
Sankhulani	Limbe	450	16	2.27%
Limbe	Mudi	770	24	-2.27%
Mudi	Blantyre	905	24	-2.27%
Blantyre	Namatunu	770	24	-1.67%
Namatunu	Balaka	860	30	1.75%
Balaka	Salima	1,200	30	-1.58%
Salima	Kanengo	600	21	1.58%
Kanengo	Mchinji	870	23	1.49%
Nkaya	Nayuchi	1,088	30	0.91%
Nayuchi	Cuamba	1,100	30	
Cuamba	Nayuchi	1,100	30	
Nayuchi	Nkaya	1,180	30	-0.91%
Mchinji	Kanengo	870	30	-1.49%
Kanengo	Salima	600	21	-1.58%
Salima	Balaka	1,200	30	1.58%
Balaka	Namatunu	860	30	-1.75%
Namtunu	Blantyre	680	22	1.67%
Blantyre	Limbe	500	16	2.27%
Limbe	Sankhulani	770	19	-2.27%
Sankhulani	Vila Nova	1,088	30	

Source: CEAR

b) Passenger Trains

Passenger trains operate as long-distance intercity trains between Limbe–Bangula–Border (Marka), Limbe–Balaka–Bilila, and Balaka–Nkaya–Nayuchi. On the Limbe–Bangula–Border (Marka) route, the section between Bangula and Border (Marka) would be operated at reduced frequency.

1) Operating Routes

The passenger train operating routes are as follows:

- Limbe–Bangula–Border (Marka)
- Limbe–Balaka–Bilila
- Balaka–Nkaya–Nayuchi

2) Train Formation and Number of Trains

The train formation was set as six passenger coaches as a standard intercity train, which can carry approximately 1,200 persons.

Locomotive + 2 Freight Wagons + 6 Passenger Coaches + Brake-van

The average number of passengers in the last 10 years is 500,000 persons annually (both ways), which means that the average number of passengers in one direction each day is approximately 1,000 persons. Therefore, one of the above standard-formation trains will be operated both ways. In addition, the maximum speed of the passenger trains was assumed to be 70 km/h and the average speed between stations to be 50 km/h. Thus, the time taken between Limbe–Border (Marka) is approximately 6 hours, including station stopping time.

Considering the convenience of residents along the line in the Study Area, at least two

passenger trains should be operated weekly.

The number of required rolling stock in the Study Area is summarized in Table 6-30.

Table 6-30 Number of the Required Rolling Stock

Item / Section	Commodity Type	Freight Transport Volume (tonnes/day/direction)			Type of Rolling Stock	Number of Required Rolling Stock			Number of Rolling Stock to be Procured		
		2015	2020	2030		2015	2020	2030	2015	2020	2030
Freight Blantyre - Border (Marka)	General	499	686	1,682	DL	1	1	2	1	0	1
					Wagon	20	20	60	30	0	30
	Fuel	234	297	1,093	DL	0	0	1	0	0	1
					Wagon	10	10	30	0	0	30
	Ore	0	860	1,720	DL	0	1	2	0	1	1
					Wagon	0	30	60	0	30	30
Passenger Limbe - Nsanje		-	-	-	DL	1	1	1	0	1	0
					Coach	6	6	6	0	6	0
Total		733	1,843	4,495	DL	2	3	6	1	2	3
					Wagon	30	60	150	30	30	90
					Coach	6	6	6	0	6	0

Source: Study Team

c) Improvement Plan for Rolling Stock, Workshop and Depot

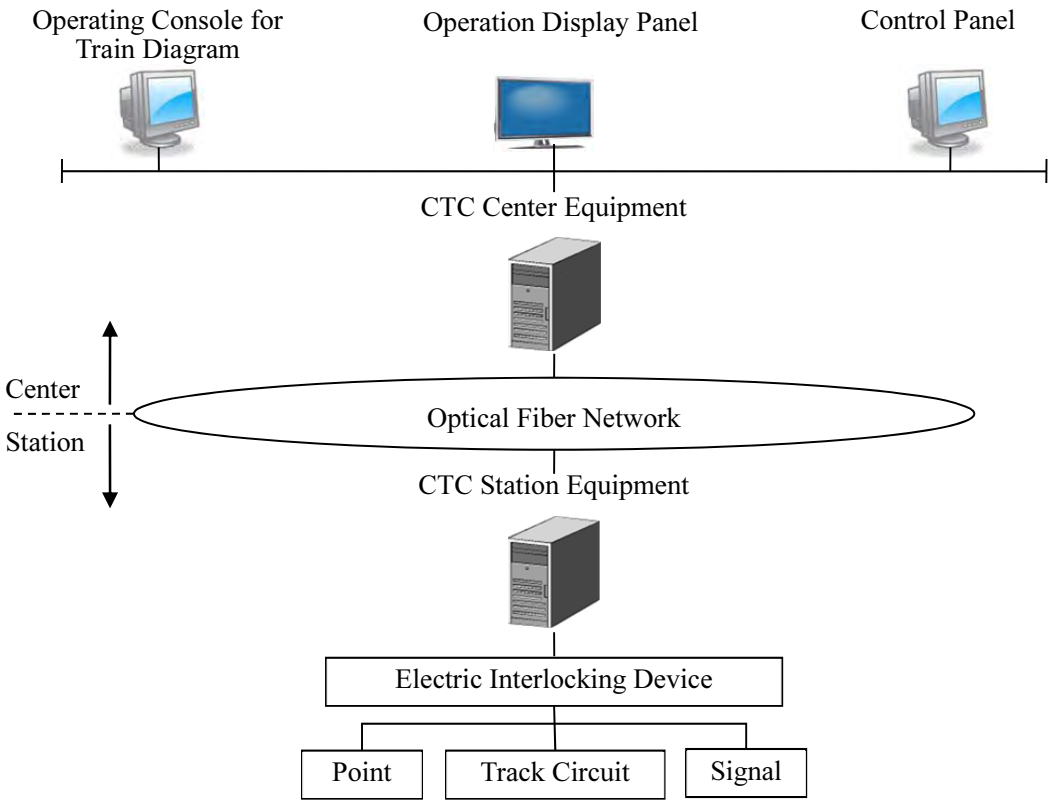
The CEAR and CDN are unable to meet the demand due insufficient operational rolling stock: this shortfall must be eliminated urgently. In addition to procuring newly manufactured and reconditioned rolling stock and replenishing the maintenance and repair parts, a priority issue is to improve the rolling stock operating rate by enhancing the ability to maintain the rolling stock.

Although the CEAR has a workshop at Limbe that is capable of carrying out locomotive, freight wagon, and passenger coach overhauls for inspecting and repairing the rolling stock, the workshop is not modern. The workshop needs to be modernised so that it can efficiently inspect and repair rolling stock. The issues affecting the workshop include: i) replenishment of maintenance and spare parts, ii) workshop modernization for inspection and repair of rolling stock, and iii) education and training to improve the skills for maintaining rolling stock.

In addition, locomotive depots and freight wagon repair shops to cope with the rolling stock required for coal transportation by Vale should be prepared at Limbe and Liwonde.

(5) Train protection systems

Regarding signalling and telecommunication train protection systems to be adopted on the target routes, in principle consideration was given to preventing confusion during operations, facilitating maintenance, and making connections to both end stations of existing routes, as it is preferable to create similar systems to those used on existing routes at present. A schematic diagram of the proposed signalling and telecommunication systems is shown in Figure 6-20.



Source: Study Team

Figure 6-20 Schematic Diagrams of the Proposed Signalling and Telecommunication Systems

a) Signalling System

The signalling system should be installed to ensure precise, efficient for the train operations. This system should include the equipment and facilities described below appropriate for railway signalling and train operations for long-distance freight transportation.

In Japan, various signal systems have been developed and operated on high-speed railway lines, urban railway lines and local railway lines, and Japanese signalling and telecommunication technology is used worldwide. Malawi has very few trains in operation and they are operated without signalling. However, the signalling and telecommunication system is absolutely essential when the number of trains is increased. The system called COMBAT (Block system with Balise type train detector) developed by the Railway Technical Research Institute in Japan is the solution. This is a low-cost block system mainly for single-track lines with light traffic and is suitable for the railway in Malawi.

b) Telecommunication system

1) Features of Railway Telecommunication Networks

With the exception of major city traffic networks, the operating units of railway telecommunication networks are generally laid out linearly along the railway route. Each of the units generally consists of a small normal station, junction stations where operations are highly concentrated and major stations that serve as a headquarters.

In line with these characteristics, the railway telecommunication network will stretch

alongside the railway line, and will be a combination of voice cables, multiple carriers, wireless systems, and other transmission methods. These should be suitable for linking the major stations by transmission, voice, data switching devices, or data processing.

Railway telecommunication system must be able to handle situations such as running trains, allocations of railway rolling stock, and freight movements. Accordingly, compared to the public telecommunication equipment of telecommunication companies in Malawi, advanced real-time precise telecommunication are required. Therefore, dedicated transmission lines (direct lines without exchange) will be installed to cover most areas along the railway line. In addition, mobile telecommunication between the wayside and trains will require a separate request item. The system should include a maintenance-free self-rectification function with GPS receiver.

(6) Operation and Maintenance Plan

a) Basic Policy on the Operation and Maintenance Plan

Revising the operation and management plan for the existing railway is a rather complex exercise, requiring time and support information on the fixed profile of the network, ownership, financial control, etc. However, to effectively manage and maintain the facilities and rolling stock based on the improvement plan and to rationalize the number of staff and the management system, an operation and maintenance plan should be established. This should aim for efficient operation management and safe transportation since the railway serves an important social role. In addition, a plan for training employees, as well as management and maintenance of facilities and rolling stock, should be established.

b) Organizations

Organization should be established to suit the scale of the railway, transportation situation and current state of Malawi. The job specifications and chain of command should be defined for each organization, and train operations should be efficiently managed.

Organization is often divided into indirect departments which deal with administrative work such as general affairs and accounting, and direct departments which are responsible for operation of stations, train operation and maintenance of facilities and rolling stock. The details of each department are shown in Table 6-31.

Table 6-31 Responsibilities of Each Department

Department	Responsibility
Civil Engineering Department	Management of track, structures and buildings
Electrical and Mechanical Engineering Department	Management of rolling stock (wagons, locomotives, plant and machinery)
Operation and Commercial Department	Management of day-to-day operational activities (train and station operation) and business functions
Marketing Department	Business development activities and client relationships
Finance Department	Maintaining accounts and regulatory requirements

Source: Study Team

From the viewpoint of the chain of command and the location of each organization, a central organization and local organizations are established.

It is proposed that the central organization of the railway be located in Limbe. Taking into consideration the location of load/traffic generating centres, it is proposed that three local organizations may be established on the network to monitor operations as well as provide technical support for maintenance of facilities and rolling stock. The proposed locations are:

- Kanengo (Lilongwe)
- Liwonde
- Nsanje

Blantyre/Limbe is an important centre of trade for domestic and export-import traffic, particularly in containers. In addition, six freight terminals at Nsanje, Bangula, Luchenza, Balaka, Liwonde and Kanengo should be rehabilitated. A regional office at Liwonde is an obvious choice as in addition to being a junction station for both the freight of Malawi and Vale, it will have workshop facilities for rolling stock. As important traffic-generating locations, it was found necessary to locate regional offices at Nsanje, Liwonde and Lilongwe (Kanengo): these offices will oversee operations. Services other than these offices should be outsourced.

c) Management of Freight Terminals

The Study Team suggests setting up seven inland container depots at Nsanje, Bangula, Luchenza, Blantyre/Limbe, Balaka, Liwonde and Kanengo for handling container traffic. These depots may be run by private agencies that may develop and equip the terminals. Similarly, freight terminals for handling bulk traffic can be given to private agencies with minimum traffic guarantees.

Similarly, the management of maintenance facilities (workshop) for rolling stock may also be outsourced. However, certain minimum performance standard must be prescribed. Regarding the rail yards that serve gateway ports, these may either be developed by port authorities themselves or jointly developed by port and railway authorities on a cost-sharing basis.

d) Working Capital for Operation and Maintenance

Regarding the working capital for operation and maintenance, funding will be arranged through the following methods:

i) Market borrowing

ii) Borrowing from bi-lateral or multi-lateral agencies, such as the AfDB, OPEC, WB (IBRD) and other international agencies

iii) PPP under which the GoM forms a joint venture company with the participation of private-sector agencies, particularly actual users of the railway

6.6 Evaluation of Proposed Projects for the Master Plan

6.6.1 Alternative Transport Networks for Evaluation

Based on the overview for the development of the Sena Corridor and assumptions of external factors for the Master Plan as well as the improvement viewpoints mentioned above, alternative transport networks for evaluation, including traffic assignment and the essential factors of the network, are proposed as shown in Table 6-32, and Figure 6-21 shows alternative transport networks for the evaluation.

- Alternative 1 is defined as a full transport network
- Alternative 2 is defined as a full transport network with the disconnection at Chiromo on S151.
- Alternative 3 is defined as a transport network formed by road connecting to Beira Port and railway connecting to Nsanje Port.

Table 6-32 Alternative Transport Networks for the Evaluation

Alternative	Transport Network	
	Road	Railway
Alt. 1	Connecting to Beira Port	Connecting to Beira Port
Alt. 2	Disconnecting S151 at Chiromo washway	Connecting to Beira Port
Alt. 3	Connecting to Beira Port	Connecting to Nsanje Port

Source: Study Team

6.6.2 Evaluation Items

(1) Economic Evaluation

The major evaluation item in the Study is the economics of alternative networks (**Economic Internal Rate of Return (EIRR)**). Details of the economic evaluation are described in Section 6.5.3. Benefits include VOC savings and TTC savings.

(2) Environmental Impact

The **Strategic Environmental Assessment (SEA)** is implemented at the policy, planning, and programme levels and uses a range of "analytical and participatory approaches that aim to integrate environmental considerations into policies, plans and programmes and evaluate the inter-linkages with economic and social considerations" (Organization for Economic Co-operation and Development (OECD), Applying Strategic Environmental Assessment, 2006). The SEA includes three assessed impacts: environmental impact, social impact and local economic impact.

Another item in this field is a **CO_2 emission reduction effect** in the light of global environmental protection. The period for estimating CO_2 emissions from vehicles including passenger cars, buses and trucks, and railways is from 2020 to 2044 (project evaluation period).

(3) Transport Viewpoints

Fuel, which accounts for about 10% of imports by value, is a significant contributor to Malawi's import surplus. When the Sena Corridor is developed and fuel consumption is reduced,

the Corridor will greatly contribute to the national economy. Thus, **foreign currency saving** is included as an evaluation item, in association with diesel saving, to focus on cargo transportation which is expected to achieve considerable fuel savings.

Alternative 1

Alternative 2

Alternative 3

Source: Study Team

Figure 6-21 Alternative Transport Networks

The reduction in gross freight transport time[9] contributes to improving **transport reliability** through securing punctuality and quick delivery owing to shorter transport times, and is also expected to have knock-on effects on Malawi's economic development by improving the corporate profits of logistics companies such as shipping firms and transporters.

6.6.3 Evaluation of Alternative Transport Networks

(1) Economic Evaluation

a) Objective and Evaluation Indexes of Economic Analysis

The economic analysis, which is one of the items for evaluating proposed projects for the Master Plan, analyses and evaluates the viability of implementing the project from the viewpoint of the national economy. A comparative analysis of the costs and benefits both in the case of executing the project ("With project") and not executing the project ("Without project") is carried out. EIRR, Benefit and Cost Ratio (B/C Ratio) and Economic Net Present Value (ENPV) are used as the evaluation indexes.

b) Premises

In this study, the economic analysis is based on the following premises:

- The Social Discount Rate (SDR) is 12.0%[10].
- Economic prices exclude transferable items such as various taxes, import duties and subsidies from the market prices. All figures are based on constant prices in 2011.
- The exchange rate is assumed to be US$1.00 = MWK150.80 = JPY82.45 as of 1st June 2011. All costs are given in US$.
- The inflation rate is not considered in the analysis.
- The period of the analysis is set at 33 years including the construction (investment) period from 2012, and 30 years of operation from 2015 to 2044.
- The residual value in the last year (2044) of the analysis is counted as a negative investment cost, and is calculated based on the life cycle of facilities.

c) Cases of the Analysis

In the analysis, costs and benefits are defined as the difference between the cases of "With project" and "Without project". The projects are determined in this Chapter and are summarized as follows.

- There are three "With project" cases (Alternative 1 to Alternative 3) according to combinations of road and railway programmes.
- The "Without project" case is Zero Option[11]. This case consists of existing (ongoing, committed and planned) programmes, and does not include the programmes proposed by the Study Team.

[9] Freight time values are very lower than passenger time values, so that fright time values hardly contribute to economic benefits.
[10] Social Discount Rate (SDR) is applied as the opportunity cost of capital in economic analyses. Depending on the growth rate of the country, the rate varies from 9% to 12% in developing countries. In Malawi, an SDR of 12% is widely applied in the analysis of infrastructure projects conducted by international agencies.
[11] Future transport networks to be considered for the Zero Option: (1) Only inland waterway accessible to Beira Port other than Tete road, (2) Road and railway access to Nacala Port, (3) on-going /committed road projects are completed.

d) Project Costs

Project costs consist of investment costs and operation and maintenance (O&M) costs. All costs are shown in economic price.

1) Investment Costs

The investment costs of Alt. 1 to Alt. 3 are summarized in Table 6-33. Furthermore, a contingency of 8.0% is added to the total investment cost.

Table 6-33 Investment Costs of the "With Project" Cases (in Economic Price)

(Unit: US$ million)

Alternative	Project		Short Term (2015)	Medium Term (2020)	Long Term (2030)	Total
Alt. 1	Road	Reconstruction of S151: Makhanga–Bangula	28.16	15.65		390.43
		Upgrading of M1: Climbing lane for steep section		2.00		
		Upgrading of S152: Thabwa–Seven		80.13		
		Upgrading of D379: New access road to Mozambique			13.74	
	Railway	Reconstruction of Makhanga- Bangula		20.39		
		Rehabilitation of Limbe–Luchenza		30.20		
		Rehabilitation of Luchenza–Makhanga		53.20		
		Reconstruction of Bangula–Nsanje			29.50	
		Reconstruction of Nsanje–Border (Marka)			18.60	
		Provisional roads		1.85		
		Signalling and telecommunication system		15.68	8.61	
		DL		15.00	15.00	
		Wagon		5.40	8.10	
		Passenger coach		0.30		
Alt. 2	Road	Upgrading of M1: Climbing lane for steep section		2.00		343.12
		Upgrading of S152: Thabwa–Seven		80.13		
		Upgrading of D379: New access road to Mozambique			13.74	
	Railway	Reconstruction of Makhanga–Bangula		20.39		
		Rehabilitation of Limbe–Luchenza		30.20		
		Rehabilitation of Luchenza–Makhanga		53.20		
		Reconstruction of Bangula–Nsanje			29.50	
		Reconstruction of Nsanje–Border (Marka)			18.60	
		Provisional roads		1.85		
		Signalling and telecommunication system		15.68	8.61	
		DL		15.00	15.00	
		Wagon		5.40	8.10	
		Passenger coach		0.30		
Alt. 3	Road	Reconstruction of S151: Makhanga–Bangula	28.16	15.65		342.04
		Upgrading of M1: Climbing lane for steep section		2.00		
		Upgrading of S152: Thabwa–Seven		80.13		
		Upgrading of D379: New access road to Mozambique			13.74	
	Railway	Reconstruction of Makhanga–Bangula		20.39		
		Rehabilitation of Limbe–Luchenza		30.20		
		Rehabilitation of Luchenza–Makhanga		53.20		
		Reconstruction of Bangula–Nsanje			29.50	
		Provisional roads		1.85		
		Signalling and telecommunication system		15.68	5.51	
		DL		15.00		
		Wagon		5.40		
		Passenger coach		0.30		

Source: Study Team

2) Operation and Maintenance (O&M) Costs

In this analysis, when the difference in tonne-km between “With project” and “Without

project" becomes positive, those project costs are calculated as O&M costs. Annual O&M costs for railways are estimated from the differences in freight tonne-km and unit cost of O&M. From CEAR's financial statements, the unit cost of O&M is calculated at US$0.03/tonne-km as a variable cost. The annual fixed cost is estimated from the length of the rehabilitated railway section at a unit cost of US$4,200/km. Furthermore, the cost of maintaining the railway bridge once every 10 years after completion is added. Annual routine maintenance cost and periodic maintenance cost are also included as costs for road projects.

e) Project Benefits

The quantified benefits of Vehicle Operating Cost (VOC) savings and Transport Time Cost (TTC) savings are estimated in the analysis. The benefits and measures are summarized in Table 6-34.

Table 6-34 Project Benefits

Benefit		Measure
VOC saving	Freight by road	("With project" - "Without project" (tonne-km)) x (unit VOC of road)
	Freight by railway	("With project" - "Without project" (tonne-km)) x (unit VOC of railway)
	Passenger transport by car and bus	("With project" - "Without project" (vehicle-km)) x (unit VOC of car and bus)
TTC saving	Freight by road	("With project" - "Without project" (tonne-hour)) x (unit time value)
	Freight by railway	("With project" - "Without project" (tonne-hour)) x (unit time value)
	Passenger transport by car and bus	("With project" - "Without project" (passenger-hour)) x (unit time value)

Source: Study Team

1) VOC Savings

The VOC savings are calculated by taking the difference in tonne-km between "With project" and "Without project". The unit VOC for roads was estimated to be US$0.10/tonne-km from the average freight transport cost. The unit VOC for railways was estimated to be US$0.07/tonne-km from CEAR's financial statements. The unit VOCs for cars and buses are US$0.26/km and US$0.43/km, respectively.

2) TTC Savings

To calculate the TTC savings for road and railway, the unit time value of freight was estimated to be US$0.03/tonne-km from the average freight value and hourly lending rate. The unit time value of passengers is US$0.09/hour.

f) Results of Economic Evaluation

The results of the economic evaluation based on the above conditions are summarized in Table 6-35. Details of the economic evaluation are shown in Tables 6-36 to 6-38.

Table 6-35 Results of Economic Evaluation

(Social discount rate = 12.0%)

Alternative	Total Investment Cost (US$ million)	Economic Internal Rate of Return (EIRR)	Benefit and Cost Ratio (B/C Ratio)	Economic Net Present Value (ENPV) (US$ million)
Alt. 1	390.43	17.1%	1.44	82.57
Alt. 2	343.12	13.3%	1.11	17.45
Alt. 3	342.04	16.5%	1.36	65.96

Source: Study Team

Table 6-36 Results of Economic Analysis for Alt. 1

(Unit: US$ million)

Seq. No.	Year	Project Costs			Project Benefits					Net Economic Benefits
		Investment	O&M	Total	VOC		TTC		Total	
					Freight	Passenger	Freight	Passenger		
-3	2012	4.41	0.00	4.41	0.00	0.00	0.00	0.00	0.00	-4.41
-2	2013	13.00	0.00	13.00	0.00	0.00	0.00	0.00	0.00	-13.00
-1	2014	13.00	0.00	13.00	0.00	0.00	0.00	0.00	0.00	-13.00
1	2015	19.69	2.63	22.31	14.05	5.60	0.10	0.44	20.18	-2.13
2	2016	23.07	2.96	26.03	16.16	4.67	0.11	0.46	21.41	-4.62
3	2017	40.70	3.30	44.00	18.27	3.74	0.13	0.49	22.63	-21.37
4	2018	89.06	3.62	92.68	20.38	2.80	0.14	0.52	23.85	-68.83
5	2019	86.47	3.97	90.43	22.49	1.87	0.16	0.55	25.07	-65.37
6	2020	0.00	4.68	4.68	24.60	0.94	0.17	0.58	26.29	21.61
7	2021	37.81	4.22	42.03	27.38	3.74	0.19	0.77	32.08	-9.95
8	2022	10.04	3.79	13.84	30.17	6.55	0.21	0.95	37.87	24.03
9	2023	13.40	3.31	16.71	32.95	9.35	0.22	1.14	43.66	26.95
10	2024	24.95	2.98	27.93	35.74	12.16	0.24	1.32	49.45	21.53
11	2025	0.00	2.80	2.80	38.52	14.96	0.26	1.51	55.25	52.45
12	2026	0.00	2.17	2.17	41.31	17.76	0.28	1.69	61.04	58.87
13	2027	0.00	1.65	1.65	44.09	20.57	0.29	1.88	66.83	65.18
14	2028	0.00	1.32	1.32	46.88	23.37	0.32	2.06	72.63	71.31
15	2029	14.83	2.60	17.43	49.66	26.18	0.35	2.25	78.43	61.00
16	2030	0.00	1.54	1.54	53.97	28.98	0.38	2.43	85.77	84.22
17	2031	0.00	1.73	1.73	57.09	31.34	0.40	2.58	91.41	89.68
18	2032	0.00	2.00	2.00	60.30	33.82	0.42	2.74	97.28	95.28
19	2033	0.00	2.38	2.38	63.61	36.43	0.44	2.91	103.39	101.01
20	2034	0.00	2.80	2.80	67.03	39.18	0.47	3.08	109.75	106.95
21	2035	0.00	5.36	5.36	70.55	42.06	0.49	3.26	116.37	111.01
22	2036	0.00	3.76	3.76	74.19	45.10	0.51	3.45	123.25	119.49
23	2037	0.00	4.51	4.51	77.93	48.29	0.54	3.65	130.41	125.90
24	2038	0.00	4.83	4.83	81.80	51.63	0.56	3.86	137.85	133.02
25	2039	0.00	6.99	6.99	85.78	55.15	0.59	4.08	145.60	138.61
26	2040	0.00	5.97	5.97	89.89	58.84	0.62	4.31	153.66	147.69
27	2041	0.00	6.59	6.59	94.12	62.72	0.65	4.55	162.03	155.44
28	2042	0.00	7.24	7.24	98.49	66.79	0.68	4.80	170.75	163.51
29	2043	0.00	8.09	8.09	102.99	71.05	0.71	5.06	179.81	171.72
30	2044	-130.90	8.70	-122.20	107.63	75.53	0.74	5.34	189.23	311.43

Source: Study Team

EIRR= 17.1%
B/C Ratio= 1.44
ENPV= US$ 82.57 million
(SDR= 12.0%)

Table 6-37 Results of Economic Analysis for Alt. 2

(Unit: US$ million)

Seq. No.	Year	Project Costs			Project Benefits					Net Economic Benefits
		Investment	O&M	Total	VOC		TTC		Total	
					Freight	Passenger	Freight	Passenger		
-3	2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-2	2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-1	2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2015	16.31	0.00	16.31	0.00	0.00	0.00	0.00	0.00	-16.31
2	2016	16.31	0.00	16.31	0.00	0.00	0.00	0.00	0.00	-16.31
3	2017	33.94	0.00	33.95	0.00	0.00	0.00	0.00	0.00	-33.95
4	2018	89.06	0.02	89.08	0.00	0.00	0.00	0.00	0.00	-89.08
5	2019	86.47	0.00	86.47	0.00	0.00	0.00	0.00	0.00	-86.47
6	2020	0.00	8.91	8.91	31.89	0.39	0.22	0.08	32.58	23.67
7	2021	37.81	7.94	45.74	34.36	0.64	0.24	0.18	35.42	-10.33
8	2022	10.04	6.98	17.02	36.82	0.89	0.25	0.28	38.25	21.23
9	2023	13.40	5.91	19.30	39.29	1.14	0.27	0.38	41.09	21.78
10	2024	24.95	5.01	29.96	41.76	1.39	0.29	0.48	43.92	13.96
11	2025	0.00	4.27	4.27	44.23	1.64	0.30	0.58	46.76	42.48
12	2026	0.00	3.08	3.08	46.70	1.90	0.32	0.68	49.59	46.52
13	2027	0.00	2.01	2.01	49.16	2.15	0.33	0.78	52.43	50.42
14	2028	0.00	1.11	1.11	51.63	2.40	0.36	0.88	55.27	54.16
15	2029	14.83	1.84	16.67	54.10	2.65	0.39	0.99	58.12	41.45
16	2030	0.00	0.86	0.86	58.56	2.90	0.43	1.09	62.97	62.11
17	2031	0.00	1.87	1.87	61.88	3.11	0.45	1.17	66.61	64.74
18	2032	0.00	2.64	2.64	65.32	3.33	0.47	1.26	70.37	67.74
19	2033	0.00	3.61	3.61	68.87	3.56	0.50	1.35	74.27	70.66
20	2034	0.00	4.65	4.65	72.53	3.80	0.52	1.45	78.31	73.66
21	2035	0.00	7.80	7.80	76.32	4.05	0.55	1.56	82.48	74.68
22	2036	0.00	6.85	6.85	80.24	4.32	0.57	1.67	86.80	79.94
23	2037	0.00	8.29	8.29	84.28	4.60	0.60	1.78	91.26	82.97
24	2038	0.00	9.33	9.33	88.46	4.89	0.63	1.90	95.88	86.56
25	2039	0.00	12.26	12.26	92.77	5.20	0.66	2.03	100.66	88.41
26	2040	0.00	12.04	12.04	97.23	5.52	0.69	2.17	105.61	93.57
27	2041	0.00	13.50	13.50	101.83	5.86	0.72	2.31	110.73	97.22
28	2042	0.00	15.06	15.06	106.59	6.22	0.76	2.46	116.02	100.96
29	2043	0.00	16.82	16.82	111.50	6.59	0.79	2.61	121.49	104.67
30	2044	-99.39	18.36	-81.03	116.57	6.98	0.82	2.77	127.15	208.18

Source: Study Team

EIRR= 13.3%
B/C Ratio= 1.11
ENPV= US$ 17.45 million
(SDR= 12.0%)

Table 6-38 Results of Economic Analysis for Alt. 3

(Unit: US$ million)

Seq. No.	Year	Project Costs			Project Benefits					Net Economic Benefits
		Investment	O&M	Total	VOC		TTC		Total	
					Freight	Passenger	Freight	Passenger		
-3	2012	4.41	0.00	4.41	0.00	0.00	0.00	0.00	0.00	-4.41
-2	2013	13.00	0.00	13.00	0.00	0.00	0.00	0.00	0.00	-13.00
-1	2014	13.00	0.00	13.00	0.00	0.00	0.00	0.00	0.00	-13.00
1	2015	19.69	2.63	22.31	14.05	5.60	0.10	0.44	20.18	-2.13
2	2016	23.07	2.96	26.03	16.16	4.67	0.11	0.46	21.41	-4.62
3	2017	40.70	3.30	44.00	18.27	3.74	0.13	0.49	22.63	-21.37
4	2018	89.06	3.62	92.68	20.38	2.80	0.14	0.52	23.85	-68.83
5	2019	86.47	3.97	90.43	22.49	1.87	0.16	0.55	25.07	-65.37
6	2020	0.00	4.68	4.68	24.60	0.94	0.17	0.58	26.29	21.61
7	2021	37.81	4.87	42.67	26.86	3.74	0.19	0.77	31.55	-11.12
8	2022	0.00	5.08	5.08	29.12	6.55	0.20	0.95	36.82	31.74
9	2023	0.00	5.24	5.24	31.38	9.35	0.22	1.14	42.09	36.85
10	2024	0.00	5.55	5.55	33.64	12.16	0.24	1.32	47.35	41.81
11	2025	0.00	6.01	6.01	35.90	14.96	0.25	1.51	52.62	46.61
12	2026	0.00	6.02	6.02	38.16	17.76	0.27	1.69	57.88	51.86
13	2027	0.00	6.14	6.14	40.42	20.57	0.28	1.88	63.15	57.01
14	2028	0.00	6.45	6.45	42.68	23.37	0.30	2.06	68.42	61.96
15	2029	14.83	8.38	23.21	44.94	26.18	0.31	2.25	73.68	50.47
16	2030	0.00	7.25	7.25	47.20	28.98	0.33	2.43	78.95	71.70
17	2031	0.00	7.20	7.20	48.62	31.34	0.34	2.58	82.88	75.68
18	2032	0.00	7.23	7.23	50.07	33.82	0.35	2.74	86.98	79.75
19	2033	0.00	7.34	7.34	51.55	36.43	0.36	2.91	91.25	83.91
20	2034	0.00	7.47	7.47	53.06	39.18	0.37	3.08	95.69	88.21
21	2035	0.00	9.72	9.72	54.61	42.06	0.38	3.26	100.31	90.59
22	2036	0.00	7.80	7.80	56.19	45.10	0.39	3.45	105.13	97.33
23	2037	0.00	8.19	8.19	57.80	48.29	0.41	3.65	110.14	101.95
24	2038	0.00	8.14	8.14	59.45	51.63	0.42	3.86	115.36	107.22
25	2039	0.00	9.90	9.90	61.14	55.15	0.43	4.08	120.80	110.89
26	2040	0.00	8.45	8.45	62.86	58.84	0.44	4.31	126.45	118.00
27	2041	0.00	8.63	8.63	64.62	62.72	0.46	4.55	132.34	123.71
28	2042	0.00	8.79	8.79	66.41	66.79	0.47	4.80	138.46	129.68
29	2043	0.00	9.14	9.14	68.25	71.05	0.48	5.06	144.84	135.71
30	2044	-103.79	9.20	-94.59	70.12	75.53	0.50	5.34	151.48	246.07

Source: Study Team

EIRR= 16.5%
B/C Ratio= 1.36
ENPV= US$ 65.96 million
(SDR= 12.0%)

g) Sensitivity Analysis

The project costs and benefits applied in the analysis include certain variations. Some margin is assumed for these factors and by identifying the variation in results due to the margin, the stability of project feasibility can be obtained. Table 6-39 shows the results of the sensitivity analysis.

Table 6-39 Results of Sensitivity Analysis

Alternative	Base Case	+10% increase in project costs	-10% decrease in project benefits	+10% increase in project costs, and -10% decrease in project benefits	+15% increase in project costs, and -15% decrease in project benefits
Alt. 1	17.1%	16.9%	15.4%	15.3%	14.4%
Alt. 2	13.3%	13.1%	12.0%	11.9%	11.2%
Alt. 3	16.5%	16.3%	14.8%	14.6%	13.7%

Source: Study Team

(2) Environmental Impact

a) Strategic Environmental Assessment

Based on the results of the scoping matrix for the four proposed alternative networks, the Study evaluates these four options for the Master Plan assuming the development of the Sena Corridor, using the SEA methodology at the Initial Environmental Evaluation (IEE) level. The option of no investment in the Sena Corridor (Zero-option) is also evaluated for comparison. Details of the SEA in the Study are described in Section 7.7. Table 6-40 shows the overall results for the Master Plan for the Sena Corridor.

The option of no investment is evaluated as “Significant negative impact is expected”. Regarding Alternative 1 and 3, although both the social impact and environmental impact include some expected negative factors, a local economic impact can bring a significant positive impact to the Study Area, especially because of improving the disconnection at Chiromo washaway, which will benefit the local population in terms of access to agricultural products, schools and health posts.

Table 6-40 Overall Results of SEA

Item	Zero-option	Alt.1	Alt.2	Alt.3
Local Economic Impact	D	A	B	A
Social Impact	D	B	B	B
Environmental Impact	C	B	B	B

Notes: A = Significant positive impact is expected, B = Some positive impact is expected, C = Some negative/negligible impact is expected, D = Significant negative impact is expected

Source: Study Team

b) CO_2 Emission Reduction Effect

The carbon dioxide emission reduction effect of both Alternative 1 and 2 is estimated to be 4.0% compared to the option of no investment (Zero-option). Table 6-41 shows the carbon dioxide emission reduction effect.

Table 6-41 CO_2 Emission Reduction Effect

Item		Alternative 1	Alternative 2	Alternative 3
CO_2 Emission	t-CO_2	663,725	55,299	663,543
Reduction Effect	%	4.0	0.3	4.0

Note: Estimated period is from 2020 to 2044 (project evaluation period).

Source: Study Team

(3) Transport Viewpoints

a) Foreign Currency Saving

The foreign currency saving of both Alternative 1 and 2 is estimated to be US$16.2 and 11.3 million per year, respectively, compared to the option of no investment (Zero-option). Table 6-42 shows the foreign currency saving.

Table 6-42 Foreign Currency Saving

Item		Alternative 1	Alternative 2	Alternative 3
Foreign Currency Saving	US$ million per year	16.2	11.3	8.1

Source: Study Team

b) Transport Reliability Improvement

The transport reliability improvement of Alternative 1 is the highest at 7.2% compared to the option of no investment (Zero-option). Table 6-43 shows the transport reliability improvement.

Table 6-43 Transport Reliability Improvement

		Alternative 1	Alternative 2	Alternative 3
Transport Reliability	1000 tonne-hour	15,212	13,105	6,065
Improvement	%	7.2	6.2	2.9

Notes: Transport reliability improvement is estimated and measured based on the reduction in gross freight transport time.
Source: Study Team

6.6.4 Overall Evaluation Results

(1) Overall Evaluation Results

Based on the results of evaluating each item of the alternative transport networks, the overall results are shown in Table 6-44. “Alternative 1” is selected as the most desirable transport network alternative for the Master Plan in the Study, with the highest score of “A+”.

Table 6-44 Overall Evaluation Results

Item		Alternative 1	Alternative 2	Alternative 3	Remarks
Economic Evaluation	EIRR	A+ (17.1 %)	A (13.3 %)	A (16.5 %)	
Environmental Impact	Local Economic Impact	A	B	A	refer to SEA
	Social Impact	B	B	B	refer to SEA
	Environmental Impact	B	B	B	refer to SEA
	CO_2 Emission Reduction Effect	A	B	A	
Transport Viewpoints	Foreign Currency Saving	A+	A	B	
	Transport Reliability Improvement	A	A	B	
Overall Evaluation		**A+**	**B**	**A**	

Notes: A+ = Have a relatively high effect, A = Have a high effect, B = Have a relatively inferior effect, C = No effect
Source: Study Team

Therefore, the projects included in Alternative 1 are selected for the Master Plan. Table 6-45 shows a list of projects for the Master Plan of Development of the Sena Corridor.

Table 6-45 List of Projects for the Master Plan of Development of the Sena Corridor

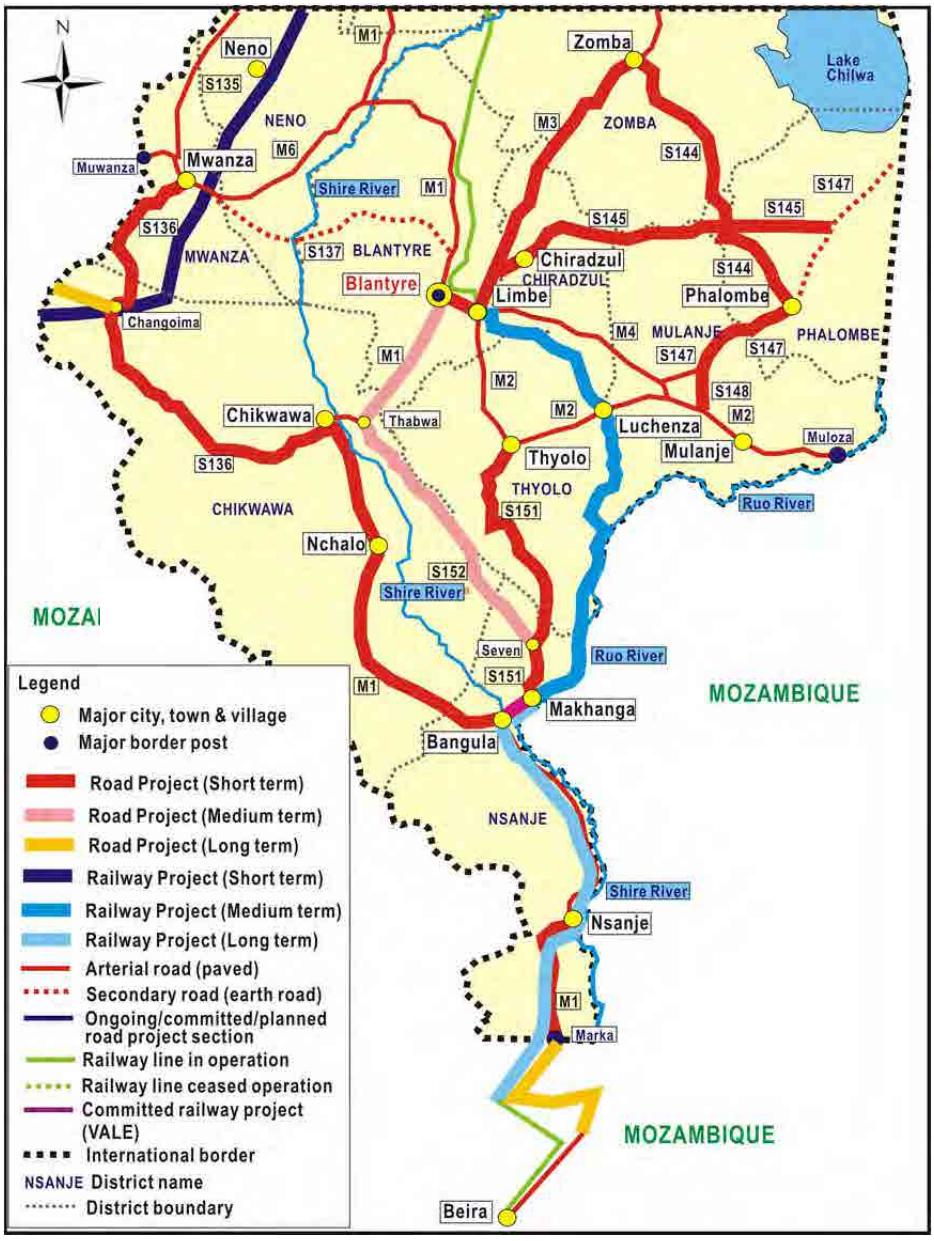
No.	Section/Item	Financial Source	Quantity	Unit	Cost (US$ million)
Road Projects in Malawi					
1	Improvement of M1 Chikwawa–Bangula (ongoing)	EDF/GoM	80	km	41
2	Improvement of M1 Nsanje–Marka (planned)	GoM	27	km	21
3	Construction of climbing lane on M1 Blantyre–Thabwa	No	5	km	2
4	Improvement of S151 Thyolo–Makhanga	Kuwait/ BADEA/ OPEC/ GoM	54	km	65
5	Reconstruction of S151 Makhanga–Bangula	No	9	km	44
6	Improvement of S152 Thabwa–Seven	No	59	km	80
7	Improvement of S136 Mwanza–Chikwawa (planned)	GoM	106	km	117
8	Improvement of D379-New access road to Mozambique from S136	No	13	km	14
Sub-total					**384**
Railway Projects in Malawi					
1	Rehabilitation of Limbe–Luchenza section	No	44	km	30
2	Rehabilitation of Luchenza–Makhanga section	No	77	km	53
3	Reconstruction of Makhanga–Bangula section	No	9	km	20
4	Reconstruction of Bangula–Nsanje section	No	45	km	30
5	Reconstruction of Nsanje–Border (Marka) section	No	26	km	19
6	Installation of signal and telecommunication system	No	200	km	25
	6.1 Limbe–Bangula section	No	130	km	16
	6.2 Bangula–Nsanje section	No	45	km	6
	6.5 Nsanje–Border (Marka) section	No	26	km	3
7	Procurement of rolling stock	No			44
	7.1 Diesel Electric Locomotive (medium term)	No	3	set	15
	7.2 Diesel Electric Locomotive (long term)	No	3	set	15
	7.3 Freight wagon (medium term)	No	30	set	5
	7.4 Freight wagon (long term)	No	90	set	8
	7.5 Passenger coach (medium term)	No	6	set	1
8	Construction of new railway line by Vale	Vale		km	-
9	Emergency spot repair and bridge/culvert repair of Blantyre–Limbe–Makhanga section	GoM	1	LS	2
10	Capacity development and institutional arrangement	GoM			0.3
Sub-total					223
Total Investment in Malawi					607
Projects in Mozambique					
1	Improvement of *Vila Nova de Frontela*–Caja road section	No	140	km	134
2	Reconstruction of *Vila Nova de Frontela–Dona Ana* railway line	No	44	km	21
3	Installation of signal and telecommunication system	No	44	km	5
Total Investment in Mozambique					27
Total Investment in the Master Plan					**634**

Source: Study Team

6.7 Transport Master Plan Programmes

6.7.1 Implementation Schedule

The proposed projects for the Master Plan are classified as short-term, medium-term and long-term projects as shown in Figure 6-22.



Source: Study Team

Figure 6-22 Projects Classified by Implementation Stage

The implementation schedule for existing and proposed projects is prepared for the short term (2015), medium term (2020) and long term (2030), considering level of needs for each project, engineering judgment as well as investment environment for each transport sector (road and railway) by development partners, as shown in Table 6-46.

Table 6-46 Implementation Schedule of Projects

Project	Investment Cost (US$ million)	2015	2020	2030
1. Road Project				
a) Upgrading M1 Chikwawa–Bangula	41	→		
b) Upgrading M1 Nsanje–Marka	21	→		
c) Upgrading S151 Thyolo–Makhanga	65	→		
d) Upgrading S136 Chikwawa–Mwanza	117	→		
e) Reconstruction S151 Makhanga–Bangula	44	→		
f) Construction of climbing lane on M1	9		→	
g) Upgrading S152 Thabwa–Seven	59		→	
h) Upgrading D379 new access to Mozambique	13			→
i) 1) Upgrading Caia–Shire River (MOZ)	58			→
2) Upgrading Shire River–Mutarara (MOZ)	46			→
3) Upgrading Mutarara–*Vila Nova de Frontela* (MOZ)	30			→
j) Capacity development and institutional arrangement	-	→		
2. Railway Project				
a) Construction of new railway line by Vale	n.a.	→		
b) Emergency spot repair Blantyre–Limbe–Makhanga	2	→		
c) Capacity development and institutional arrangement	0.3	→		
d) Rehabilitation of Limbe–Luchenza	30	→	→	
e) Reconstruction of Makhanga–Bangula	20		→	
f) Rehabilitation of Luchanza–Makhanga (including maintenance of access local roads)	53		→	
g) Reconstruction of Bangula–Nsanje	30			→
h) Reconstruction of Nsanje–Border (Marka)	19			→
i) Installation of signal & telecommunication system	24		→	→ →
j) Procurement of rolling stock	44		→	→ →
k) Reconstruction of *Vila Nova de Frontela–Dona Ana* (MOZ)	21			→
l) Installation of signal & telecommunication (MOZ)	5			→
3. Inland Waterway Project				
a) Start operation of Shire-Zambezi Waterway	n.a.	→	→	

Note: Shaded projects are on-going/committed/planned project by the GoM and other financial sources.
Source: Study Team

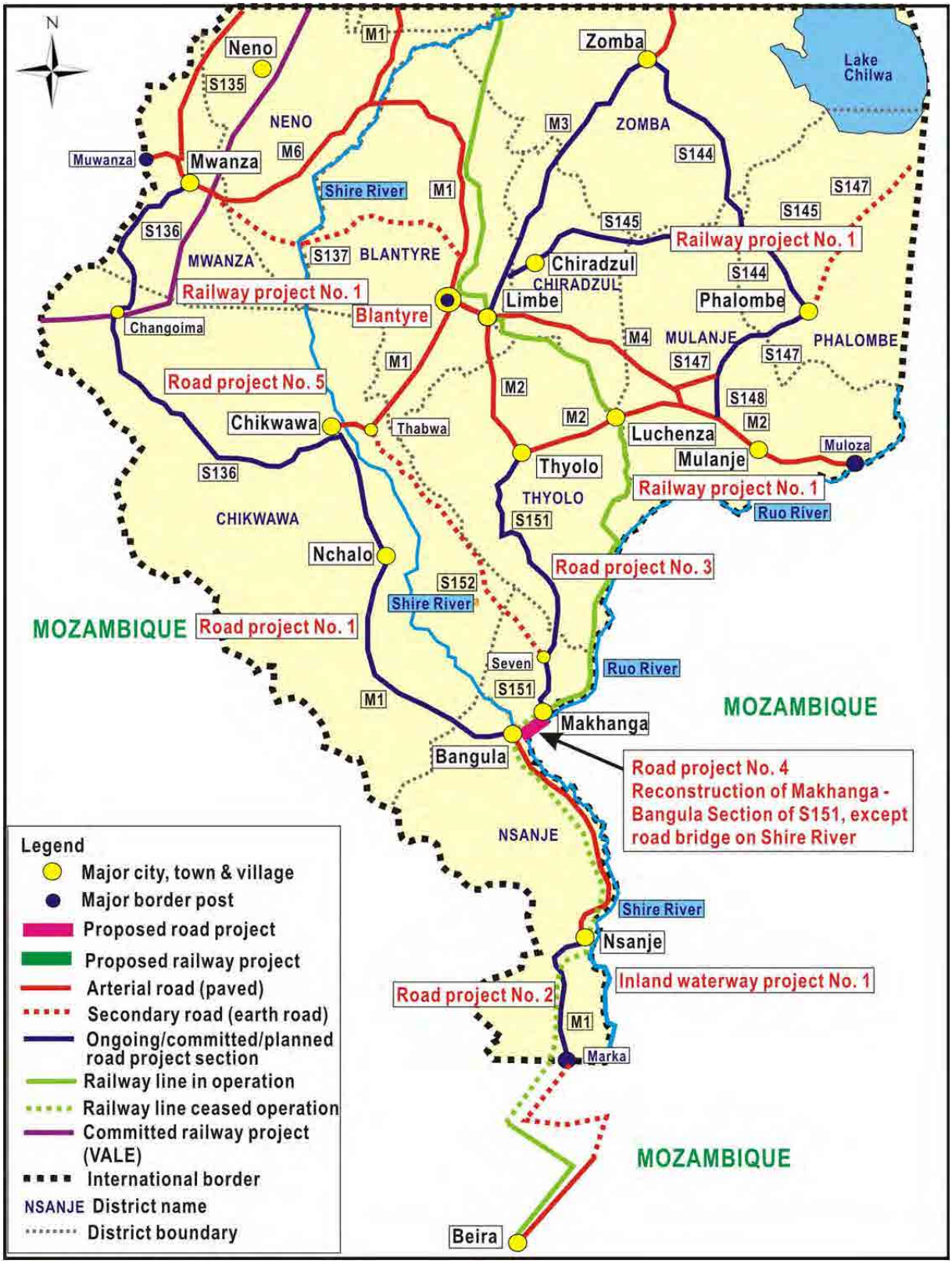
6.7.2 Short-Term Programme

Projects listed in Table 6-47 and shown in Figure 6-23 are selected for the short-term programmes.

Table 6-47 List of Projects for the Short Term Implementation Programme

No.	Section/Item	Financial Source	Quantity	Unit	Cost (US$ million)
Road Projects in Malawi					
1	Upgrading of M1 Chikwawa–Bangula (on-going)	EDF/GoM	80	km	41
2	Upgrading of M1 Nsanje–Marka (planned)	GoM	27	km	21
3	Upgrading of S151 Thyolo–Makhanga	Kuwait/ BADEA/ OPEC/ GoM	54	km	65
4	Reconstruction of S151 Makhanga–Bangula	No	9	km	28
5	Upgrading of S136 Mwanza–Chikwawa (planned)	GoM	106	km	117
Sub-total					272
Railway Projects in Malawi					
1	Construction of new railway line by Vale	Vale	138	km	-
2	Emergency spot repair and bridge/culvert repair of Blantyre–Limbe–Makhanga section	GoM	1	LS	2
3.	Capacity development and institutional arrangement	GoM			0.3
Sub-total					2
Inland Waterway Projects in Malawi					
1	Start operation of Shire-Zambezi Waterway	GoM		km	-
Sub-total					-
Total Investment in Malawi					274

Source: Study Team



Source: Study Team

Figure 6-23 Location of Selected Projects for the Short-Term Implementation Programme

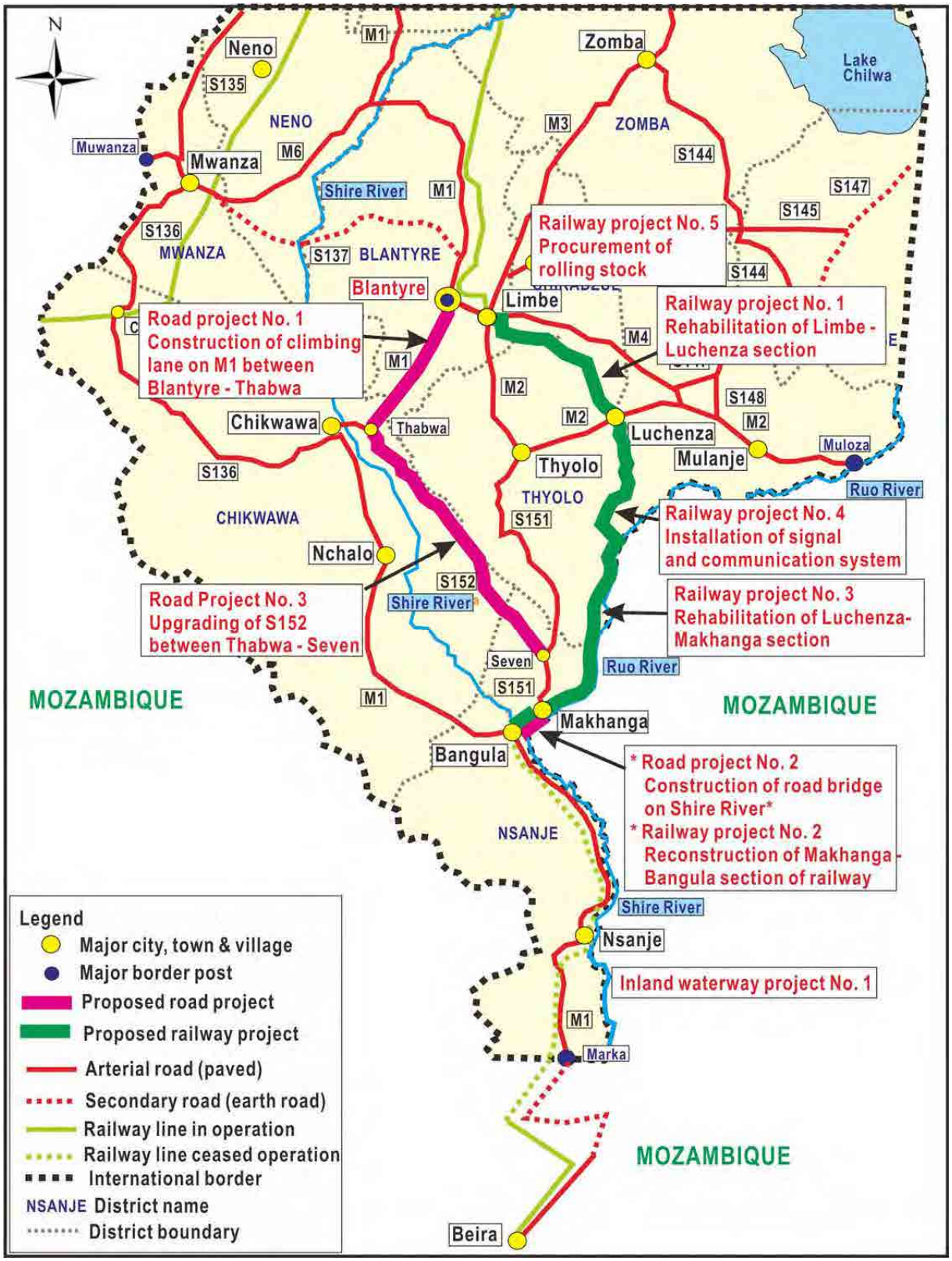
6.7.3 Medium-Term Programme

Projects listed in Table 6-48 and shown in Figure 6-24 are selected for the medium-term programme.

Table 6-48 List of Projects for the Medium-Term Implementation Programme

No.	Section/Item	Financial Source	Quantity	Unit	Cost (US$ million)
Road Projects in Malawi					
1	Construction of climbing lane on M1 Blantyre–Thabwa	No	5	km	2
2	Reconstruction of S151 Makhanga–Bangula (New Shire Bridge)	No	9	km	16
3	Upgrading of S152 Thabwa–Seven	No	59	km	80
Sub-total					98
Railway Projects in Malawi					
1	Rehabilitation of Limbe–Luchenza section	No	44	km	30
2	Reconstruction of Makhanga–Bangula section	No	9	km	20
3	Rehabilitation of Luchenza–Makhanga section	No	77	km	53
4	Installation of signal and telecommunication system	No	130	km	16
5	Procurement of rolling stock	No			21
Sub-total					140
Inland Waterway Projects in Malawi					
1	Rehabilitation of Shire-Zambezi Waterway	GoM		km	-
Sub-total					-
Total Investment in the Master Plan					**238**

Source: Study Team



Source: Study Team

Figure 6-24 Location of Selected Projects for the Medium-Term Implementation Programme

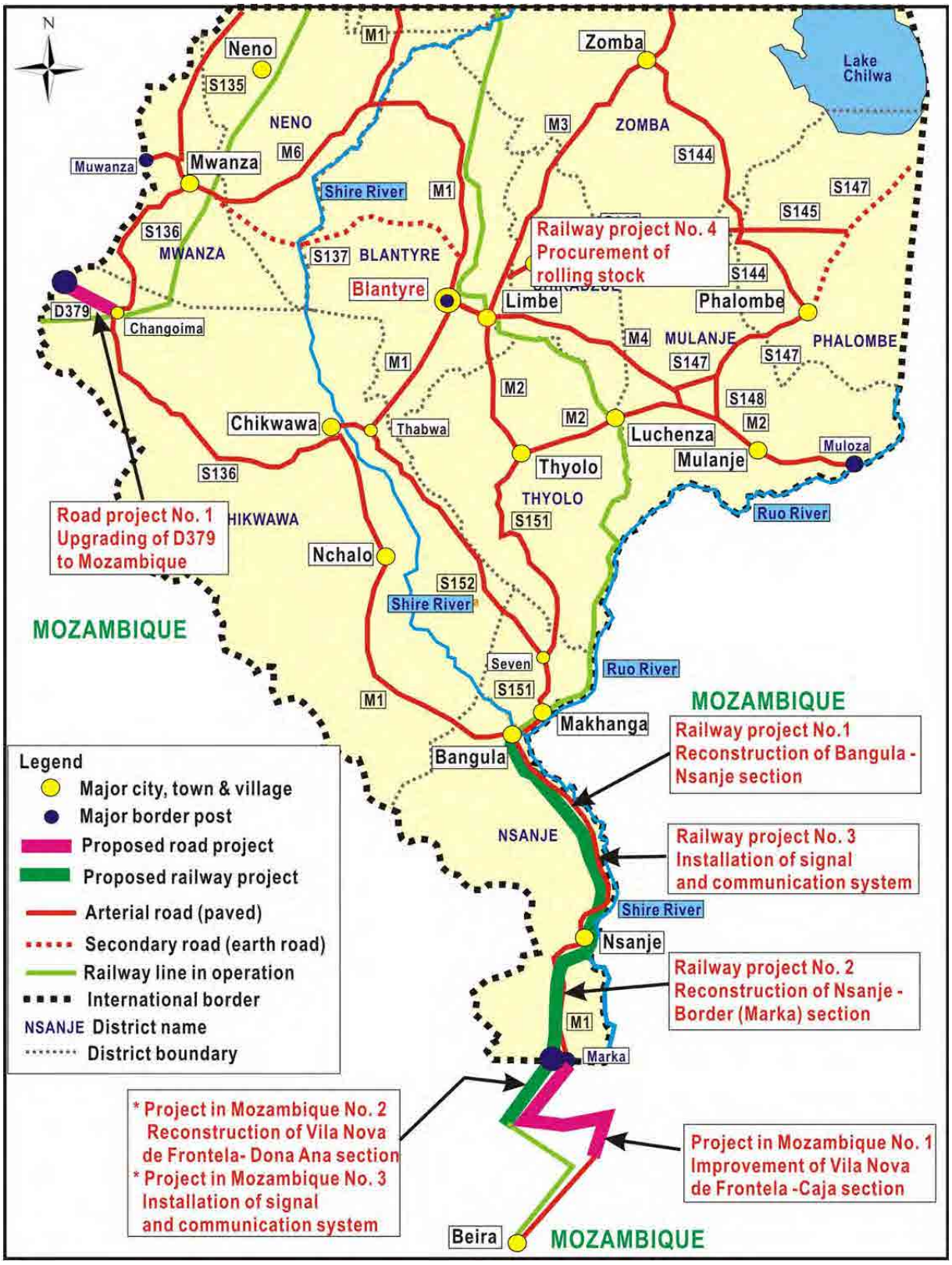
6.7.4 Long-Term Programme

Projects listed in Table 6-49 and shown in Figure 6-25 are selected and verified by the economic evaluation for the long-term programme.

Table 6-49 List of Projects for the Long-Term Implementation Programme

No.	Section/Item	Financial Source	Quantity	Unit	Cost (US$ million)
Road Projects in Malawi					
1	Upgrading of D379-New access road to Mozambique from S136	No	13	km	14
Sub-total					14
Railway Projects in Malawi					
1	Reconstruction of Bangula–Nsanje section (including. rehabilitation of freight yards)	No	45	km	30
2	Reconstruction of Nsanje-Border (Marka) section	No	26	km	19
3	Installation of signal and telecommunication system	No	71	km	9
4	Procurement of rolling stock	No			23
Sub-total					81
Total Investment in Malawi					**95**
Projects in Mozambique					
1	Improvement of *Vila Nova de Frontela*–Caia road section	No	140	km	134
2	Reconstruction of *Vila Nova de Frontela–Dona Ana* railway line	No	44	km	21
3	Installation of signal and telecommunication system	No	44	km	5
Total Investment in Mozambique					**161**

Source: Study Team



Source: Study Team

Figure 6-25 Location of Selected Projects for the Long-Term Implementation Programme

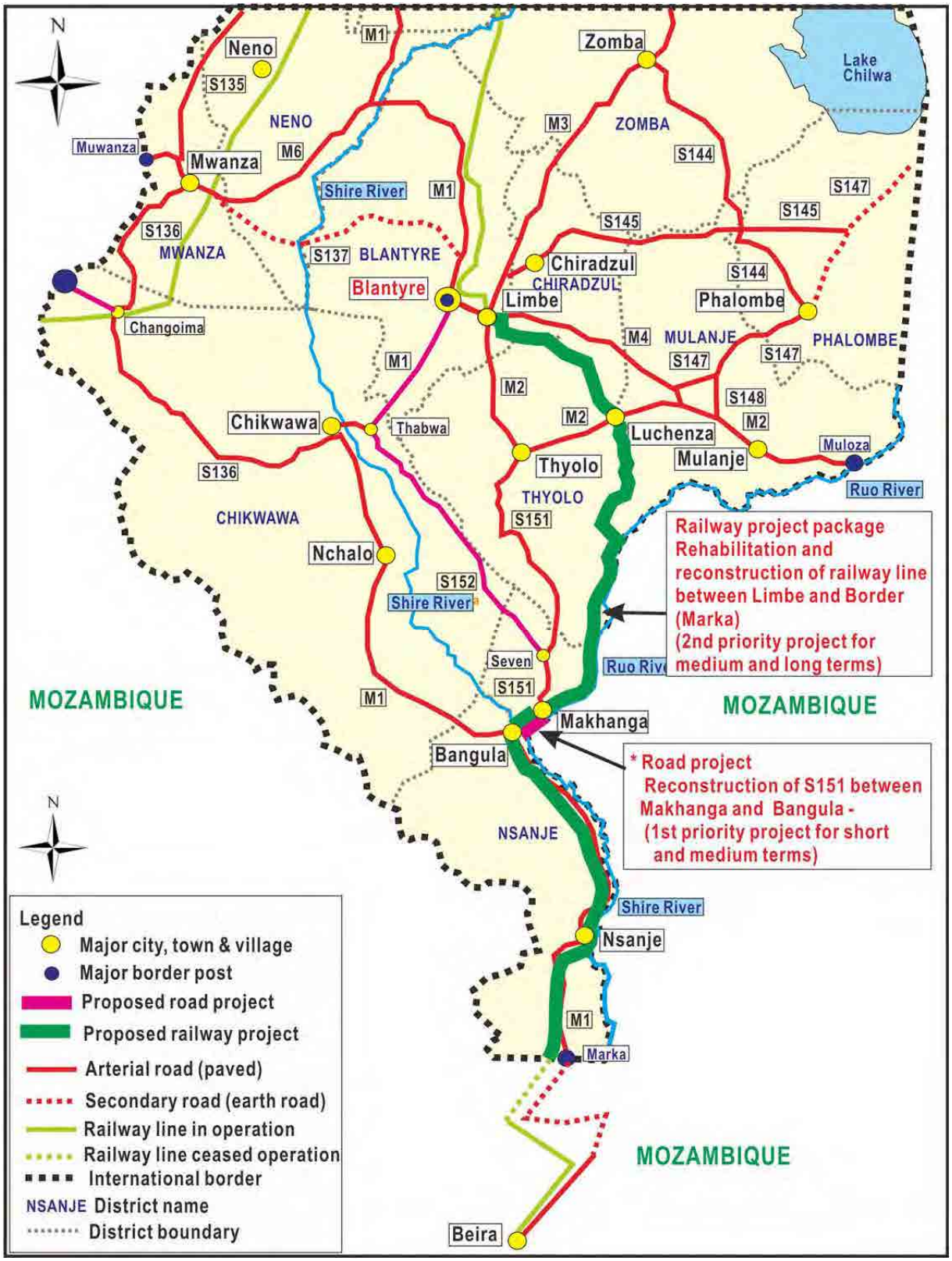
6.8 Proposed Projects for the Pre-F/S

The first-priority projects that are urgently needed for the development of the Study Area are tentatively selected from the short-term programme, i.e. “Reconstruction of S151 Road between Makhanga and Bangula”. In addition, one package of five railway projects (“Rehabilitation and Reconstruction of Railway Line between Limbe and Border (Marka)) is also selected as a second-priority project for the medium and long term programme. Candidate projects for the Pre-F/S are selected from infrastructure projects without a previous F/S. The final selection of projects for the Pre-F/S was made by the Steering Committee. Table 6-50 shows selected projects for the Pre-F/S.

Table 6-50 List of Selected Projects for the Pre-F/S

No.	Section/Item	Financial Source	Quantity	Unit	Cost (US$ million)
Road Projects (First Priority)					
1	Reconstruction of S151 Road between Makhanga and Bangula	No	9	km	44
Railway Projects (Second Priority)					
1	Rehabilitation and reconstruction of railway between Limbe and Border (Marka) via Bangula	No	201	km	152

Source: Study Team



Source: Study Team

Figure 6-26 Location of Projects for Pre-F/S