REPUBLIC OF MALAWI
MINISTRY OF TRANSPORT AND PUBLIC INFRASTRUCTURE (MOTPI)

PROJECT FOR THE STUDY ON DEVELOPMENT OF THE SENA CORRIDOR IN THE REPUBLIC OF MALAWI

FINAL REPORT

SUMMARY

FEBRUARY 2012

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CENTRAL CONSULTANT INC.
NIPPON KOEI CO., LTD.
YACHIYO ENGINEERING CO., LTD.
TOSTEMS, INC.

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1. Introduction

Malawi is a land locked country, and due to long transport distances to ocean ports in neighbouring countries, transport costs to ports are very high, reducing the sustainable international competitiveness of domestic products. The Sena Corridor defined in the Study connects the Southern Region of Malawi and Beira Port by road, railway and inland waterway, which presently suffers obstacles such as disconnection at the Chiromo Washaway and deteriorated conditions of the roads and railway in Mozambique.

The objectives of the Study are as follows:

- To prepare a Master Plan for the development of the Sena Corridor in order to secure multiple international corridors for national security.
- To carry out a Pre- F/S for the projects selected based on the results of the Master Plan. The following projects have been selected for the Pre-F/S:
  - Reconstruction of the S151 road between Makhanga and Bangula (9 km).
  - Rehabilitation and reconstruction of the railway between Limbe and Border (Marka) (201 km).

The Study Area in Malawi covers nine districts in the Southern Region of Malawi and four provinces in Mozambique.

2. Outline of the Study Area

(1) Sena Corridor and Regional Coordination

- The Sena Corridor is defined as a traffic route connecting Blantyre to Beira Port and an additional southern gateway to Malawi in view of its historical background.
- It is necessary for Malawi to coordinate with other member countries of SADC and COMESA to strengthen international transport corridors to secure transport routes for export and import products.

(2) Economic and Social Conditions in Malawi and the Study Area

- The GDP per capita has remained lower in Malawi (US$ 343 in 2010) than in neighbouring countries.
- Foreign direct investment (FDI) into Malawi is very low (US$ 140 million in 2010) compared with the three neighbouring countries.
- Land use in the Study Area is mainly agriculture, with widespread cultivation of tea, nuts, pigeon peas, food crops, sugar, cotton and bananas, and cattle breeding.
- The population in the Study Area is mainly distributed in highland districts, owing to the higher proportion of arable land for cultivation and plantations, while the population distribution in the Lower Shire is limited.

- The poverty ratio is highest in the Southern Region with 64.4% below the poverty line[1]. The ultra poverty ratio in the Southern Region is also the highest at 31.5%, compared with 22.4% for the whole of Malawi. Nsanje District has both the highest poverty ratio (76.0%) and ultra poverty ratio (44.3%).
- Water overflowed into Elephant Marsh when backwater of the Shire River washed away the embankment of the railway and S151 road near Bangula in March 1997. Problems caused by the regional disconnection at the Chiromo washaway are 1) Additional burden of transport cost by boat, 2) Longer travel time between origin and destination, 3) Impassable conditions during the rainy season, 4) Risk to life and 5) Decrease of monthly income for people living in Chiromo and Makhanga. The Chiromo washaway also affects people living along the railway line between Luchenza and Sankhulani who lost the opportunity to sell products at markets because the train now runs only weekly instead of daily.

(3) National Development Policy and Programmes

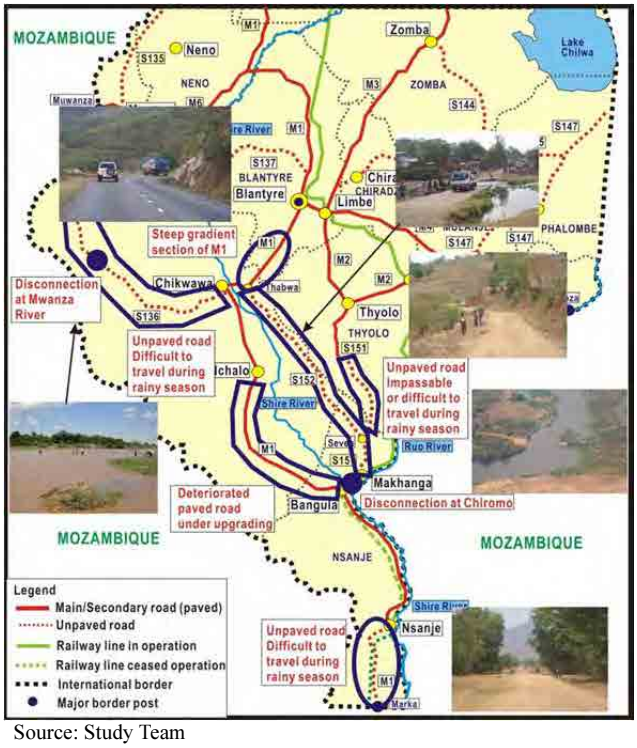
- Sustainable economic growth is one of the main targets of MGDS. Sustainable economic growth is central to Malawi's ability to reduce poverty, achieve the MGDS and gain food self-sufficiency.
- The selected projects listed in PSIP are those identified programmes and projects that are consistent with the GoM's strategic objectives and priorities as aligned with the MGDS and that are linked to available financing mechanisms.

3. Present Situation of Transport System in the Study Area

(1) Present Situation of the Road Sub-sector

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.

M1 is one of the most important arterial roads as both a domestic and international corridor in Malawi; it links the northernmost Tanzania border and the southernmost Mozambique border, forms the north-south axis between Blantyre and Marka border post, and links major towns in the Study Area. M2 and M4 connect Blantyre with the Muloza border post. M6 connects Blantyre with Mwanza



Source: Study Team

Figure 1 Major Problems of Road Sub-sector

[1] Poor: MWK 16,165 per annum, Ultra poor: MWK 10,029 per annum

border post.

There are two transportation routes between Blantyre and Bangula, the latter being a town north of Nsanje District. The main route in the Study Area is M1 passing through Chikwawa District and a potential alternative is the secondary road S151 passing through Thyolo District. S152, which runs along the district's boundary between Chikwawa and Thyolo districts, links M1 and S151 which form the arterial road network in the Study Area.

The major problems of the road sub-sector are summarised in Figure 1.

(2) Present Situation of the Railway Sub-sector

CEAR currently operates 706 km of single-track line by the concession agreement signed in 1999. The railway network of Malawi is a non-electrified single-track line of narrow gauge (1,067 mm).

Vale signed a MoU and a concession agreement with the GoM on the construction/ rehabilitation and operation of a railway line from Moatize to *Nacala-á-Velha* Port in Mozambique, through Malawi.

The major problems of the railway sub-sector are summarised in Figure 2.

Source: Study Team

Figure 2 Major Problems of Railway Sub-sector

At present, the SADC Secretariat is preparing to select a consultant to carry out the feasibility study of the Shire–Zambezi Waterways Development Project, which will be financed by AfDB. The results of this feasibility study will form the basic policy of the GoM and the GoMZ for developing the Shire–Zambezi Waterway Corridor and international cooperation for its operation.

(3) Inland Waterway Transport Sub-sector

(4) Transport Corridor Development in Neighbouring Countries

The existing transport corridor networks connecting with Malawi are the Beira, Durban, Nacala and Dar es Salaam Corridors. The Durban Corridor carries 51% of Malawi's international cargos by value, and the Beira Corridor carries 41% by volume.

The major issues for both the Beira and Nacala Corridors are summarised below.

- To develop domestic transport networks which will strengthen export routes to Nacala Port.
- To promote a modal shift to change the transit system.
- To establish an efficient logistics system by developing a modern railway system and minimising transhipment time and cost.
- To build alternative routes to secure and strengthen access to Beira Port.

- To strengthen and improve internal access to border posts.
- To communicate and formulate a comprehensive Sena Corridor co-development programme for the development of the Sena routes.

4. Future Traffic Demand Forecast

(1) Results of Traffic Surveys

Freight traffic trips are spread over a wide area. Especially, trips to Nacala and Beira Ports as well as to RSA are predominant. This means that freight traffic in the Southern Region of Malawi extends over a wide area.

(2) Results of Logistics Survey

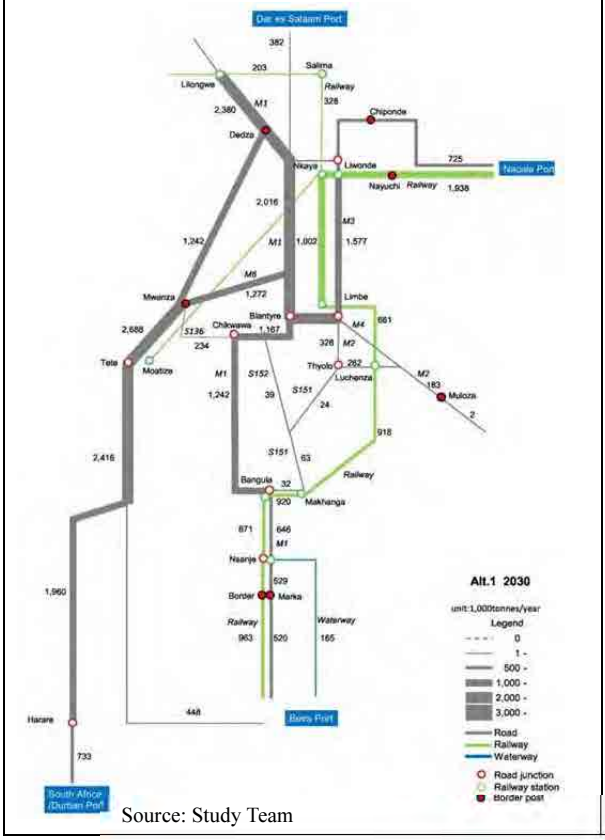
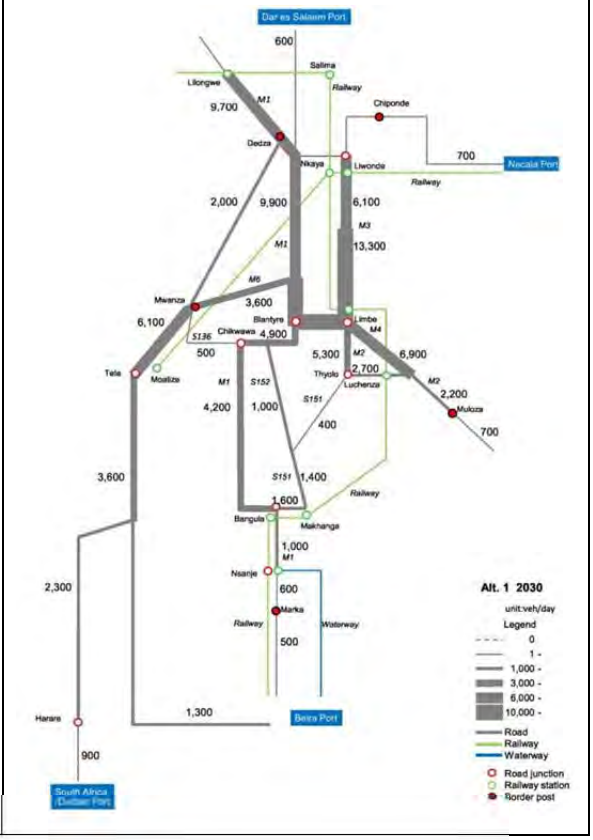
- The value of exports and imports for Malawi from 1994 to 2010 has been increasing in line with economic growth. The value of imports is almost twice that of exports in Malawi.
- Tobacco has been Malawi's leading export for over 30 years and the situation has not changed. Sugar and tea occupy second or third place by value every year. Regarding imports, fuel is always in top place by volume.
- The main transportation mode is by truck/trailer with containers taking almost 90%. Railway accounts for less than 10%.
- The transport cost of import and export commodities is higher on the Durban and Dar es Salaam Corridors; in particular, the import transport cost from Durban Port is the highest.
- Products are mainly placed in containers at Blantyre or Limbe (logistics centre).
- Sugar is mainly transported to Nacala Port by railway, except exports to Zimbabwe by truck (bulk).
- Pigeon peas are transported to Nacala (by railway), Beira and Durban Ports (by road).
- Longer transport routes to Durban and Beira Ports (tea, tobacco, cotton, pigeon peas).
- Steep gradient sections between Blantyre and Thabwa hinder transportation by limiting the loading capacity.

(3) Future Traffic Demand Forecast

- Approximately 80% of export cargo uses the Beira Corridor to Beira Port and the Durban Corridor to RSA and Durban Port at present.
- Approximately 64% of import cargo uses the Beira and Durban Corridors from Beira Port and RSA, while 14% of import cargo uses the Nacala Corridor at present.

  In 2030, about 51% of export cargo will use the Nacala Corridor, while the share of the Beira and Durban Corridors will decrease to 43%.
- The huge demand for coal from the Moatize coal mine and copper from Zambia will consume most of the capacity of the Nacala Railway with only the remaining capacity available for freight to/from Malawi.
- The Beira Corridor carries 41% of Malawi's international cargo at present, which will decrease to less than 17% in 2030. The Nacala Corridor accounts for 18% at present, which will increase to 44% in 2030. The Sena Corridor will account for at least 19% by 2030.

- The results of assignment of future freight volume and vehicular traffic to alternative transport networks indicate that 1,648 million tonnes/year of freight will go through the Sena Corridor if every transport network is connected to Beira Port (see Figure 3).

Freight Demand in 2030	Road Traffic Demand in 2030
	

Source: Study Team

Figure 3 Freight and Road Traffic Demand in 2030 (Alt. 1)

5. Basic Policy for Development of the Sena Corridor

(1) Significance of Development of the Sena Corridor

For Malawi, there are several transport routes to neighbouring countries and some of the existing corridors are defined as international transport corridors as part of the North–South Transport Corridor defined by the SADC as gateways to neighbouring countries and ocean ports, as follows:

- Beira Corridor to Beira Port: Southwestern gateway
- Durban Corridor to RSA and Durban Port: Southwestern gateway
- Nacala Corridor to Nacala Port and Zambia: Eastern and Western gateway
- Dar es Salaam Corridor to Dar es Salaam Port: Northern gateway

If the Sena Corridor is developed, it will serve as both an international corridor as well as a domestic corridor in the Study Area, instead of only as a domestic corridor at present.

(2) Basic Concept of Developing the Sena Corridor

The development potentials in Malawi and the Study Area are as follows:

- The main industry in Malawi is agriculture and export-oriented products, which have long been cultivated. The productivity of these products can be increased by providing farmers with sufficient materials, such as fertilizer.
- Since Blantyre serves as the commercial and agro-processing centre in Malawi, the district centres in the Southern Region will serve as rural growth centres to support Blantyre.
- There is mining potential in Mulanje and Nsanje Districts, and tourism potential in Chikwawa, Nsanje and Mulanje Districts in the Study Area.

To maximize the development potential of the Study Area, three basic concepts for developing the Sena Corridor are prepared (see Table 1).

Table 1 Basic Concepts and Targets of the Sena Corridor

Area	Basic Concept	Target
South-eastern Africa	・ Development of infrastructure network to support economic integration in South-eastern Africa	• Achieve sustainable economic growth • Strengthen redundancy of transport network
Malawi	・ Development of arterial transport network to support efficient export and import	• Achieve sustainable economic growth • Improve international competitiveness of export products • Strengthen redundancy of transport network
Study Area	・ Development of transport network to alleviate poverty	• Achieve sustainable economic growth • Alleviate poverty • Improve living condition in the Study Area

Source: Study Team

The development goals of the Sena Corridor are sustainable economic growth and poverty alleviation in Malawi and the Study Area by improving the inadequate transport network and boosting regional development.

6. Master Plan for the Development of the Sena Corridor

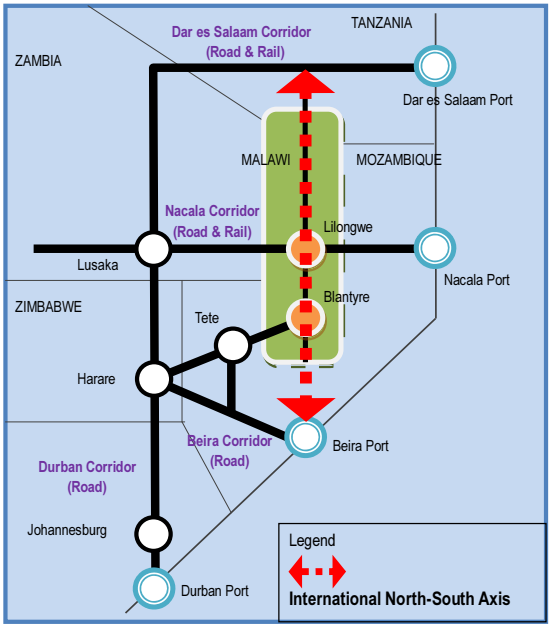
(1) Objective of the Master Plan

The objective of the Master Plan for the development of the Sena Corridor is to prepare improvement plans for the transport sub-sectors, i.e. road, railway and inland waterway sub-sectors, which form the Sena Transport Corridor. The Master Plan describes definite plans for the transport system and its services in the Southern Region of Malawi.

(2) Overview of the Development of the Sena Corridor

- The development of a north-south international corridor linking the 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 4).
- Based on the 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.

- For Malawi, the Sena Corridor is a part of the national north-south axis. The development of the Sena Corridor is expected to contribute to 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.
- 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.



Source: Study Team

Figure 4 Imternational North-South Axis

(3) Assumptions of External Factors for the Master Plan

- External Factors for the Road Sub-sector: Upgrading of the unpaved road section from *Vila Nova de Frontela* to Caia on N1 road in Mozambique (140 km).
- External Factors for the Railway Sub-sector: Rehabilitation of the existing railway section from *Vila Nova de Frontela* to *Dona Ana* in Mozambique (44 km).

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.

The proposed evaluation items are “Transport Reliability” for Malawi and “Qualitative Benefit” for Mozambique. As a result of evaluating assumptions for the Master Plan, **Assumption 1** is evaluated as the most advantageous for both Malawi and Mozambique.

(4) 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, including regional development issues and potentials.

- Establishing regional growth axes by improving access to Blantyre and Beira Port
- Strengthening transport network redundancy by providing alternative transport routes
- Developing markets by improving access to markets at both rural and international levels
- Formulating an internationally competitive distribution network 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

(5) Preparation of Development Plans for the Transport Sub-sectors

Development plans for the short, medium and long term of the transport sub-sectors have been prepared, as shown in Table 2.

Table 2 Development Plans for the Transport Sub-sectors

Transport Sub-sector	Development Plan for Short Term (2015)	Development Plan for Medium Term (2020)	Development Plan for Long Term (2030)
1. Road sub-sector	* Upgrading of M1 Chikwawa–Nchalo (ongoing) * Upgrading of M1 Nsanje–Marka (planned) * Upgrading of S151 Thyolo–Makhanga (committed) * Improvement of S136 Mwanza–Chikwawa (planned) * Reconstruction of S151 Makhanga– Bangula	* Construction of climbing lane on M1 Blantyre–Thabwa * Upgrading of S152 Thabwa–Seven	* Upgrading of D379-New access road to Mozambique * Improvement of *Vila Nova de Frontela*–Caia road section (Mozambique)
2. Railway sub-sector	* Construction of new railway line by Vale	* Rehabilitation of Limbe–Luchenza section * Rehabilitation of Luchenza–Makhanga section * Reconstruction of Makhanga–Bangula section * Installation of signal and telecommunication system * Procurement of rolling stock	* Reconstruction of Bangula–Nsanje section * Reconstruction of Nsanje–Border (Marka) section * Installation of signal and telecommunication system * Procurement of rolling stock * Reconstruction of *Vila Nova de Frontela–Dona Ana* railway line (Mozambique) * Installation of signal and telecommunication system (Mozambique)
3. Inland waterway	* Start operation of Shire–Zambezi Inland Waterway	* Rehabilitation of Shire–Zambezi Inland Waterway	-

Source: Study Team

(6) Evaluation of Proposed Projects for the Master Plan

The Study Team has prepared three alternative transport networks based on the development plan for the transport sub-sectors in the Study Area and assumptions for external factors in Mozambique mentioned above in consideration of the essential factors as shown in Table 3.

Table 3 Alternative Transport Networks for Evaluation

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

Source: Study Team

The overall evaluation shown in Table 4 identified A**lternative 1** (connection of both road and railway in Mozambique) as having the highest score.

Table 4 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

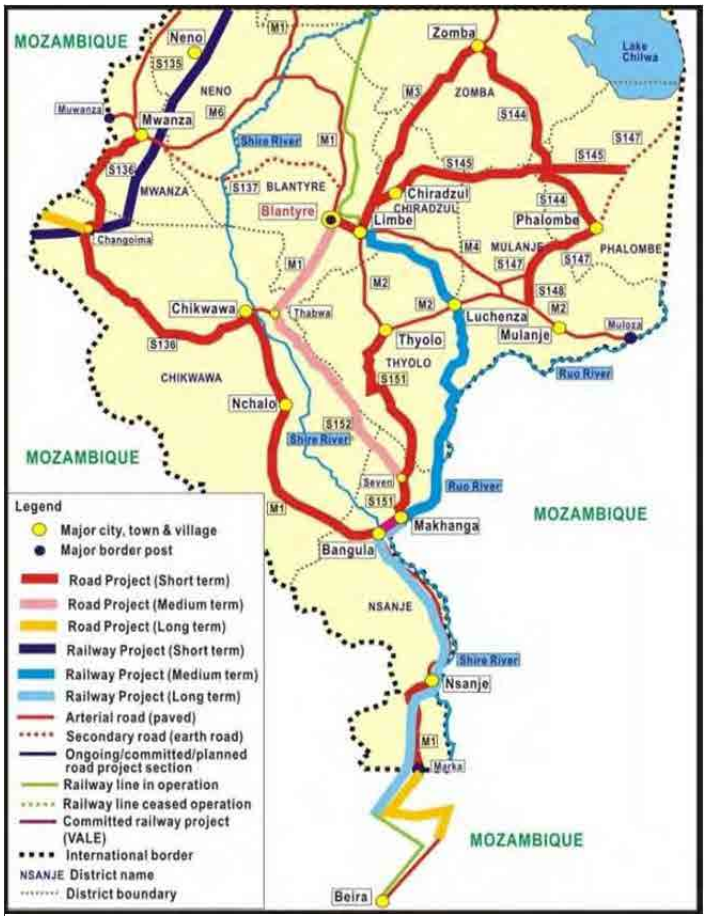
(7) Transport Master Plan Programmes

The proposed projects for the Master Plan are classified as short-term (2015), medium-term (2020) and long-term (2030) projects as shown in Figure 5. The implementation schedule for existing and proposed projects, considering the level of needs for each project, engineering judgment as well as investment environment for each transport sector (road and railway) by development partners, is prepared for each term.

(8) Proposed Projects for Pre-F/S

The following projects were selected for the Pre-F/S by the Steering Committee.

- Reconstruction of S151 Road between Makhanga and Bangula
- Rehabilitation and Reconstruction of Railway between Limbe and Border (Marka)



Source: Study Team

Figure 5 Projects Classified by Implementation Stage

7. Results of Hydrological Analyses

- Since the past maximum discharge volume has never exceeded 1,500 m^3/sec and floods on the Ruo River continue for a long time, the planned maximum discharge volume as a peak discharge volume can be considered to equal the maximum discharge volume at Kamuzu Truss Bridge.
- The planned high water level (HWL) during flooding at the washaway section is estimated as 48.4 m.

- The Study Team has proposed to apply protection works for the abutments and piers of the proposed bridges and railway embankment.

8. Pre-Feasibility Study on Reconstruction of S151 Road between Makhanga and Bangula

(1) Preliminary Design of Road Section between Makhanga and Bangula

The required height of the raised road should be determined considering expected flood levels. The estimated height of raising the S151 road is 2.3 m on average for the total projected extension.

The Study Team conducted a comparison of three alternatives regarding where the raised road should be built outside of Makhanga. As a result of the comparison, the existing road alignment is considered as more advantageous in terms of i) measures for ground stabilization and ii) construction cost. The Study Team also conducted a comparison of three alternatives in the Makhanga area. As a result of the comparison, the alignment following the railway line is considered as most advantageous in terms of i) design element, ii) the Ruo River bank erosion, iii) road damage caused by flood and iv) construction cost.

(2) Preliminary Design of Chiromo Road Bridge

The best bridge construction position was selected among the three alternatives mentioned using the results of a comparative study on the bridge construction positions and access roads of the three alternatives.

The preferred bridge type was selected by a two-phase comparison of bridge types based on economic efficiency, construction efficiency, structural performance, and reduction of river cross-section. As a result, an Extradosed bridge is selected as the preferred type of bridge. However, when the detailed hydraulic analysis is carried out at the time of the feasibility study and if the HWL falls as a result, a PC 3-span continuous box-girder bridge may be selected instead.

(3) Preliminary Design of New Shire Bridge

The best bridge construction position was selected among the three alternatives mentioned using the results of a comparative study on the bridge construction positions and access roads of the three alternatives.

The preferred bridge type was selected by comparison of bridge types based on economic efficiency, construction efficiency, structural performance, and reduction of river cross-section. As a result, a PC 3-span continuous box-girder bridge is selected as the preferred type of bridge.

(4) Preliminary Cost Estimation

Table 5 summarizes the estimated project cost for the reconstruction of the S151 road between Makhanga and Bangula.

(5) Economic Analysis of Reconstruction of S151 Road between Makhanga and Bangula

Table 6 shows the result of economic analysis using the HDM-4 model.

Table 5 Estimated Project Cost

Cost Item		Estimated Project Cost (US$ million)	
Improvement of Road between Makhanga and Bangula		14.52	
Chiromo Road Bridge	Superstructure works	15.64	22.08
	Substructure works	6.44	
New Shire Bridge	Superstructure works	12.80	19.48
	Substructure works	6.68	
Total Project Cost		56.08	

Source: Study Team

Table 6 Results of Evaluation of Basic Options

(SDR = 12.0%)

	Engineering Option	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)
1	Without Project	0.547	0.0%	0.0	0.000
2	With Project (Option-1) (Road improvement and Construction of Chiromo Road Bridge and New Shire Bridge)	42.358	26.0%	1.697	71.876
3	With Project (Oprion-2) (Road improvement and Construction of only Chiromo Road Bridge)	28.005	50.0%	6.421	179.831

Source: Study Team

Based on the above analysis, Option-1, the improvement of road section between Makhanga and Bangula with the construction of the Chiromo Road Bridge and the New Shire Bridge, is technically and economically viable, but in the worst case scenario the EIRR is near marginal at 14.2%. This would therefore need further confirmation by robust economic evaluation at the full feasibility study stage to be conducted later.

9. Pre-Feasibility Study on Rehabilitation/Improvement of the Railway between Limbe and Border (Marka)

(1) Basic Transportation Plan

- From the yearly cross sectional transportation volume of freight calculated based on the demand forecast, the daily average transportation volume is calculated and the number of trains required to transport freight multiplied by a fluctuation factor due to the seasons is decided.
- Passenger trains will operate on the section between Limbe and Bangula in the medium-term plan. In the long-term plan, the section will be extended to Border.

(2) Rehabilitation/Reconstruction Plan for Railway Infrastructure

- Three major places at the Chiromo Washaway section and near Sankhulani are found to need major earthworks.
- The bridges between Border and Limbe which should be rehabilitated or reconstructed were identified. The combination of “steel simple truss bridge + PC 5-span post-tensioned T-girder

bridge" is selected for the Chiromo Railway Bridge, and PC girder, RC girder and RC slab bridges for the remaining sections.

- To secure safe and stable transportation, all tracks are planned to be replaced, including sleepers and rails.

(3) Installation of Signalling and Telecommunication Systems and Procurement of Rolling Stock

- The Study Team proposed to install a signalling and telecommunication system covering the whole section between Limbe and Border.
- When the section between Border and Limbe is reopened, additional DLs, freight wagons and passenger coaches will be required.

(4) Preliminary Cost Estimate

The project costs are summarized in Table 7.

Table 7 Summary of Preliminary Cost Estimate

Unit: US$ million

Section / Route Length / Item	Border–Nsanje 25.6 km	Nsanje–Bangula 45.4 km	Bangula–Makhanga 8.7 km	Makhanga–Luchenza 76.6 km	Luchenza–Limbe 44.0 km	Total 200.3 km
Earth Works	0.186	0.161	0.789	0.683	0.155	1.974
Bridge	10.232	4.480	17.550	3.911	4.407	40.579
Track	13.243	21.764	5.674	36.028	21.486	98.195
Station	0.138	0.275	0.413	0.688	0.688	2.200
Level Crossing	0.000	0.125	0.250	0.000	0.250	0.625
Signal & Telecommunication System	0.651	1.205	1.070	2.533	7.126	12.585
Sub-Total	24.449	28.009	25.746	43.841	34.112	156.158
Rolling Stock	0.000	0.000	0.000	0.000	46.500	46.500
Engineering Cost (10%)	2.445	2.801	2.575	4.384	3.411	15.616
Contingency (10%)	2.445	2.801	2.575	4.384	3.411	15.616
Total	29.339	33.611	30.895	52.610	87.434	233.890

Source: Study Team

(5) Economic and Financial Analyses

The results of the economic evaluation are summarized in Table 8.

Table 8 Results of Economic Evaluation

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)
198.81	17.40 %	1.53	72.43

Source: Study Team

The results of the financial evaluation based on the above conditions are summarized in Table 9.

Table 9 Results of Financial Analysis

Financial Internal Rate of Return (FIRR)	Weighted Average Cost of Capital (WACC)	Financial Net Present Value (FNPV)
2.05 %	1.53 %	US$ 22.70 million

Source: Study Team

As a result, rehabilitation/reconstruction of the railway between Limbe and Border is considered to be economically and financially viable.

10. Environmental and Social Considerations

(1) SEA

The Study uses the SEA methodology to evaluate qualitatively the environmental, social, and economic impacts of the regional transport development programme for the Sena Corridor.

The overall cumulative results for the Sena Corridor's Master Plan are summarised in Table 10. Regarding Alternatives 1 and 3, although both the social impact and environmental impact include some expected negative factors, a local economic impact can have a significant positive impact on the Study Area. For example, improving the disconnection at Chiromo will benefit the local population in terms of access to agricultural products, schools and health posts.

Table 10 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

(2) IEE

a) Possible Environmental and Social Impacts of the Projects

- Significant positive impacts for local residents by construction of the Chiromo Road Bridge.
- Significant positive impacts for local residents along the railway line by rehabilitation and reconstruction of the railway between Limbe and Border.
- Members of the boat association will lose their main source of income.
- Resettlement of about 20 huts and shops with grass structure in Makhanga.
- Land acquisition will be necessary for realignment of the road and railway line.
- Relocation of huts illegally occupying the railway.
- The expected difficulty of draining flood water on the land between the existing railway embankment and planned road embankment.
- Increase of dust, diesel emissions, noise, vibration, solid waste, risk of traffic accidents, and prevalence of HIV/AIDS by workers may be expected during construction.
- Risk of traffic accidents after improvement of the road.
- Risk of accidents between a train and a vehicle, bicycle or pedestrian at level crossings and on the Kamuzu Truss Bridge.

b) Mitigation Measures

Table 11 summarized mitigation measures to be taken for the above negative impacts.

(3) Necessity of EIA

The executing agencies of the project should prepare an EIA during the feasibility study phase, including public consultations. The results of the EIA should be incorporated in the Environmental Management and Monitoring Plan, which is mandatory in Malawi.

Table 11 Mitigation Measures

Impact	Mitigation Measure
Member of boat association will lose main source of income	- Introduce other job opportunities - Mitigation measures to create a source of income will be prepared in the F/S
Resettlement by realignment of road and railway reconstruction	- Compensation according to GoM regulation. - Provision of alternative land plots
Land acquisition by realignment of road and railway	- Acquire land according to GoM regulation - Provision of alternative land plots
Stop farming in railway ROW	- Compensation according to GoM regulation
Increase of dust, diesel emissions, noise, vibration, solid waste, risk of traffic accidents and prevalence of HIV/AIDS by workers during construction	- Environmental management plan by contractor
Risk of traffic accidents by vehicle traffic with pedestrians and bicycles	- Installation of traffic safety devices - Traffic safety education in primary schools
Risk of accidents by train with vehicles, bicycles and pedestrians	- Installation of safety devices at level crossing - Traffic safety education in primary schools.

Source: Study Team

11. Institutional Arrangements for Implementing the Master Plan Programme

(1) Institutional Arrangements for the Road Sub-sector

MoTPI and RA should focus on the operation and maintenance of road assets, by routine and periodic maintenance by the following programmes:

- Routine maintenance work should be carried out according to the O&M programmes.
- Periodic maintenance work should be carried out according to the O&M programmes for priority road sections identified by the HDM-4 model.
- Inspection and maintenance of drainage structures and bridges should be carried out annually to identify and repair/clean disorderly parts of structures.

(2) Institutional Arrangements for the Railway Sub-sector

The following institutional arrangements are necessary for executing the Master Plan for the railway:

- The Railway Division of MoTPI must be given greater authority to supervise CEAR.
- The tariff policy must be established.
- The problems and issues of the current concession with CEAR should be considered carefully for revision of the concession agreement.

12. Capacity Development Programme

(1) Capacity Development Programme in the Study

- The capacity development was planned to be carried out mainly through OJT training while Japanese experts were carrying out their studies in Malawi.
- JICA selected one counterpart personnel for one of the Training and Dialogue Programmes entitled “National and Regional Development Policy”.

(2) Evaluation of Capacity Development Programme in the Study

- Ability of counterparts to prepare the transport master plan and the Pre-F/S for both the road and railway projects has definitely been improved, particularly by process of studies carried out by JICA through OJT and preparation/presentation in technology transfer seminars.

13. Conclusions and Recommendations

(1) Conclusions

- The Basic Policy for development of the Sena Corridor is proposed in line with the national development policy for sustainable economic growth and poverty.
- Based on the Basic Policy, development of the Sena Corridor is examined in terms of the international north-south axis, the domestic north-south axis and arterial transport networks in the Study Area.
- Master Plans for the road and railway sectors are proposed divided into short-term (2015), medium-term (2020) and long-term (2030), followed by the Development Concept and Strategy.
- The proposed projects for the Master Plan in the Study are judged as technically and economically feasible. Hence, it is necessary to start preparing an investment programme for the Master Plan.
- The projects in the Master Plan will greatly contribute to sustainable economic growth, poverty alleviation and improvement of living conditions in the Study Area to sustainable economic growth, improving the international competitiveness of export products, and strengthening the redundancy of transport networks in Malawi, and to strengthening the international north-south axis in the region in Southeastern Africa.
- Reconstruction of the S151 road between Makhanga and Bangula is judged as technically and economically feasible.
- Rehabilitation and reconstruction of the railway between Limbe and Border (Marka) is technically, economically and financially feasible.
- The results of the IEE for both the road and railway projects identified minimal negative environmental and social impacts as a result of these projects.

(2) Recommendations for Project Implementation

- The GoM should continue dialogs with counterparts in the GoMZ.
- MoTPI can inform the outcome of the Master Plan as well as the Pre-F/S to development partners for possible assistance with project implementation.
- MoTPI should carry out the F/S and the EIA of priority projects identified as feasible under the Pre-F/S at an early stage.
- MoTPI should allocate sufficient budget to the compensation and land acquisition.

(3) Recommendations for Institutional Arrangements

- RA could consider changing the classification of S151 to “Main Road”.
- MoTPI needs to secure adequate budget for operation and maintenance of the road sub-sector to maximise use of the existing road assets.

- MoTPI needs to strengthen the organisation of the Railway Division, develop the capacity of personnel, and revise the Railway Act to supervise and check the performance of CEAR.
- MoTPI will need to review the present concession with CEAR starting from 2014.

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EXECUTIVE SUMMARY

SUMMARY

1. Introduction

(1) Background of the Study

Malawi is a land locked country, surrounded by Mozambique, Zambia and Tanzania, with a population of about 13 million and a per capita gross national income of US$ 280 in 2008. Due to long transport distances to ocean ports in neighbouring countries, transport costs to ports are very high, and this is one obstacle to the attainment of sustainable international competitiveness of domestic products. Under these circumstances, the Government of Malawi (GoM) has selected "Development of Transport Infrastructure" as one of the most important sectors in the Malawi Growth and Development Strategy (MGDS) prepared in 2006.

The Sena Corridor defined in the Study used to be the main route from Malawi to the ocean when the roads and railways were well maintained. However, during the civil war in Mozambique, these infrastructures were destroyed making most sections impassable. In addition, embankments of the railway and road between Chiromo and Bangula were washed away by floods in 1997, causing both the road and railway to become impassable at that section.

(2) Objectives of the Study

- To prepare a Master Plan for the development of the Sena Corridor in order to secure multiple international corridors for national security,
- To carry out a pre-feasibility study (F/S) for the projects selected based on the results of the Master Plan. Selected projects for the pre-F/S are as follows:
  - Reconstruction of S151 road between Bangula and Makhanga (9 km).
  - Rehabilitation and reconstruction of railway between Limbe and Border (Marka) (201 km).

(3) Study Area

The Study Area in Malawi covers nine districts in the Southern Region of Malawi and four provinces in Mozambique as shown in Figure 1.

Source: Study Team

Figure 1 Study Area

2. Outline of the Study Area

(1) Definition of the Sena Corridor

The Sena Corridor is defined as a traffic route connecting Blantyre to Beira Port and an additional

southern gateway to Malawi from its historical backgrounds. Figure 2 shows the location of the Sena Corridor.

(2) Regional Coordination Programmes

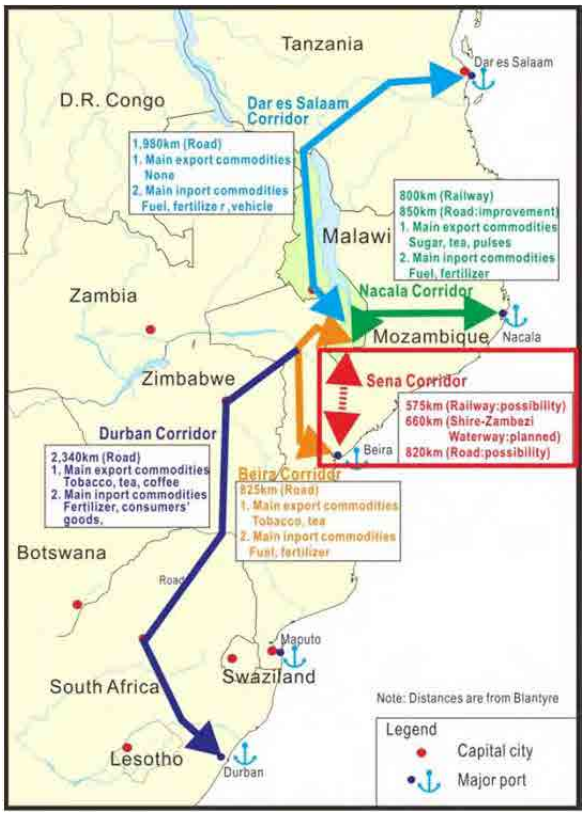
Malawi is a member of the Southern African Development Community (SADC) and Common Market for Eastern and Southern Africa (COMESA). It is necessary for Malawi to coordinate with other member countries to strengthen international transport corridors to secure transport routes for export and import products.

(3) Economic Condition in Malawi and the Study Area

The GDP per capita has been lowest in Malawi (US$ 343 in 2010), however, the GDP growth rate was higher in Malawi than in neighbouring countries between 2007 and 2009.

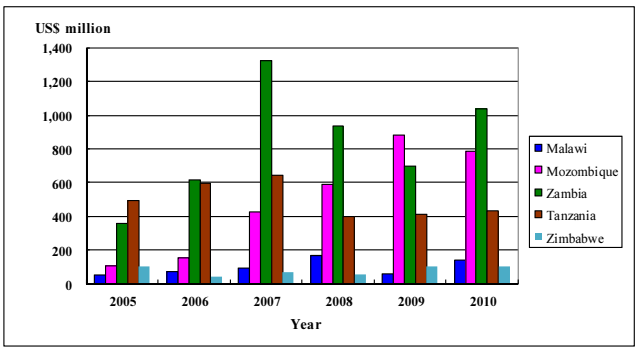
Foreign direct investment (FDI) into Malawi is very low (US$ 140 million in 2010) compared with other three neighbouring countries (Mozambique: US$ 789 million, Zambia: US$ 1,041 million, Tanzania: US$ 433 million) (see Figure 3). This situation is considered by business people as the following reasons;

- Strict foreign exchange control,
- Shortage of power and fuel supply
- Higher transport costs



Source: Study Team

Figure 2 Location of the Sena Corridor



Source: Compiled by the Study Team using WB databank, Jan. 2012

Figure 3 Foreign Direct Investment

(4) Social Conditions in Malawi and the Study Area

a) Land Use in the Study Area

Land use in the Study Area is mainly agricultural, consisting of the Shire Highland with widespread cultivation of tea, nuts, pigeon peas and food crops, the Lower Shire area (western side) with cultivation of sugar and cotton, and cattle breeding (dry area) and the Lower Shire area (eastern side) with cultivation of food crops, bananas and cattle breeding (see Figure 4).

b) Population

In the Southern Region, the population in Blantyre (1,001,984 in 2008) is particularly high while that in Mwanza (92,947 in 2008) is low. The population by region and district and annual increase rate between 1998 and 2008 (average of 2.4% of Southern Region) are shown in Table 1.

Table 1 Population by Region and by District for the Southern Region

Region/District	1988	1998	2008	Growth Rate 1998/2008
Northern Region	911,787	1,233,560	1,708,930	3.3%
Central Region	3,110,986	4,066,340	5,510,195	3.1%
Southern Region	3,965,734	4,633,968	5,858,035	2.4%
Mangochi	496,578	610,239	797,061	2.7%
Machinga	301,849	369,614	490,579	2.9%
Balaka	213,416	253,098	317,324	2.3%
Zomba	441,615	546,661	667,953	2.0%
Chiradzulu	210,912	236,050	288,546	2.0%
Blantyre	589,525	809,397	1,001,984	2.2%
Mwanza	121,513	63,220	92,947	3.9%
Neno	N/A	74,795	107,317	3.7%
Thyolo	431,157	458,976	587,053	2.5%
Mulanje	419,928	428,322	521,391	2.0%
Phalombe	218,134	231,990	313,129	3.0%
Chikwawa	316,733	356,682	434,648	2.0%
Nsanje	204,374	194,924	238,103	2.0%
Total	7,988,507	9,933,868	13,077,160	2.8%

Source: Population and Housing Census 2008 and 1998
Note: Shaded lines are districts in the Study Area

c) Population Density

The population in the Study Area is mainly distributed in highland districts, i.e. Thyolo District (0.34 person/km^2) owing to the higher proportion of arable land for cultivation and plantations, while the population distribution in the Lower Shire, i.e., Chikwawa (0.09 person/km^2) and Nsanje Districts (0.12 person/km^2), is limited. In addition, the fact is that the population is high in the area along arterial roads (Main Roads and Secondary roads).

d) Poverty Ratio

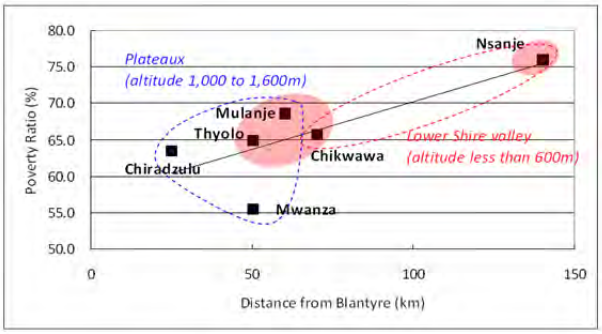
The poverty ratio is highest in the Southern Region with 64.4% below the poverty line[1]. The ultra poverty ratio in the Southern Region is also the highest at 31.5%, compared with 22.4% for the whole of Malawi. Nsanje District has highest poverty ratio (76.0%) and ultra poverty ratio (44.3%) (see Figure 5). Thyolo District has largest population in poverty (381,000) (see Figure 6).

e) Problems Caused by Regional Disconnection in the Chiromo Washway Area

Water overflowed into Elephant Marsh when backwater of the Shire River washed away the embankment of the railway and S151 road near Bangula in March 1997. The regional disconnection at Chiromo makes life difficult for people living on the eastern side of the washaway section.

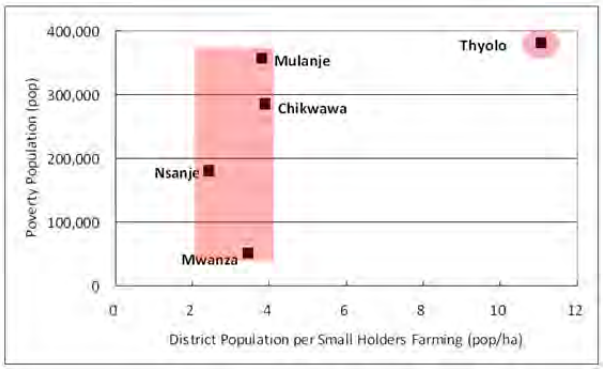
Source: Study Team

Figure 4 Land Use Pattern in the Study Area



Source: Prepared by Study Team based on IHS2

Figure 5 Poverty Ratio and Distance from Blantyre



Source: Study Team

Figure 6 Poverty Population and District Population per Small Holder Farming

[1] Poor: MWK 16,165 per annum, Ultra poor: MWK 10,029 per annum

Problems caused by this event are 1) Additional burden of transport cost by boat, 2) Longer travel time between origin and destination, 3) Impassable during the rainy season, 4) Risk to life and 5) Decrease of monthly income for people living in Chiromo and Makhanga. The washaway at Chiromo also affects people living along the railway line between Luchenza and Sankhulani who lost the opportunity to sell products at markets because the train now runs only weekly instead of daily.

(5) National Development Policy and Programmes

a) MGDS

Sustainable economic growth is one of the main targets under the MGDS. Sustainable economic growth is central to Malawi's ability to reduce poverty, achieve the MGDS and gain food self-sufficiency. Without this growth, it will be impossible to create wealth and employment for all the people of Malawi, transform from a consumption-based economy to a production-based economy, and gradually emerge as an industrial nation.

b) PSIP

The Ministry of Development Planning & Cooperation (MoDPC) received proposals from relevant government agencies, and identified programmes and projects that are consistent with GoM's strategic objectives and priorities as aligned with the MGDS and links them to available financing mechanisms. Those selected projects are listed in the Public Sector Investment Programme (PSIP).

3. Present Situation of Transport System in the Study Area

(1) Present Situation of Road Sub-sector

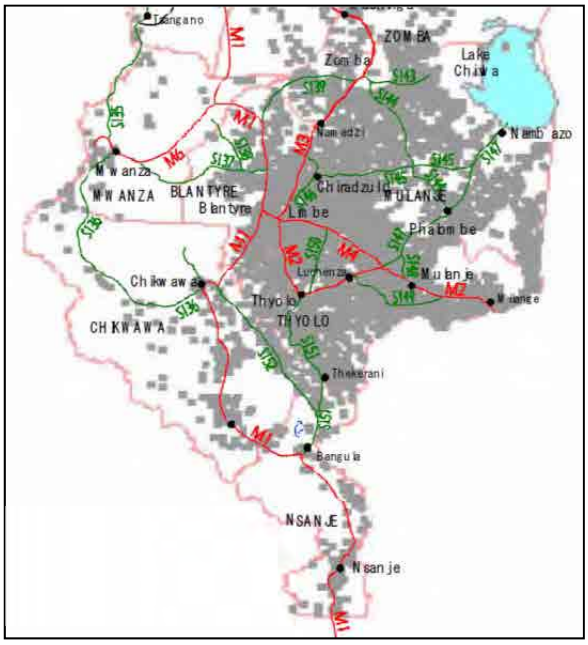
a) Road Network

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.

b) Arterial Road Network in the Study Area

M1, which is one of the most important arterial roads as both a domestic and international corridor in Malawi, links the northernmost Tanzania border, the capital city of Lilongwe, the commercial city of Blantyre and the southernmost Mozambique border. The M1 road in the Study Area forms the north-south axis, between Blantyre and Marka Border Post, and linking major towns such as Nsanje, Bangula and Chikwawa (see Figure 7).

The east-west transportation axis in the Study Area is formed by three main roads (M2, M4 and M6). The M2 and M4 connect Blantyre with Muloza town at the



Source: Study Team

Figure 7 Population Distribution and Arterial Road Network in the Study Area

border post for Malawi and Mozambique in the southeast of the country. The M6 road connects Blantyre with Mwanza town which is at the border post between Malawi and Mozambique in the southwest. There are two transportation routes between Blantyre and Bangula, the latter being a town north of Nsanje District. The main route is the M1 road passing through Chikwawa District and a potential alternative is secondary road S151 passing through Thyolo District. S152, which runs along the district's boundary between Chikwawa and Thyolo Districts, links M1 and S151 which form the arterial road network in the Study Area. General condition of arterial road network in the Study Area is shown in Table 2.

Table 2 General Condition of Arterial Roads

Items	M1	S136	S151	S152
	Nsanje – Marka (26.9 km)	Chikwawa – Mwanza (106.4 km)	Makhanga – Bangula (9.7 km)	Thabwa – Seven (59.1 km)
1. Number of Lane :	1	1	1	1
2. Road Width :	6.0 m	4.0 to 5.0 m	5.0 m	6.0 m
3. Road Surface :	Earth	Earth	Earth	Earth
4. Travel Speed :	40 km/h	30 km/h	30 km/h	35 km/h
5. Terrain :	Flat (altitude 100 m)	Flat/Rolling/Mountainous (altitude 100 to 900 m)	Flat (altitude 100 m)	Flat/Rolling (altitude 100 m)

Source: Study Team

c) Major Problems of Road Sub-sector

Major problems of road sub-sector are summarised in Table 3 and Figure 8.

Table 3 Major Problems of Road Sub-sector

Major Problems	Routes-related			
	M1	S136	S151	S152
There is no alternative route for M1 between Blantyre and the Lower Shire area due to the disconnection of S151 at Chiromo.	X		X	
The service level of M1 between Blantyre and Thabwa is low due to its steep gradient.	X			
Earth road sections are impassable for several hours or days when wadis become flooded in the rainy season.	X	X	X	
The road section between Vila Nova and Caia in Mozambique, which can be a part of the international corridor connecting to Beira Port, is unpaved, with a ferry crossing on the Shire River.	X			
There is no alternative international corridor for the Tete Corridor which links with Beira Port.	X			
The transport route from Chikwawa and Nsanje Districts to the Tete Corridor depends on M1 passing through Blantyre with steeper gradient and longer transport distance than the S136 route.	X	X		
Local roads to some railway stations between Khonjeni and Thekerani are in poor condition.			X	
The budget for maintaining paved roads (periodic and pothole patching) accounts for only about 1% of the entire maintenance programme.	X			
All roads are being maintained routinely, however the budget is very small and so repairing of drainage structures and cleaning of drains are inadequate.	X	X	X	X
The one-lane Shire Bridge will become a bottleneck when the Makhanga–Bangula section is reconstructed.			X	
Routes for transporting agricultural products in Thyolo and Chikwawa Districts with high population density are mostly unpaved.			X	X
The disconnection at Chiromo and the Mwanza River hinders the mobility and access of local people to markets, schools and medical facilities.		X	X	

Source: Study Team

(2) Present Situation of Railway Sub-sector

a) Railway Operator

Central East African Railways Company (CEAR) currently operates 710 km of single-track line. The concession agreement allowing it to operate was signed between the GoM and CEAR on 15th November, 1999, with operation actually beginning on 1st December, 1999. The move to privatise the railway was driven by the need to improve the transport efficiency within Malawi and between Malawi and Nacala Port, to reduce the government subsidies for the railway, and to encourage private investment. Although the railway used to carry most of Malawi's international traffic, the freight transport service continues to decline and switch to road transport.

b) Railway Network

The railway network of Malawi is a non-electrified single-track line of narrow gauge (1,067 mm). The total length of lines is 797 km, 706 km of which is operational. There are two rail routes in Malawi, a 696 km long route from the Border Station at Marka (the border post with Mozambique) to Mchinji (the border post with Zambia), and a 101 km long route from Nkaya to Nayuchi (the border post with Mozambique).

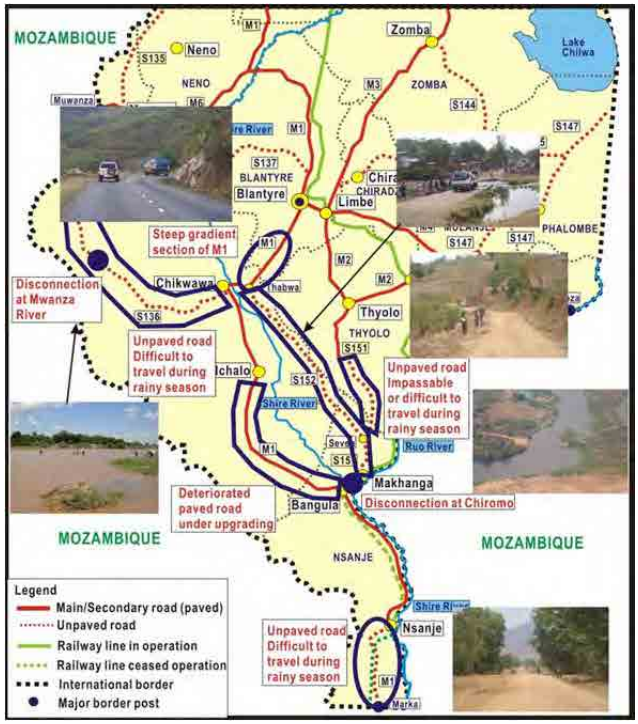
c) New Line Construction Plan

Brazilian company Vale (*Brazilian Companhia Vale do Rio Doce*) signed a Memorandum of Understanding (MoU) in April 2011 and a concession agreement in December 2011 with the GoM on the construction/rehabilitation and operation of a railway line from Moatize in Mozambique to *Nacala-á-Velha* Port in Mozambique, through Malawi.

Vale plans to construct a new line connecting the Moatize coal mine with Nacala Port via Thambani

Source: Study Team

Figure 9 Major Problems of Railway Sub-sector



Source: Study Team

Figure 8 Major Problems of Road Sub-sector

Vale plans to construct a new line connecting the Moatize coal mine with Nacala Port via Thambani

in Chikwawa District and Nkaya in Balaka District to transport their coal. The route distance is 906 km. The design load criterion being considered is 26 tonnes/axle compared with CEAR's construction standard of 20 tonnes/axles, but this design has not been finalised. Construction work will commence within 2012 and completion is planned for 2014. They also plan to construct a new locomotive workshop at Liwonde where a small workshop is operated now, to maintain the locomotives.

d) Major Problems of Railway Sub-sector

Major problems of railway sub-sector are summarised in Table 4 and Figure 9.

Table 4 Major Problems of the Railway Sub-sector

Major Problems	Section-related					
	A	B	C	D	E	F
Passenger trains run only once a week.	X	X				
There are no freight trains services since the washaway.			X	X	X	X
There is no proper maintenance due to lack of financial resources.	X	X	X	X	X	X
30kg/m rails on aged steel sleepers and insufficient ballast	X	X	X	X	X	X
A GPS-based communication system is not used.	X	X				
Operation of freight trains is unreliable due to insufficient rolling stock.	X	X				
Transport capacity is insufficient due to lack of diesel locomotives.	X	X				
CEAR is not properly supervised by MoTPI.	X	X	X	X	X	
There is no OJT for CEAR personnel.	X	X	X	X	X	
Wooden sleepers on the bridges are badly rotten	X	X	X	X	X	X
➢ Some sections without drainage have been flooded. ➢ The area between Sankhulani and Osiyani stations is often flooded. ➢ There are many bushes, which must be cut down properly.		X				
➢ The length of the major washaway section is 380 m. ➢ The toes of the embankments are encroached upon by the river ➢ There are seven pipe culverts with insufficient cross-sectional area			X			
Although there is no washaway part in this section, there are minor collapses of embankments at 19 locations.				X		
Eight washaway sections were found, among them the section with a 60m wide wadi should be reconstructed with bridges.					X	

NOTE: A: Limbe–Luchenza, B: Luchenza–Makhanga, C: Makhanga–Bangula, D: Bangula–Nsanje, E: Nsanje–Border (Marka), F: Villa Nova-Dona Ana

Source: Study Team

(3) Present Situation of the Inland Waterway Transport Sub-sector

At present, the SADC Secretariat is preparing to select a consultant to carry out the feasibility study of the Shire–Zambezi Waterways Development Project, which will be financed by AfDB. The results of this feasibility study will form the basic policy of the GoM and the Government of Mozambique (GoMZ) for developing the Shire–Zambezi Waterway Corridor and international cooperation for its operation.

The overall objective of the project is to contribute to the provision of an efficient transport system, with affordable

Source: Study Team

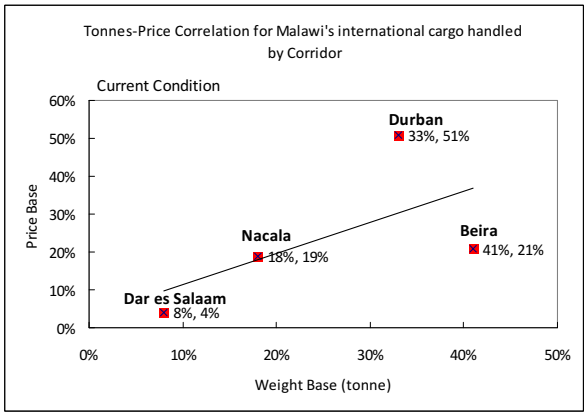
Figure 10 Location of Shire-Zambezi Inland Waterway

costs and reliable modes for the countries sharing the Zambezi River Basin by opening up the Shire and Zambezi Rivers for navigation to the Indian Ocean (see Figure 10).

(4) Transport Corridor Development in Neighbouring Countries

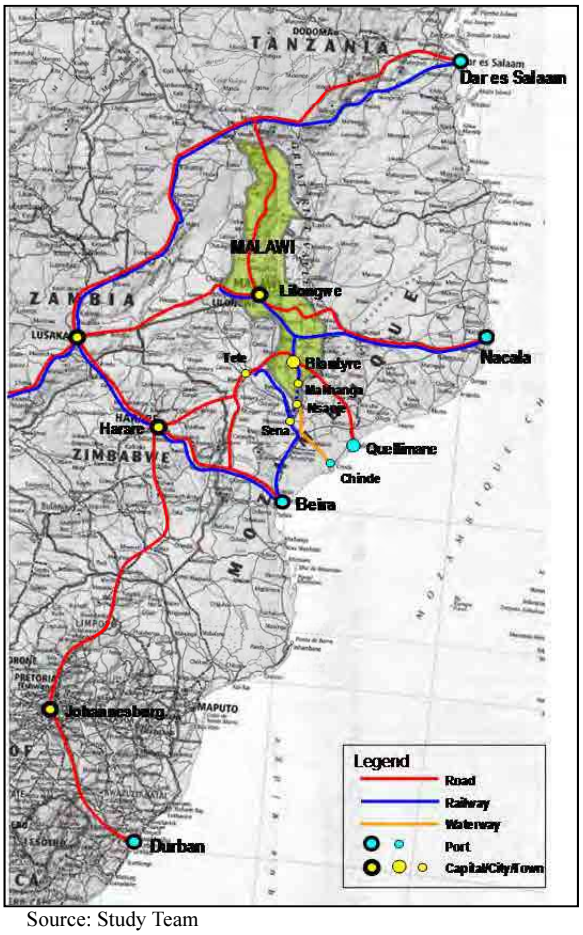
a) Transport Corridor Network

The existing transport corridor networks connecting with Malawi are Beira, Durban, Nacala and Dar es Salaam Corridors. Durban Corridor (to/from Durban Port and the Republic of South Africa (RSA)) carries 51% of Malawi's international cargos by value. Beira Corridor carries 41% of Malawi's international cargos by value (see Figure 11 and 12).



Source: Study Team

Figure 11 Tonnes-Price Correlation for Malawi's International Cargos Carried by Corridor



Source: Study Team

Figure 12 Transport Corridor Networks

b) Major Issues of the Beira and Nacala Corridors

The major issues for both the Beira and Nacala Corridors are summarised below.

- To develop domestic transport networks which will strengthen export routes to Nacala Port, in consideration of increasing traffic capacity and logistics efficiency owing to the Nacala development programmes.
- To promote a modal shift to change the transit system which depends heavily on roads, because traffic demand will grow for the Nacala road due to large-scale mineral products coming from neighbouring countries to Nacala Port by railway, and also for the Tete road in accordance with Malawi's economic growth.
- To establish an efficient logistics system by developing a modern railway system and minimising transhipment time and cost. In practice, transit costs by road are similar to those by railway for a distance of around 700 km because transhipment is required.
- To build alternative routes to secure and strengthen access to Beira Port, because Malawi's regional socio-economic activity would struggle to continue if its only transport route to/from

Beira Port were to be cut, and because it is also difficult to guard against unforeseen situations outside Malawi.

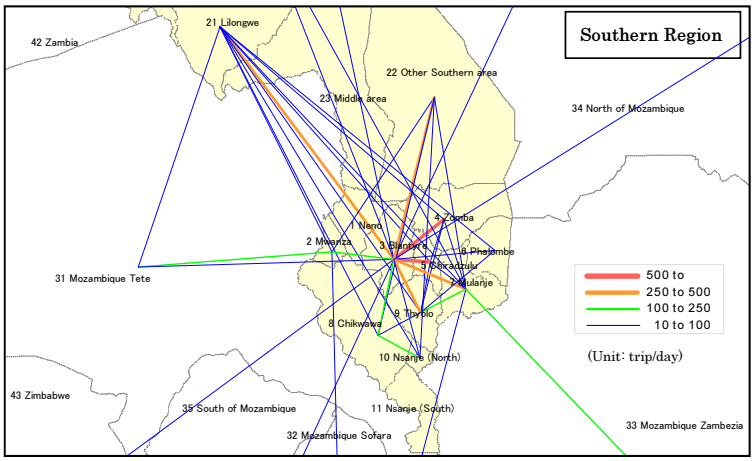
- To strengthen and improve internal access to border posts, especially those which are positioned as the Southern Gateway, in accordance with future traffic demand.
- To communicate and formulate a comprehensive Sena Corridor co-development programme for the development of the Sena routes bilaterally involving state governments, regional initiatives, donors and the private sector.

4. Future Traffic Demand Forecast

(1) Result of Traffic Surveys

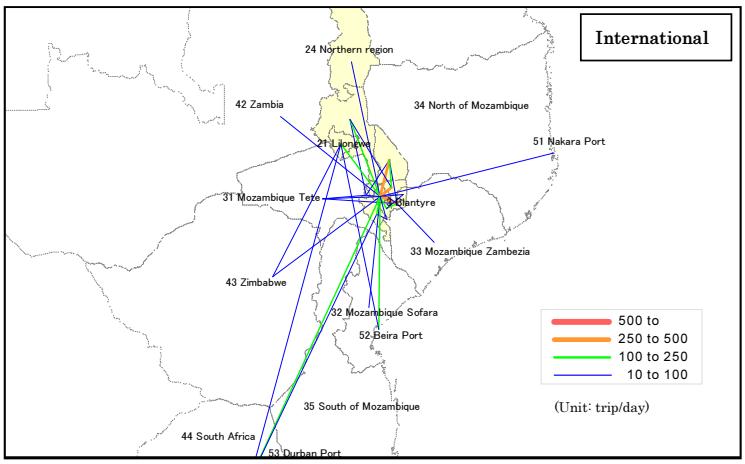
The Study Team carried out traffic surveys (traffic volume count survey and roadside origin and destination (O/D) survey) to assess the present traffic situation and to formulate O/D matrices of passenger trips and freight trips related to the Sena Corridor. The O/D distribution patterns of passenger cars and freight traffic are shown in Figures 13 and 14, respectively.

Freight traffic trips are spread over a wide area. Especially, trips to Nacala and Beira Ports as well as to Republic of South Africa (RSA) are predominant. This means that freight traffic in the Southern Region of Malawi extended over a wide area.



Source: Study team

Figure 13 O/D Distribution Pattern of Passenger Cars



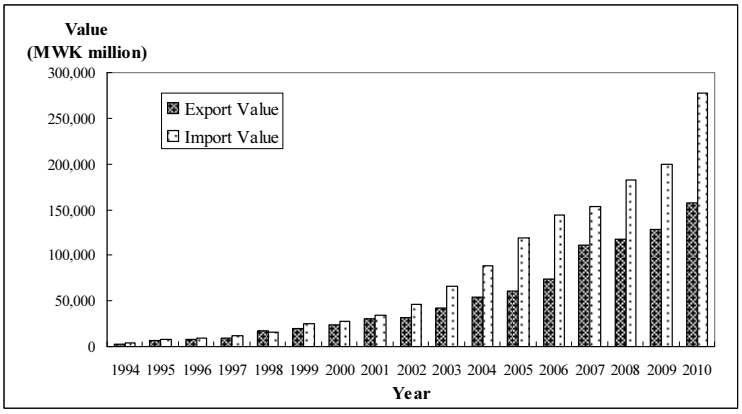
Source: Study team

Figure 14 O/D Distribution Pattern of Freight Traffic

(2) Results of Logistics Survey

a) Exports and Imports

- The value of exports and imports for Malawi from 1994 to 2010 has been increasing in line with economic growth. The value has been increasing for both imports and exports. Value of imports is almost

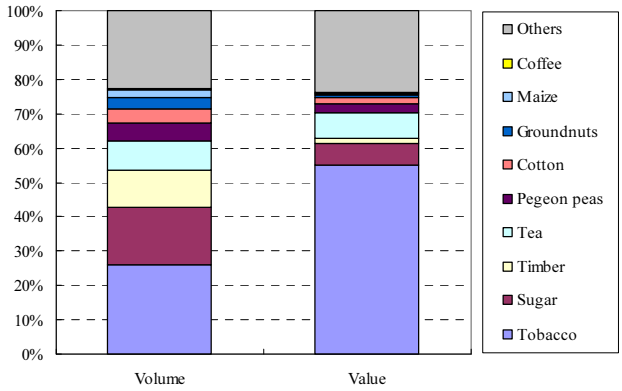


Source: Reserve Bank of Malawi

Figure 15 Export and Import Value

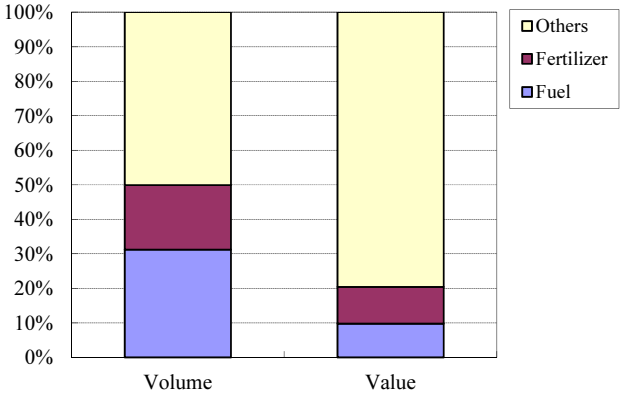
twice the value of exports in Malawi (see Figure 15).

- Tobacco has been Malawi's leading export for over 30 years and the situation has not changed. Sugar and tea occupy second or third place by value every year. Regarding import, fuel (petrol, diesel oil and paraffin) is always in top place by volume (see Figure 16 and 17).
- The main transportation mode is by truck/trailer with containers taking almost 90%. Railway accounts for less than 10%
- Europe accounts for the highest proportion of export at 30%, while RSA accounts for a dominant 43% of imports, regarding the share of origin/destination of 2010 export/import by volume.



Source: 2010 Customs data, Malawi Revenue Authority

Figure 16 Main Export Commodities (2010)



Source: 2010 Customs data, Malawi Revenue Authority

Figure 17 Main Import Commodities (2010)

b) Transport Cost

The transport cost of import and export commodities is higher on the Durban and Dar es Salaam Corridors; in particular, the import transport cost from Durban Port is the highest (US$ 7,500 per 40 ft container) due to its longest transport distance (see Table 5).

Table 5 Comparison of Transport Cost by Corridor

Corridor	Distance to/from Blantyre (km)	Transport Cost (US$/40ft Container)	
		Export	Import
Beira	825	2,300	2,800
Nacala	800	1,940	2,500
Durban	2,340	4,400	7,500
Johannesburg	1,820	3,200	5,800
Dar es Salaam	1,980	3,500	5,000

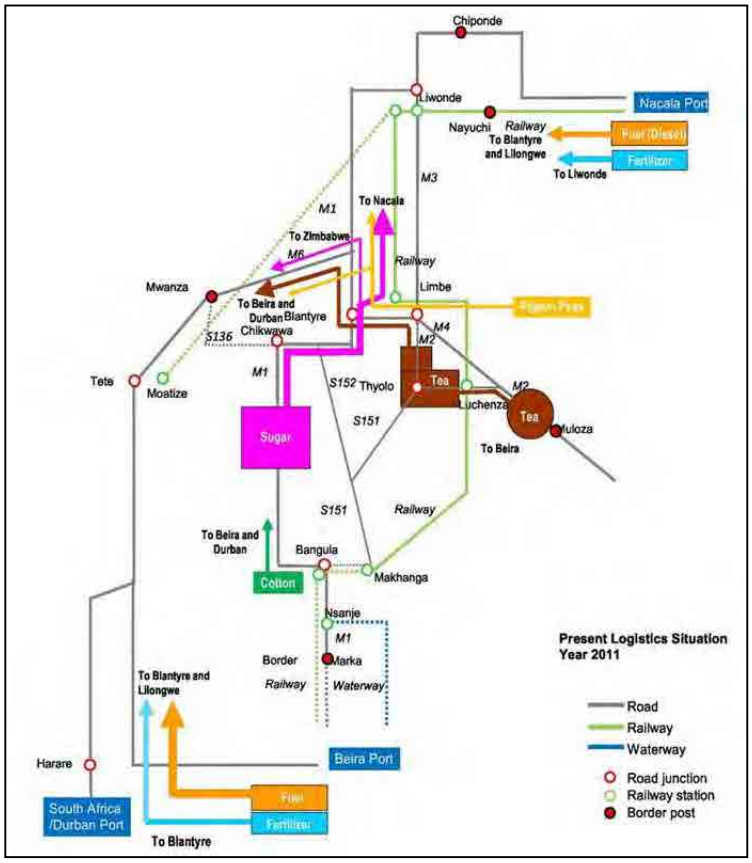
Source: Study Team

c) Cash Crop Transport Route (2011)

Cash crops cultivated in the Study Area are transported to ocean ports by the following routes and characteristics as shown in Figure 18.

- Products are mainly placed in containers at Blantyre or Limbe (Logistics centre).
- Sugar is mainly transported to Nacala Port by railway, except exports to Zimbabwe by truck (bulk).
- Pigeon peas are transported to Nacala (by railway), Beira and Durban Ports (by road).

- Longer transport routes to Durban and Beira Ports (Tea, Tobacco, Cotton, Pigeon Peas).
- Steep gradient sections between Blantyre and Thabwa hinder transportation by limiting the loading capacity.



Source: Study Team

Figure 18 Cash Crop Transport Route (2011)

(3) Future Traffic Demand Forecast

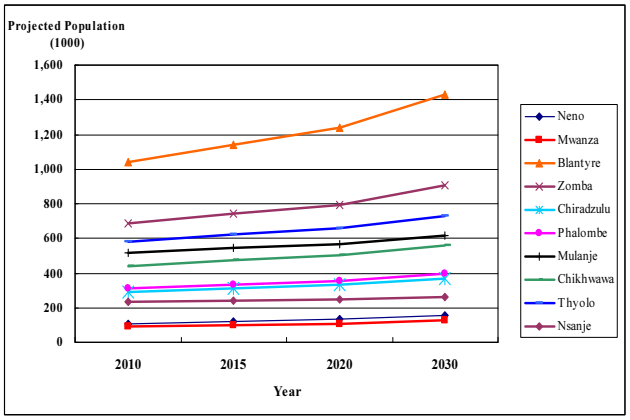
a) Methodology of Future Traffic Demand Forecast

In forecasting future traffic demand, passenger vehicles and freight vehicles are estimated separately.

- As for passenger vehicles and buses, the trip generation/ attraction model using the future socio-economic framework as variables is initially built based on the traffic survey results. The number of passenger cars and buses are forecasted using the share between passenger car and buses as well as average number of passengers.
- Regarding the forecast of freight vehicles, the volume of export and import is estimated separately. The future transportation volume is estimated based on the export and import volume of each commodity by using the modal share by commodity and converted into the number of freight vehicles with loading capacities by commodity.

b) Future Socio-economic Framework

- Projected population by district is used for forecasting import volume of commodities, domestic consumption of agricultural products and passenger flow volume. Future population projection shows in Figure 19.
- Projected population in 2030 is 1.38 times than in 2010.
- GDP growth ratio is used to forecast import volume and passenger flow volume. Future GDP projection shows in Figure 20.
- Projected GDP in 2030 is 3.03 times that in



Source: Study Team

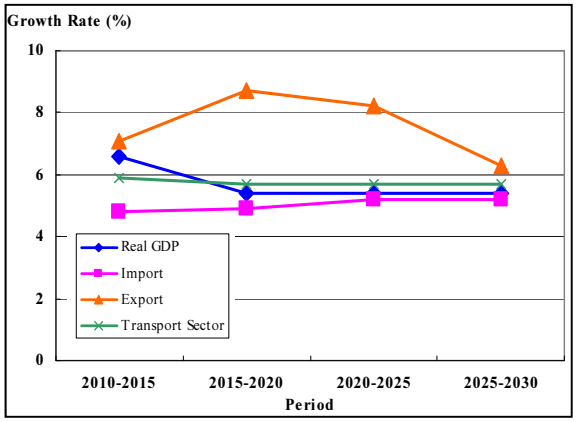
Figure 19 Future Population Projection

2010.

c) Cargo Movement Forecasts

The major findings of the cargo movement forecasts are as follows:

- Approximately 80% of export cargo uses the Beira Corridor to Beira Port and the Durban Corridor to RSA and Durban Port at present.
- Approximately 64% of import cargo uses the Beira and Durban Corridors from Beira Port and RSA, while 14% of import cargo uses the Nacala Corridor at present.



Source: TSIP

Figure 20 Future GDP Projection

- In 2030, about 51% of export cargo will use the Nacala Corridor, while the share of the Beira and Durban Corridors will decrease to 43%.
- The huge demand for coal from the Moatize coal mine and copper from Zambia will consume most of the capacity of the Nacala Railway with only the remaining capacity available for freight to/from Malawi.
- This trend will be the same in 2030, even though the demand for import cargo will almost triple.

d) Present and Expected Future Transport Conditions

The Beira Corridor (road) carries 41% of Malawi's international cargo at present, which will decrease to less than 17% in 2030. The Nacala Corridor (road and railway) accounts for 18% at present, which will increase to 44% in 2030. The Sena Corridor will account for at least 19% by 2030. The present and expected future transport conditions by each corridor are summarised in Table 6.

Table 6 Present and Expected Future Transport Conditions

Corridor	Mode	Distance from Blantyre (km)	Present Condition		Expected Future Condition	
			Share (tonne)	Commodity	Share (tonne)	Commodity
Beira (Tete)	Road	825	41 %	Export: Tobacco, Tea, Sugar, Cotton Import: Fuel, Fertilizer, Wheat	(17 %)*	Export: Tobacco, Tea, Sugar, Cotton Import: Fuel, Fertilizer, Wheat
Nacala	Railway	800	18 %	Export: Sugar, Tea, Pulses Import: Fuel, Fertilizer	32 %	Export: Sugar, Tea, Pulses, Nickel Import: Fuel, Fertilizer
	Road	850		-	12 %	Export: Tea, Pulses Import: Fuel, Fertilizer
Durban	Road	2,340	33 %	Export: Tobacco, Tea, Coffee Import: Fertilizer	2 %	Import: Fertilizer
Johannesburg	Road	1,820		Import: Consumer goods	11 %	Import: Consumer goods
Dar es Salaam	Road	1,980	8 %	Import: Fuel, Fertilizer, Vehicles	7 %	Import: Fuel, Vehicles
Sena	Railway	575	-	-	14 %	Export: Tobacco, Sugar, Tea, Alumina, Titanium Import: Fuel, Fertilizer
	Road	820	-	-	(17 %)*	Export: Tobacco, Tea Import: Fertilizer, Fuel
	Inland waterway	530	-	-	5 %	Export: Cotton Import: Fertilizer

Note: * - Total share between Blantyre and Beira Port

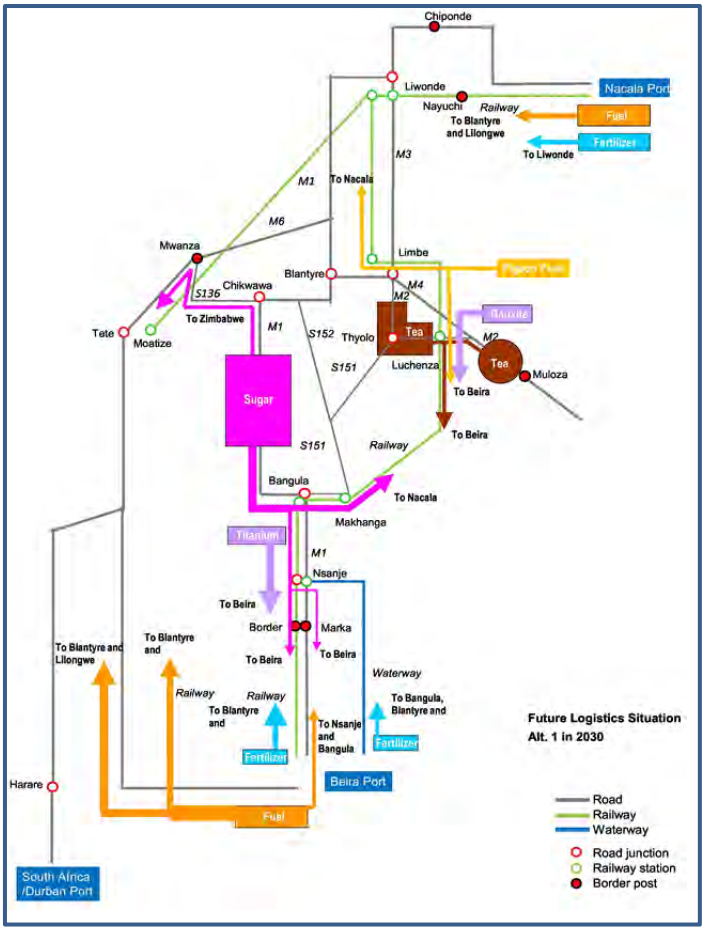
Source: Study Team

e) Cash Crop Transport Route (2030)

Cash crops cultivated in the Study Area will be transported in 2030 as shown in Figure 21.

f) Traffic Assignment (2030)

The results[2] of assignment of future freight volume and vehicular traffic on alternative transport networks indicate that 1,648 million tonnes/year of freight will go through the Sena Corridor if every transport network is connected to Beira Port (see Figure 22). This increased freight volume partly results from diversion of freight demand from the Tete Corridor. The cumulative freight-km will decrease from 8.6 billion tonnes-km (Zero option[3]) to 8.0 billion tonne-km (Alt. 1).



Source: Study Team

Figure 21 Cash Crop Transport Route (2030)

5. Basic Policy for Development of the Sena Corridor

(1) Significance of Development of the Sena Corridor

a) Historical Background on the Sena Corridor

- Before 1970: The Sena Corridor was the major gateway to Malawi
- 1970–1983: The Sena Corridor and Nacala Railway were the major gateways to Malawi
- 1983–1992: Malawi suffered greatly from loss of access to ports in Mozambique
- 1992–Present: Beira and Durban Corridors are major transport corridors

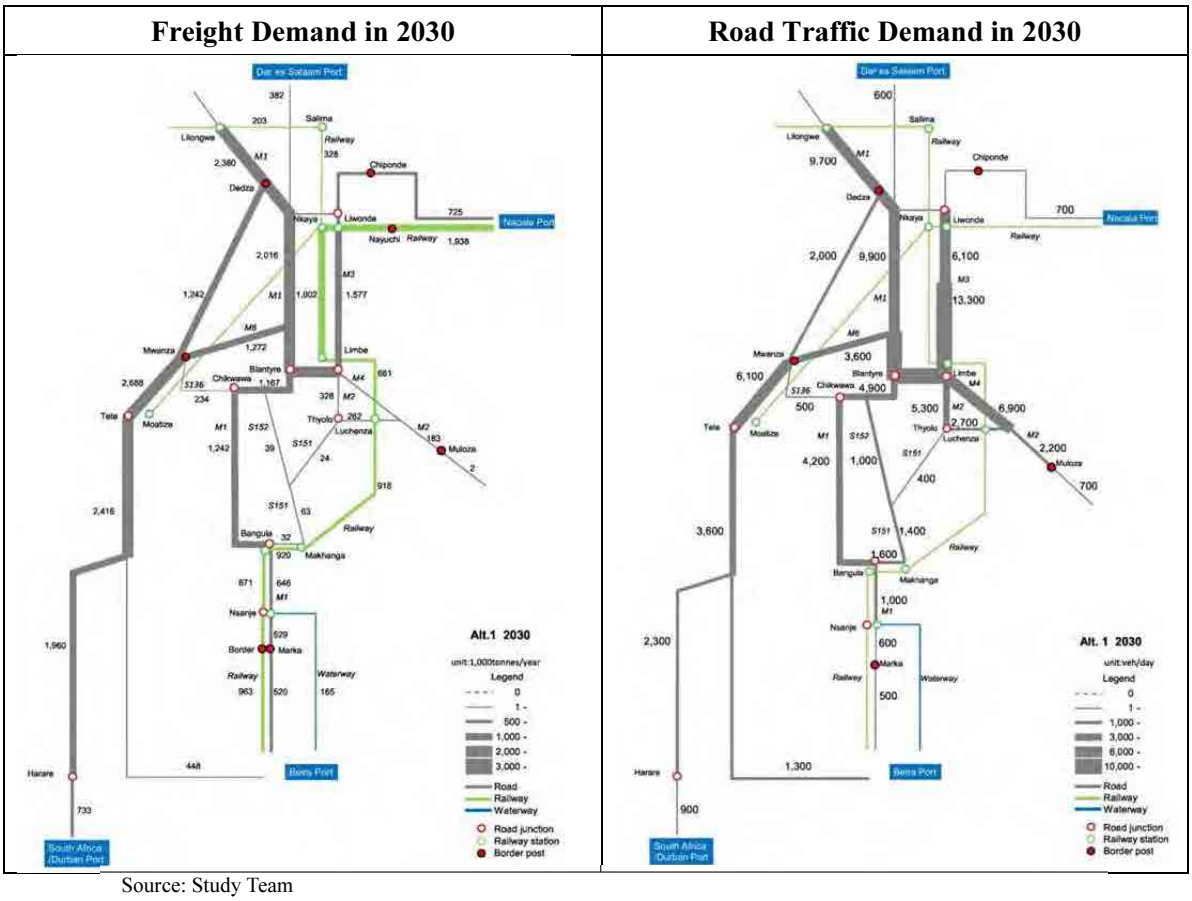
b) Landlocked Country and International Transport Corridors

For Malawi, there are several transport routes to neighbouring countries and some of the existing corridors are defined as international transport corridors as part of the North–South Transport Corridor defined by the SADC as gateways to neighbouring countries and ocean ports, as follows:

- Beira Corridor to Beira Port: Southwestern gateway
- Durban Corridor to RSA and Durban Port: Southwestern gateway
- Nacala Corridor to Nacala Port and Zambia: Eastern and Western gateway
- Dar es Salaam Corridor to Dar es Salaam Port: Northern gateway

[2] The results of assignment of future freight volume and vehicular traffic are based on the results of scenarios for developing the Sena Corridor followed by the alternative transport network for the Corridor.

[3] 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.



Source: Study Team

Figure 22 Freight and Road Traffic Demand in 2030 (Alt. 1)

c) Expected Future Function of the Sena Corridor

If the Sena Corridor is developed, it will serve as both an international corridor as well as a domestic corridor in the Study Area, instead of only as a domestic corridor at present.

(2) Basic Concept of Developing the Sena Corridor

a) Development Potentials and Major Issues

The development potentials and major issues in Southeastern Africa, Malawi and the Study Area are summarized in Table 7.

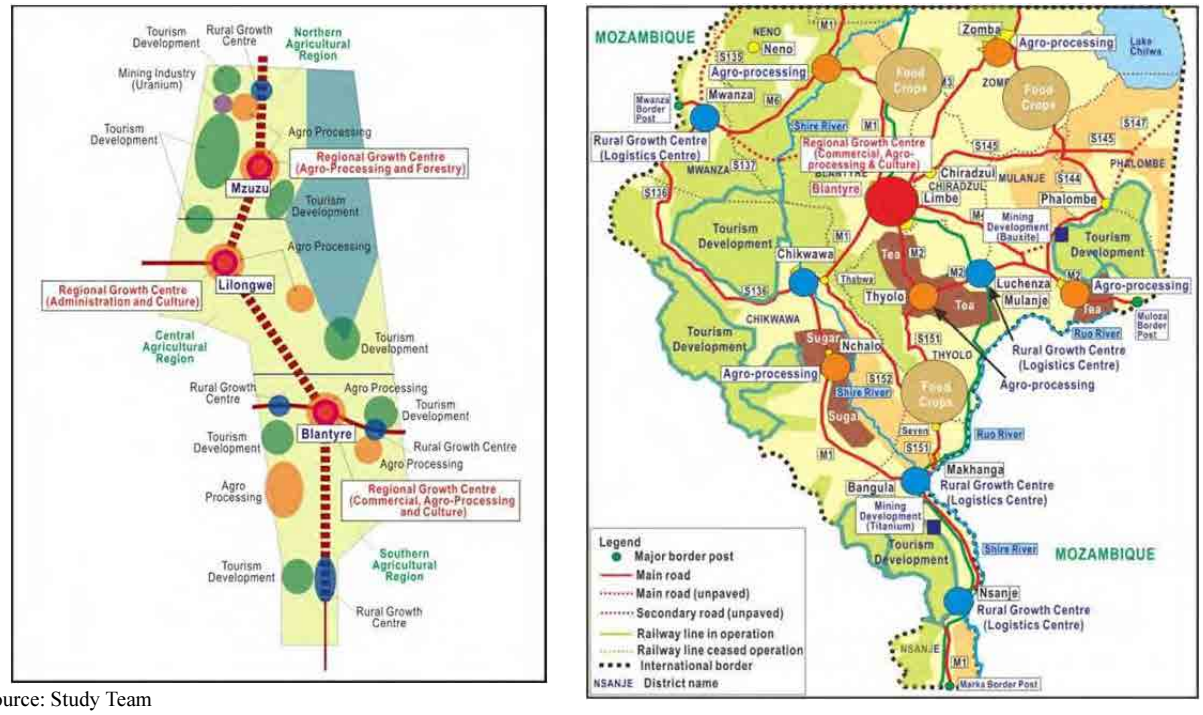
b) Development Potentials in Malawi and the Study Area

- The main industry in Malawi is agriculture and export-oriented products, such as tobacco, sugar, tea, and pulses, which have long been cultivated. The productivity of these products can be increased by providing farmers with sufficient materials, such as fertilizer.
- Figure 23 schematically illustrates the areas where investment is expected following the present PSIP. Since Blantyre serves as the commercial and agro-processing centre in Malawi, the district centres in the Southern Region will serve as rural growth centres to support Blantyre.
- There is mining potential in Mulanje and Nsanje Districts, and tourism potential in Chikwawa, Nsanje and Mulanje Districts in the Study Area.

Table 7 Present and Expected Future Transport Conditions

Area	Development Potentials	Major Issues
Southeastern Africa	1. Mineral deposit development. 2. Agricultural development. 3. Increase of workforce.	1. Transport network for logistics. 2. Regional economic integration under SADC Treaty.
Malawi	1. Functional classification of regional growth centres. 2. Development of agro-processing industry and tourism development. 3. Increase of workforce. 4. Exploitation of mineral deposits (uranium, bauxite, nickel, etc.).	1. Expensive and unreliable transport. 2. Lower Foreign Direct Investment (FDI) and merchandise trade. 3. Negative trade balance. 4. Lower international competitiveness of export products. 5. High poverty ratio.
Study Area	1. Increase in the production of cash crops (sugar, cotton). 2. Promote its function as a food supply centre in Malawi. 3. Develop Blantyre as a commercial and agro-processing centre. 4. Develop the agro-processing industry, mining and tourism to attract more FDI. 5. Increase of workforce.	1. Highest poverty ratio in Malawi. 2. Economic disparity by area 3. Expensive logistics cost with long detour to ocean port. 4. Disconnection of transport network.

Source: Study Team



Source: Study Team

Figure 23 Regional Development Potentials in Malawi and the Study Area

c) Necessity of Developing the Sena Corridor

The necessity of developing the Sena Corridor from the viewpoint of Southeastern Africa, the whole of Malawi and the Study Area is described below considering the basic concept and the target of developing the Corridor (see Table 8).

Table 8 Necessity of Developing the Sena Corridor

Area	Necessity
Southeastern Africa	・Huge demand for transporting mineral products to Nacala Port from the Moatize coal mine and Zambian copper mine is expected. The railway transport capacity of Malawi is limited to 2 million tonnes per year. ・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.
Malawi	・Since roads handle 87% of Malawi's international cargo, it is necessary to shift to a multimodal transport system that includes roads, railways and inland waterways. ・With the change of port business environment, Malawi's cargo handled at Durban Port is expected to shift to both Beira Port and Nacala Port. Thus, since the distance will be about one third, it is necessary to improve access to both ports in order to contribute to international competitiveness. ・To secure the sustainable economic growth of Malawi and alleviate poverty, it is indispensable to build links among residential areas, markets and centres of industry.
Study Area	・Both domestic and international freight demand will increase owing to the increase of population and agricultural products, as well as mining development. Based on the characteristics and advantages of road and railway transport, it is necessary to formulate an efficient transport network that strategically meets these freight demands. ・After formulating an efficient transport network, road transportation of exported sugar to Zimbabwe could be shortened by around 180 km and the altitude between the sugar factory and the international border connecting the Tete Corridor could be decreased by around 200 m. ・The splitting of communities due to the disconnections reduces incomes and increases expenses for poor populations who face difficult access to markets. It is necessary to improve access to the commercial centres, rural centres and markets.

Source: Study Team

d) Basic Concept and Target of the Sena Corridor

To maximize the development potential of the Study Area, three basic concepts for developing the Sena Corridor are prepared (see Table 9).

Table 9 Basic Concept and Target of the Sena Corridor

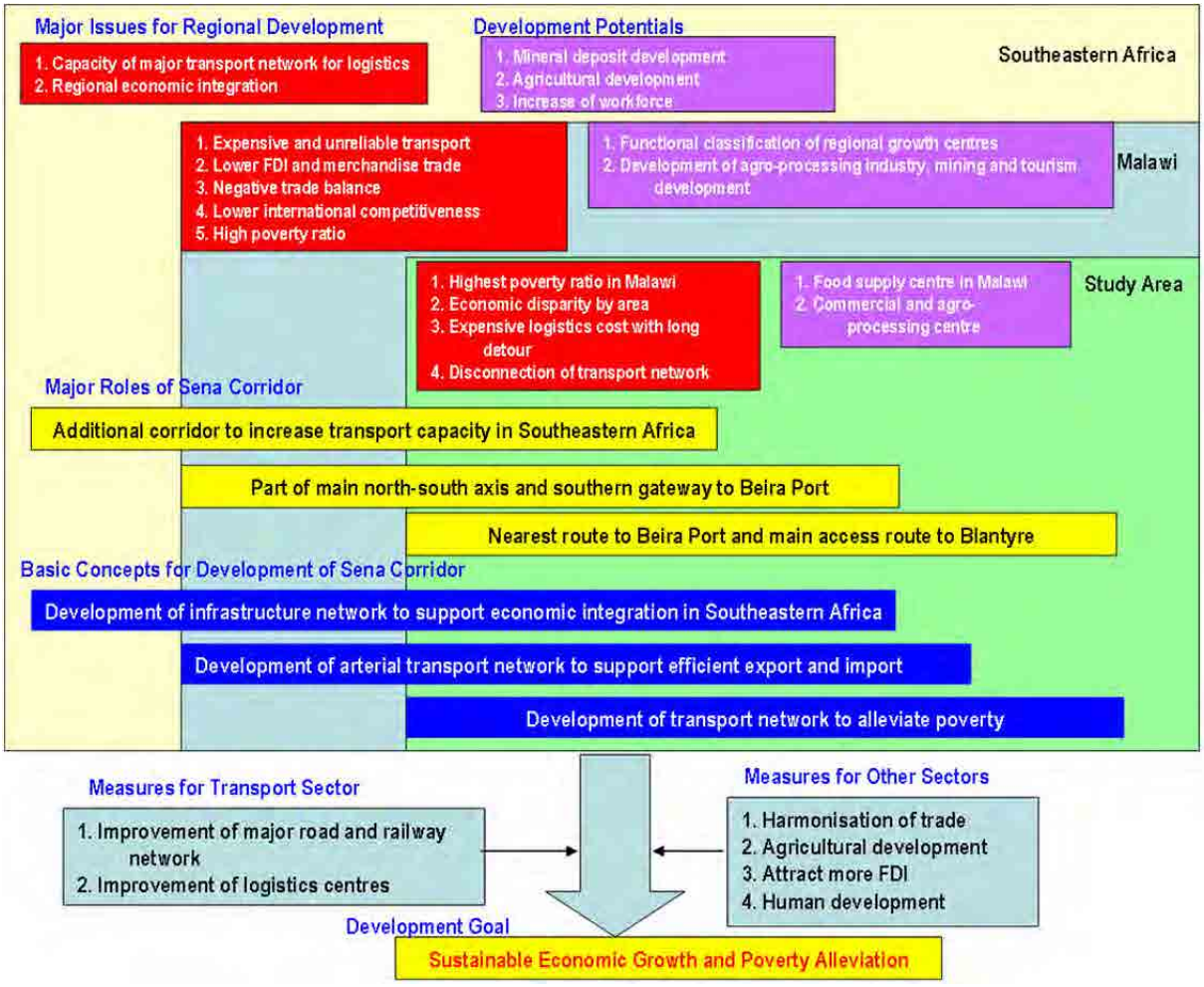
Area	Basic Concept	Target
South-eastern Africa	・Development of infrastructure network to support economic integration in South-eastern Africa	• Achieve sustainable economic growth • Strengthen redundancy[4] of transport network
Malawi	・Development of arterial transport network to support efficient export and import	• Achieve sustainable economic growth • Improve international competitiveness of export products • Strengthen redundancy of transport network
Study Area	・Development of transport network to alleviate poverty	• Achieve sustainable economic growth • Alleviate poverty • Improve living condition in the Study Area

Source: Study Team

e) Development Goals

The development goals of the Sena Corridor are sustainable economic growth and poverty alleviation in Malawi and the Study Area by improving the inadequate transport network and boosting regional development (see Figure 24).

[4] In this case, "redundancy" means multiplicity and substitutability.



Source: Study Team

Figure 24 Development Goals of the Sena Corridor

6. Master Plan for Development of the Sena Corridor

(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 Master Plan indicates definite plans for the transport system and its services in the Southern Region of Malawi.

(2) Overview for the Development of the Sena Corridor

a) Viewpoint of Southeastern Africa

Current Situation

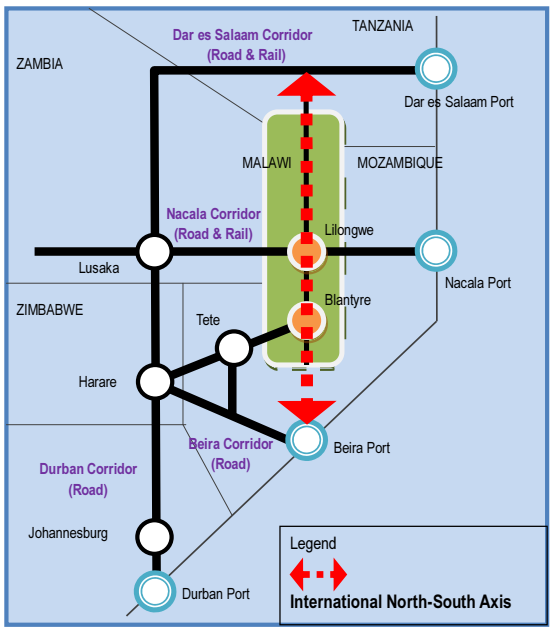
- SADC aims to achieve economic growth, poverty alleviation and improvements in people's living standards through regional integration by regional infrastructure development.
- At present, the ratios of volume transported by corridor are 41% by the Beira Corridor, 18% by the Nacala Corridor, 33% by the Durban Corridor and 8% by the Dar es Salaam Corridor.

Major Issues

- Recently, some critical issues facing the transport sector have become more pronounced, such as 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 transport infrastructure is an urgent issue.

Roles and Functions

- 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 25).
- 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.



Source: Study Team

Figure 25 Imternational North-South Axis

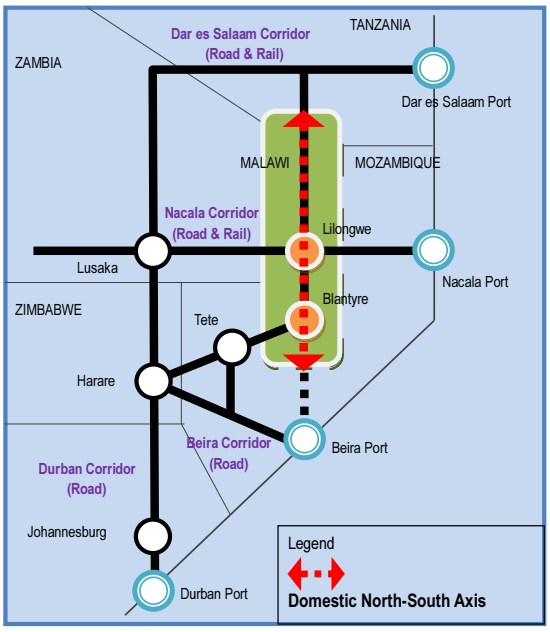
b) Viewpoint of Malawi

Current Situation

- 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%).
- 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.

Major Issues

- 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.



Source: Study Team

Figure 26 Domestic North-South Axis

Roles and Functions

- For Malawi, the Sena Corridor (borders from Blantyre) is part of the national north-south axis (see Figure 26). 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.

c) Viewpoint of the Study Area

Current Situation

- A large part of the Study Area is in low-lying land, whereas all operating Border Posts[5] are located at an altitude of more than 1,000 m. Transport costs tend to be high due to this large difference in altitude.

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.

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.

(3) Assumptions of External Factors for the Master Plan

a) Definition of Assumptions

- External Factors for the Road Sub-sector: Upgrading of the unpaved road section from the international border 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 the results of evaluation of assumptions for the Master Plan, **Assumption 1** is evaluated the most advantageous for both Malawi and Mozambique.

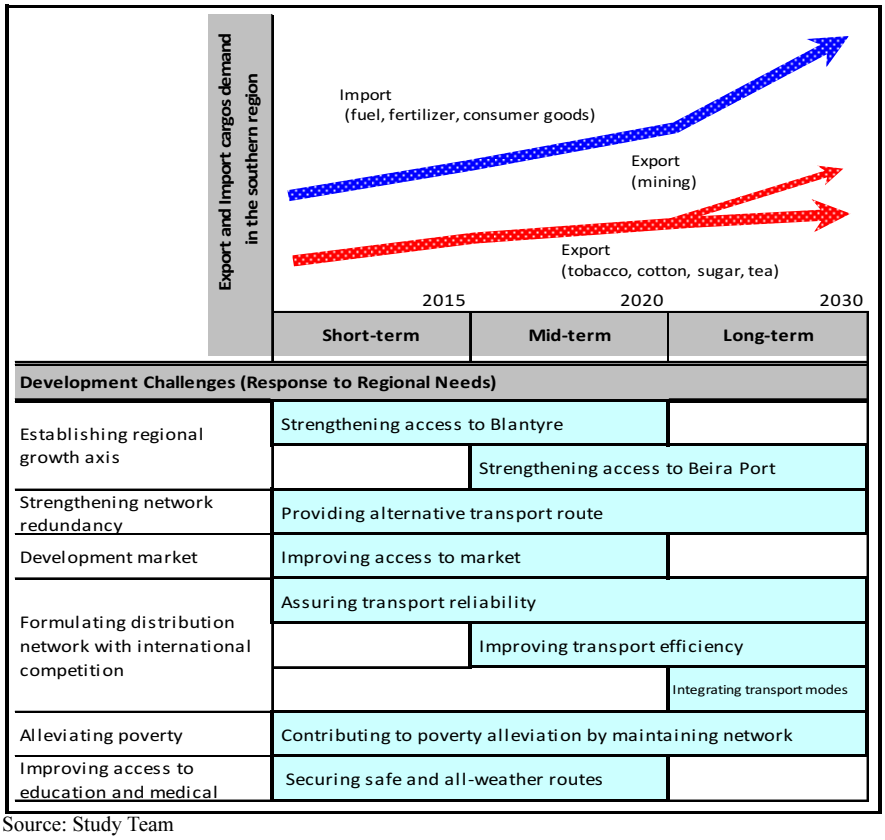
(4) Development Concept of Each Transport Sub-sector

The development concept for the Sena Corridor in the southern region of Malawi is to fully address the

[5] Mwanza BP, Dedza BP, Songwe BP, Mchinji BP and Muloza BP, which account for 99.6% of the total international cargo

proposed six development challenges shown below corresponding to the basic concept for developing the Sena Corridor, including regional development issues and potentials (see Figure 27).

- 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 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 27 Development Concept of the Sena Corridor

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 (see Table 10).

(5) Strategy for Development of Each Transport Sub-sector

a) Road Sub-sector

The long-term development strategies for the road sub-sector are summarized in Table 11. The development objectives and strategies are divided into four areas: Operation and Management, Infrastructure Development, Institutional Capacity and Funding.

The functional classifications and development targets are summarized in Table 12 and Figure 28.

Table 10 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

Table 11 Development Objectives and Strategies for the Road Sub-sector

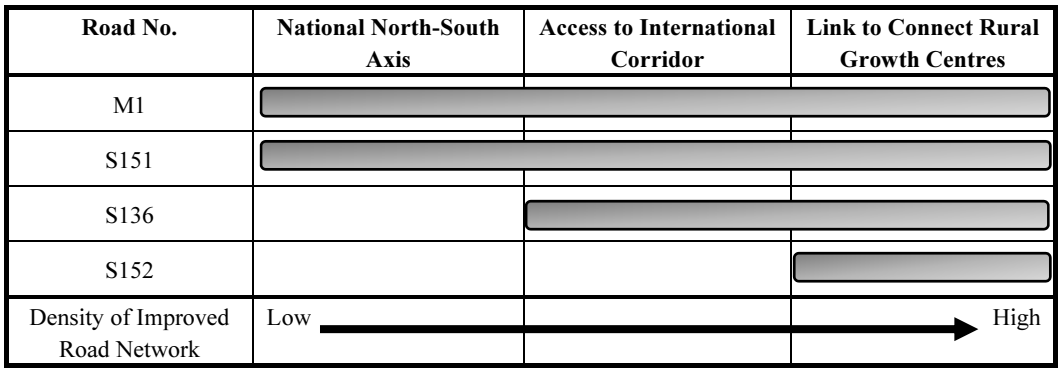
Area	Objectives	Strategies
Operation and Management	• Maintenance of infrastructure • Road safety • Minimum accessibility for the poor	• Preparation of road maintenance programme based on the road sector programme • Implementation of road safety measures based on national road safety master plan • Implementation 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

Table 12 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 28 Density of Improved Road Network in the Study Area

b) Railway Sub-sector

The long-term development strategies for the railway sub-sector are summarized in Table 13.

Table 13 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

(6) Preparation of Development Plans for the Transport Sub-sectors

a) Road Sub-Sector

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 14.

Development plans for the road sub-sector have been prepared by considering engineering considerations, investment situation and development priorities, and are summarised in Table 15 and Figure 29.

- 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 14 Major Issues and Countermeasures for the Road Sub-sector

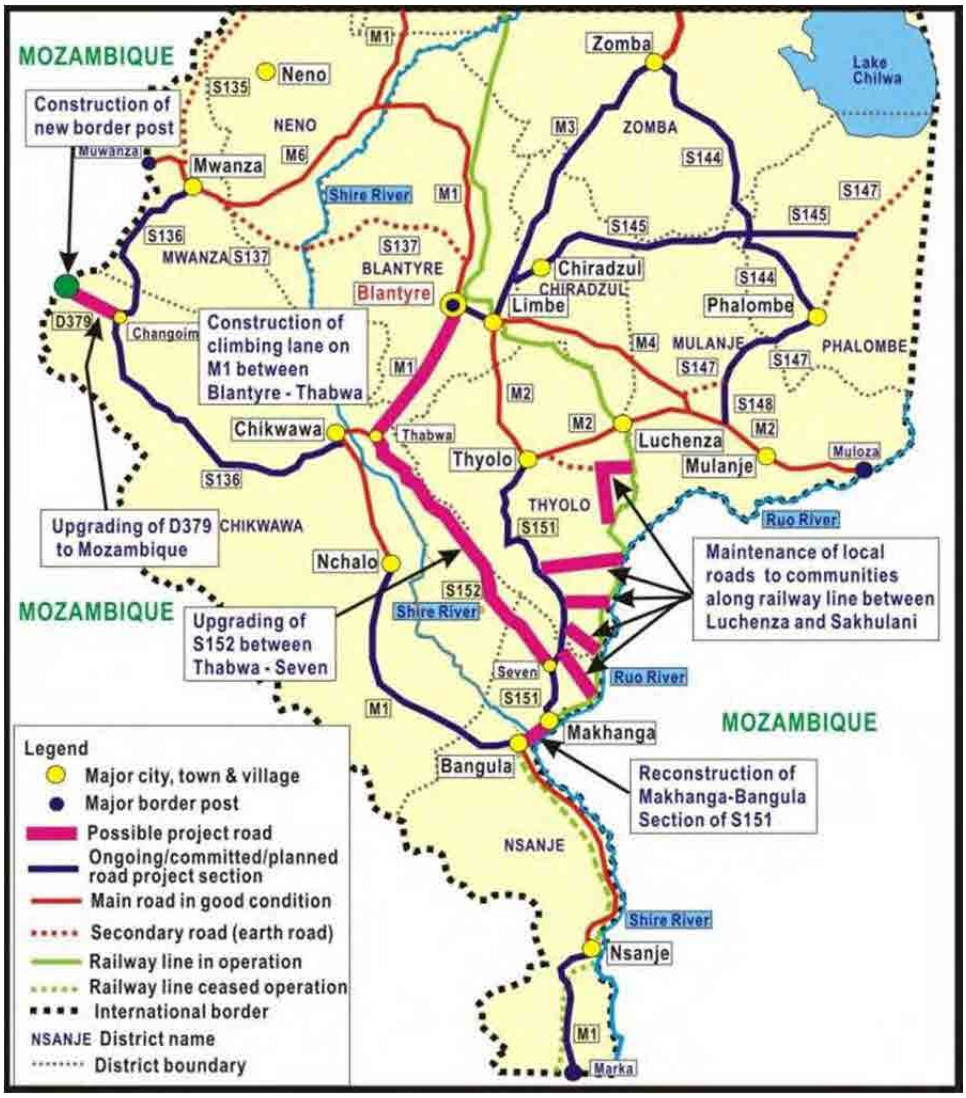
Major Issue	Policy for Improvement	Countermeasures
1. Formulation of reliable arterial road network	Proper arterial road functions	• Building all-weather roads • Upgrading to paved roads • Upgrading section between *Vila Nova de Frontela* and Caia in Mozambique • Widening at steep-gradient sections for 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 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 15 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*–Caja section (Mozambique)
3. Reduction of transport cost		-	1. Upgrading of D379 New access road to Mozambique 2. Improvement of *Vila Nova de Frontela*–Caja 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 29 Development Plans for the Road Sub-sector

b) Railway Sub-Sector

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 the improvement as shown in Table 16.

Development plans for the railway sub-sector have been prepared by considering engineering considerations, investment situation and development priorities, and are summarised in Table 17 and Figure 30.

- Construction of new bridge at 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 should be started in order to resume international freight transport to Beira Port, 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 possibility of improving the concession should be considered. 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.

Table 16 Major Issues and Countermeasures for the Railway Sub-sector

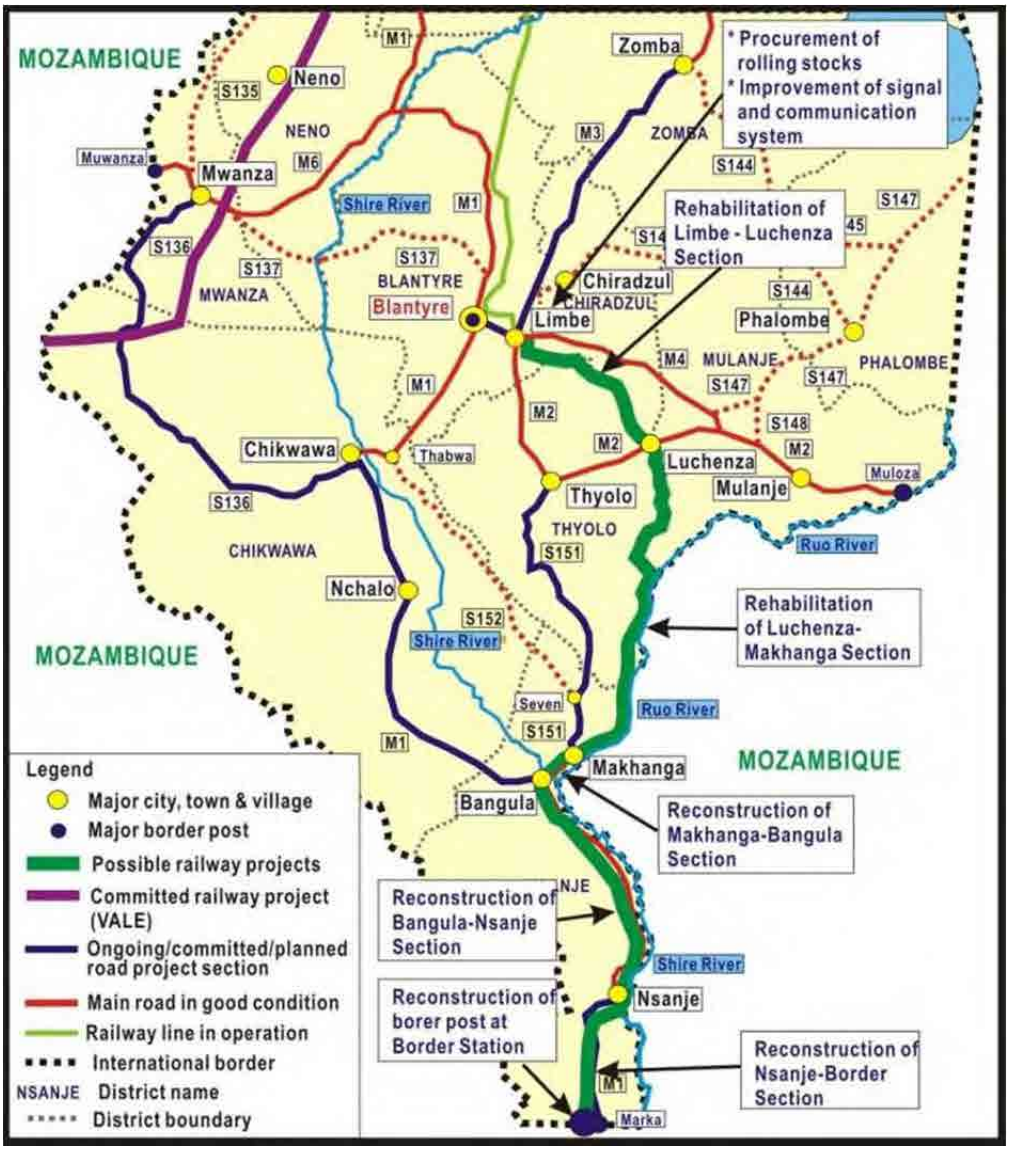
Major Issue	Policy for Improvement	Countermeasures
1. Construction of bridge at washaway section	Resolution of disconnection of the railway at Chiromo	* Construction of new bridge at washaway section
2. Rehabilitation/ reconstruction of existing railway facilities and strengthening of railway tracks	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 17 Development Plans for the Railway Sub-sector

Major Issue	Short Term (2015)	Medium Term (2020)	Long Term (2030)
1. Construction of bridge at 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 *Vila Nova de Frontela–Dona Ana* (GoMZ) 2. Installation of signal and telecommunication system for *Vila Nova de Frontela–Dona Ana* (GoMZ)

Source: Study Team



Source: Study Team

Figure 30 Development Plans for the Railway Sub-sector

c) Development Plans for the Transport Sub-sectors

Development plans for the short, medium and long term of the transport sub-sectors have been prepared, as shown in Table 18.

(7) Evaluation of Proposed Projects for the Master Plan

a) Alternative Transport Networks for Evaluation

The Study Team has prepared three alternative transport network based on the development plan for transport sub-sector in the Study Area and assumptions of external factors in Mozambique mentioned above in consideration of the essential factors as shown in Table 19 and Figure 31.

- 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 18 Development Plans for the Transport Sub-sectors

Transport Sub-sector	Development Plan for Short Term (2015)	Development Plan for Medium Term (2020)	Development Plan for Long Term (2030)
1. Road sub-sector	* Upgrading of M1 Chikwawa–Nchalo (ongoing) * Upgrading of M1 Nsanje–Marka (planned) * Upgrading of S151 Thyolo–Makhanga (committed) * Improvement of S136 Mwanza–Chikwawa (planned) * Reconstruction of S151 Makhanga–Bangula	* Construction of climbing lane on M1 Blantyre–Thabwa * Upgrading of S152 Thabwa–Seven	* Upgrading of D379-New access road to Mozambique * Improvement of *Vila Nova de Frontela*–Caia road section (Mozambique)
2. Railway sub-sector	* Construction of new railway line by Vale	* Rehabilitation of Limbe–Luchenza section * Rehabilitation of Luchenza–Makhanga section * Reconstruction of Makhanga–Bangula section * Installation of signal and telecommunication system * Procurement of rolling stock	* Reconstruction of Bangula–Nsanje section * Reconstruction of Nsanje–Border (Marka) section * Installation of signal and telecommunication system * Procurement of rolling stock * Reconstruction of *Vila Nova de Frontela–Dona Ana* railway line (Mozambique) * Installation of signal and telecommunication system (Mozambique)
3. Inland waterway	* Start operation of Shire–Zambezi Inland Waterway	* Rehabilitation of Shire–Zambezi Inland Waterway	-

Source: Study Team

Table 19 Alternative Transport Network for Evaluation

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

Source: Study Team

b) Evaluation Items

Economics

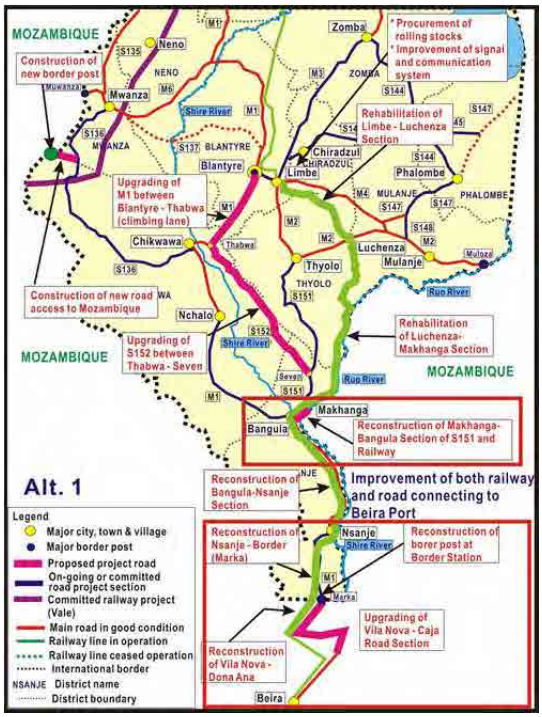
- EIRR: All alternatives are calculated as more than 12%[6] of EIRR
- Benefits: VOC saving, TTC saving

Environment

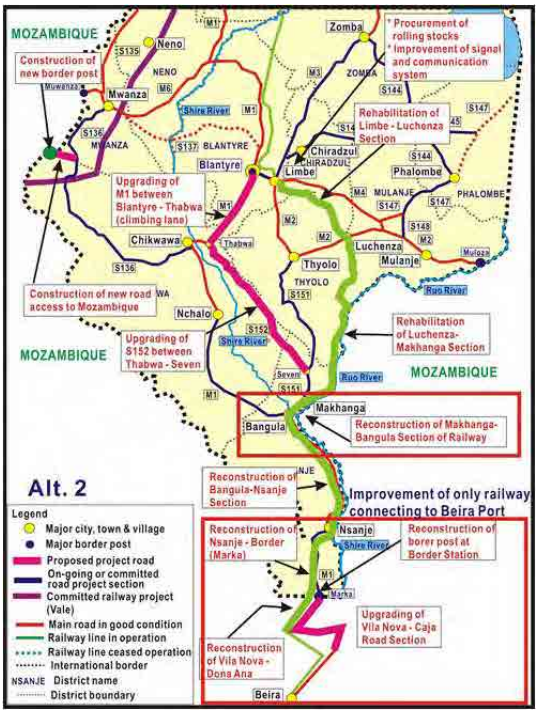
- Strategic Environmental Assessment (SEA) consists of 3 impact indicators (environment, social and local economy): Alternative 1 and 3 are judged to have relatively positive impacts
- CO_2 reduction impact (with/without): Alt. 1 (4.0%), Alt. 2 (0.3%), Alt. 3 (4.0%)

[6] 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.

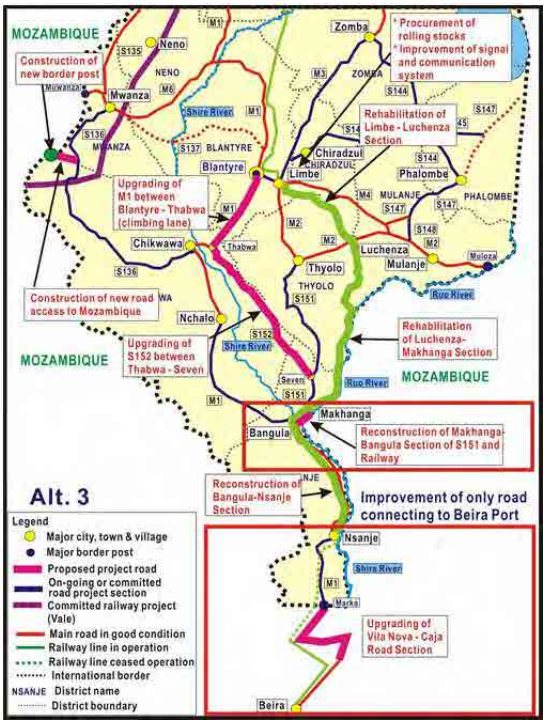
Alternative 1



Alternative 2



Alternative 3



Source: Study Team

Figure 31 Alternative Transport Networks for Evaluation

Transport Viewpoints

- Foreign currency saving (US$ million/year): Alt. 1 (16.2), Alt. 2 (11.3), Alt. 3 (8.1)
- Transport reliability (estimated tonne-hour/2030 reduction impact): Alt. 1 (7.2%), Alt. 2 (6.2%), Alt. 3 (2.9%)

c) Overall Evaluation

The overall evaluation shown in Table 20 identified A**lternative 1** (connection of both road and railway in Mozambique) as having the highest score.

Table 20 Overall Evaluation Results

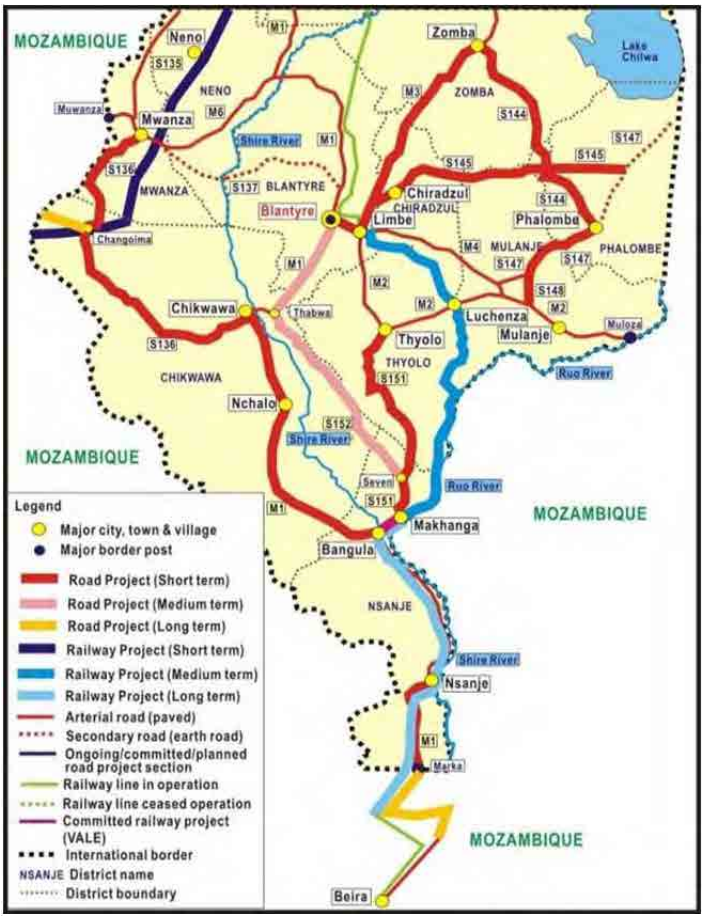
Item		Alternative 1	Alternative 2	Alternative 3	Remarks
Economic Evaluation	EIRR	A+ (17.1 %)	A (13.3 %)	A (16.5 %)	
Environmental Impact	Local Economic Impact	A	B	A	refer to SEA
	Social Impact	B	B	B	refer to SEA
	Environmental Impact	B	B	B	refer to SEA
	CO_2 Emission Reduction Effect	A	B	A	
Transport 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

(8) Transport Master Plan Programmes

a) Implementation Schedule

The proposed projects for the Master Plan are classified as short-term (2015), medium-term (2020) and long-term (2030) projects as shown in Figure 32. The implementation schedule for existing and proposed projects, considering level of needs for each project, engineering judgment as well as investment environment for each transport sector (road and railway) by development partners, is prepared for each term, as shown in Table 21.



Source: Study Team

Figure 32 Projects Classified by Implementation Stage

Table 21 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 (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–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

b) Short-Term Programme

The list of projects selected for the short-term implementation programme is shown in Table 22 and Figure 33.

Table 22 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 arrangements	GoM			0..3
Sub-total					2
Inland Waterway Projects in Malawi					
1	Start of operation of Shire–Zambezi Waterway	GoM		km	-
Sub-total					-
Total Investment in Malawi					274

Source: Study Team

Source: Study Team

Figure 33 Location of Projects for the Short-term Implementation Programme

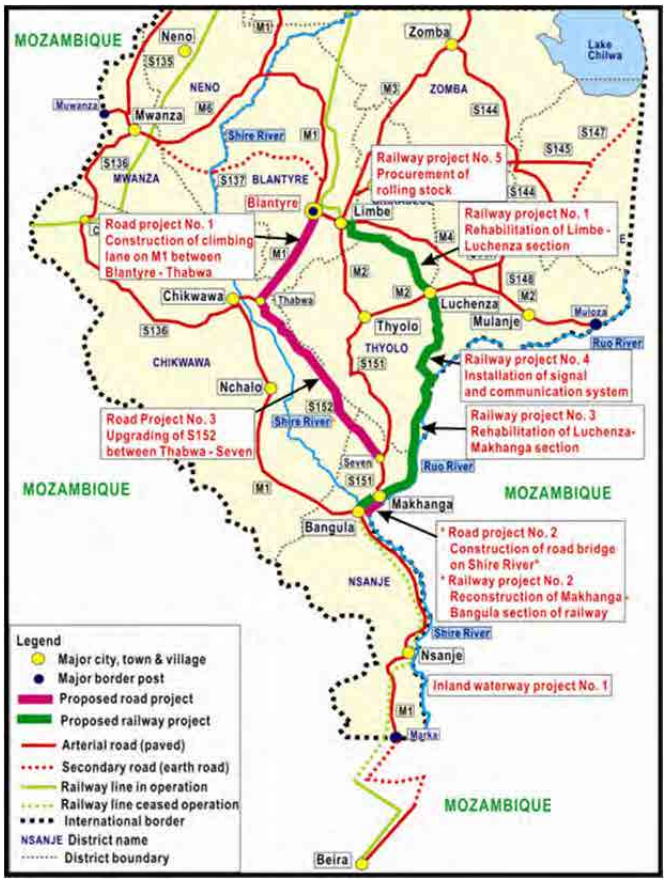
c) Medium-Term Programme

The list of projects selected for the medium-term implementation programme is shown in Table 23 and Figure 34.

Table 23 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	3
2	Reconstruction of S151 Makhanga–Bangula	No	9	km	16
3	Upgrading of S152 Thabwa–Seven	No	59	km	51
Sub-total					70
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	14
5	Procurement of rolling stock	No			8
Sub-total					125
Inland Waterway Projects in Malawi					
1	Rehabilitation of Shire–Zambezi Waterway	GoM		km	–
Sub-total					–
Total Investment in the Master Plan					**195**

Source: Study Team



Source: Study Team

Figure 34 Location of Projects for the Medium-term Implementation Programme

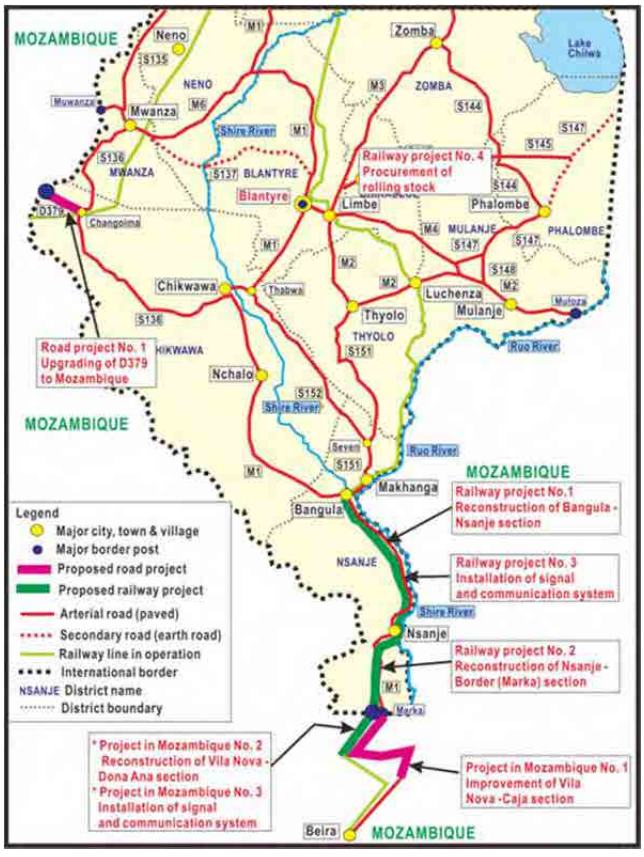
d) Long-Term Programme

The list of projects selected for the long-term implementation programme is shown in Table 24 and Figure 35.

Table 24 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	13
Sub-total					13
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	8
4	Procurement of rolling stock	No			36
Sub-total					93
Total Investment in Malawi					**106**
Projects in Mozambique					
1	Improvement of *Vila Nova de Frontela*–Caia road section	No	140	km	134
2	Reconstruction of V*ila 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 35 Location of Projects for the Long-term Implementation Programme

(9) Proposed Projects for Pre-F/S

a) Priorities

- 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 Makhanga–Bangula”.
- 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.

b) Selected Projects for the Pre-F/S

- 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 25 and Figure 36 show the selected projects for the Pre-F/S.

Table 25 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 Makhanga–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 36 Location of Selected Projects for Pre F/S

7. Results of Natural Condition Surveys and Hydrological Analyses

(1) Results of Natural Condition Surveys

The Study Team carried out the following natural condition surveys in the area between Makhanga and Bangula where major work items for the Pre-F/S of reconstruction of S151 and railway were expected.

- Topographical survey, including land survey, centre line and cross section survey for the existing road and railway line, and a river cross section survey for the washaway section of the New Shire River and the Shire River were carried
- Geotechnical investigation by drilling at 8 boreholes were carried out in order to identify the condition of soil layers where bridge foundations and road embankments are to be planned in the Study.
- The Study Team collected the water level and water discharge data of the Chiromo and Liwonde observations stations. Also, the Study Team observed the water level of the New Shire River by installing water gauges and measured the current velocity.

(2) Results of Hydrological Analyses of the Shire River and Chiromo Washaway Section

Based on collected aerial photos, hydrological data, hydraulic observation data, site investigations and interviews with local residents, the hydraulic conditions of the Shire River, the New Shire River and the Ruo River have been analysed.

- Since the past maximum discharge volume did not exceed 1,500 m^3/sec and floods on the Ruo River continue for a long time, the planned maximum discharge volume as a peak discharge volume can be considered to equal the maximum discharge volume at Kamuzu Truss Bridge.
- The planned high water level (HWL) during flooding at the Chiromo washaway section is estimated as 48.4 m.

(3) Plan for Protecting the River Section

The Study Team has considered plans to construct two bridges at the Chiromo washaway section of the New Shire River. Hence, it is desirable to secure a smooth flow of flood water and protection of abutments and piers of these bridges at river sections after constructing these two bridges.

- It is necessary to install minimum revetments using mat-shaped gabions in stepped placing. The area for installing revetments is planned to be about 30 m from the position of an abutment on both sides, as the minimum required to protect the embankment around an abutment (Revetment Type A).
- The revetment for the low flow channel is also planned to place mat shaped gabions on flat ground to prevent local scouring at the foot of the river bank. The area over which the revetment is planned to be placed is 100 m from the edge of the abutment on both sides (Revetment Type B).
- Base protection works for railway embankment are planned to be taken as countermeasures to control scouring of the foot of the railway embankment, which is the left-side bank of the New

Shire River. Base protection works will be performed with revetment by riprap (Revetment Type C).

8. Pre-Feasibility Study on Reconstruction of S151 Road between Makhanga and Bangula

(1) Justification of Reconstruction of S151 Road between Makhanga and Bangula

Disconnection of S151 road at the Chiromo washaway section has a large negative impact on the local economy and lives of the local residents, particularly those living on the eastern side of the Shire River. On the other hand, upgrading of S151 between Thyolo and Makhanga are expected to commence soon and the arterial road network in the Southern Region will be complete, except for a gap between Makhanga and Bangula. Under these circumstances, the Study Team considers that carrying out the Pre-F/S for the reconstruction of S151 between Makhanga and Bangula is justified.

(2) Preliminary Design of Road Section between Makhanga and Bangula

a) Road Raising and Alignment

The required height of the raised road should be determined considering expected flood levels. The estimated raising height of S151 road is at 2.3 m on average for the total projected extension. Moreover, The Study Team selected the proposed road alignment of the project by dividing it into the following two sections.

Section A: Outside Makhanga Village (L = 6 km)

Section B: In Makhanga Village (L = 3 km)

Road Alignment outside Makhanga Village (Section A)

The Study Team conducted a comparison of the following three alternatives regarding where the raised road should be built in Section A. As a result of the comparison, Alternative 1 is more advantageous in terms of i) measures for ground stabilization and ii) construction cost.

Alternative 1: Existing Road Alignment

Alternative 2: Between the Existing Road and the Railway Line

Alternative 3: Railway Line Alignment (Integrated Embankment of Road and Railway)

Road Alignment in Makhanga Village (Section B)

The following considerations and/or problems are identified in the Makhanga village area when the raised road is built on the exiting road alignment.

- There is a possibility that at least more than 20 houses and shops and 10 huts in the market area around the level crossing with railway could be relocated.
- There is a possibility that the progressing erosion along the right bank of the Ruo River could influence the S151 road in the future, especially, the section with only 30 m distance between the S151 road and the Ruo River.

Thus, the Study Team conducted a comparison of the following three alternatives in Makhanga area. As a result of the comparison, Alternative 3 is most advantageous in terms of i) design element, ii) the Ruo River bank erosion, iii) road damage caused by flood and iv) construction cost. However, further examinations for selecting the final alignment is recommended for the following reasons.

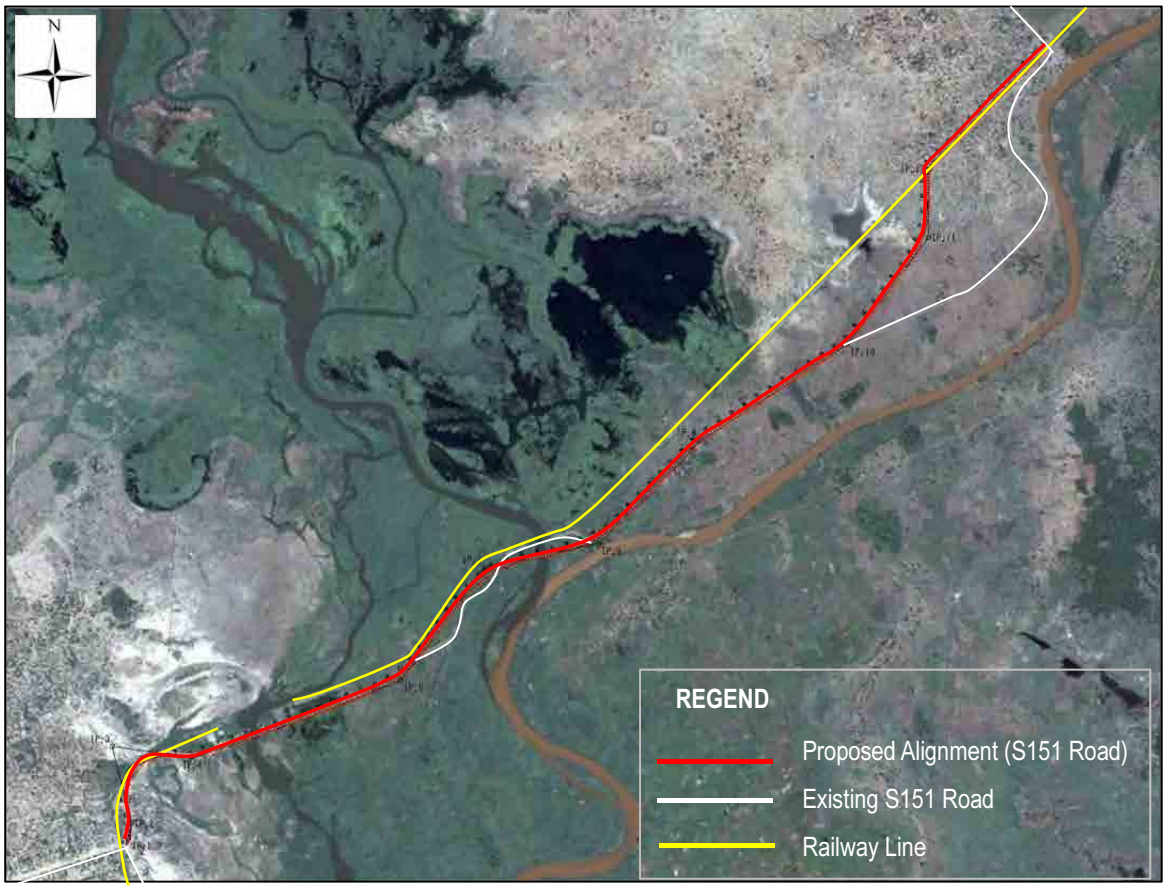
- To clarify and grasp the location and number of houses, shops and public facilities along the railway in order to set the road alignment and location of level crossings across the railway, and then to obtain social consensus.
- To clarify and grasp geological conditions in detail on the planned alignment.
- To clarify and grasp the erosion mechanism of the Ruo River bank in order to justify realignment of the road.

Alternative 1: Existing Road Alignment

Alternative 2: Market Area Detour Alignment

Alternative 3: Railway Line Alignment

Proposed road alignment is shown in Figure 37.



Source: Study Team

Figure 37 Proposed Road Alignment between Makhanga and Bangula

b) Design Speed

- Design Speed: 80 km/h
- Village area and section of level crossing with railway: 30 km/h to 60 km/h

c) Clearance for Road Longitudinal Plan

- 0.6 m from H.W.L to the road surface of embankment section
- 1.0 m from H.W.L to the bottom of bridge girder

d) Cross Section Elements

- Total Road Width: 9.7 m
- Carriageway: 6.7 m, shoulder: 1.5 m (Left and right)
- Carriageway and shoulder cross slope: 2.5%

e) Pavement Design

- Surface: Double Surface Dressing (DBST)
- Granular Base: 150 mm (Soaked CBR > 80%)
- Granular Subbase: 200 mm (Soaked CBR > 30%)
- Selected layer: 200 mm (Soaked CBR > 15%)

(3) Preliminary Design of Chiromo Road Bridge

The best bridge construction position shall be selected among the three alternatives mentioned below using the results of a comparative study on the bridge construction positions and access roads of the three alternatives. In the comparison, the three alternatives shall be analysed comprehensively, with bridge length, cost performance, alignment of the access roads, impact on the access roads to the New Shire River, flood control measures, land acquisition, construction efficiency and impact on the natural and social environments taken into full consideration.

Alternative 2 is the most preferable bridge construction position in terms of “the alignment is the best because the new road is almost straight”, “there is little impact if the New Shire River floods” and “the construction cost is the lowest because of a small-scale bank protection work”

Alternative 1: Use the existing road

Alternative 2: The best alignment

Alternative 3: Use the old road as a detour route

Three bridge types shall be compared for selecting a structure of the bridge to be constructed at the best position mentioned above. A concrete bridge shall be the first choice because of versatility and low cost of the material. However, a steel truss bridge shall also be considered as a candidate bridge type depending on the span lengths. The decision on the scale of the bridge, its length and span length shall be made based on the analysis of the results of the hydrological survey, and appropriate specifications for the width of the bridge shall be established by referring to the results of a traffic survey conducted in the Study and the road design standards of Malawi.

Alternative 2 is the most preferable bridge type because Alternative 2 is evaluated “it is slightly less economical than Alternative 1, but there is no construction in the river”, “the reduction of river cross-section is below the standard value” and “this bridge type is the most desirable alternative in overall evaluation because of superior structural performance, construction efficiency, and river characteristics”

Alternative 1: PC 8-span connected post-tensioned T-girder bridge

Alternative 2: PC 3-span continuous box-girder bridge

Alternative 3: Steel 3-span continuous truss bridge

Alternative 2 (PC 3-span continuous box-girder bridge) was selected as the most preferable bridge

type in the 1) First-Phase Comparative Study of Bridge Types above. However, this type of structure would require significantly high (8 m) girders. Such girders would require a raised road profile, resulting in very high abutments. The heights of the abutments A1 and A2 are 15m and 17.5m, respectively, for the bridge in Alternative 2. In order to reduce the abutment heights, a study on a bridge type which would reduce girder height will be needed. Since an Extradosed bridge meets such requirements, the following two alternatives shall be studied comparatively in the Second-Phase Comparative Study of Bridge Types:

Alternative 1:	PC 3-span continuous box-girder bridge
Alternative 2:	Extradosed bridge

Alternative 2 is the best bridge type mainly in terms of cost performance because Alternative 2 is evaluated "the low girders make the abutments and embankments quite low" and "although the cost for the superstructure is higher than that of Alternative 1, the cost for the substructure is considerably low and the overall construction cost is low". In addition, when the detailed hydraulic analysis is carried out at the time of the feasibility study and if the HWL falls as a result, a PC 3-span continuous box-girder bridge may be selected instead of an extradosed bridge.

(4) Preliminary Design of New Shire Bridge

The best bridge construction position shall be selected among the three alternatives mentioned below using the results of a comparative study on the bridge construction positions and access road of the three alternatives. In the comparison, the three alternatives are analysed comprehensively, with bridge length, cost-efficiency of bridge construction, alignment of the access road, impact of the Shire River on the access road, flood control measures, land acquisition, construction efficiency and impact on the natural and social environments taken into full consideration, and the best alternative shall be identified from the results of the comprehensive analysis.

Alternative 3 is the most preferable bridge construction position in terms of "despite the S-shaped curves on the access road, there will be almost no problem as the radii of curve are large", "construction of the right bridge is structurally the most recommendable" and "it is extremely cost effective, having the same construction cost"

Alternative 1: Construct a straight road

Alternative 2: Construct a bridge with the shortest centre span

Alternative 3: Construct a right bridge

Three types are compared for the bridge to be constructed at the best position selected in the pervious section. A concrete bridge shall be the first choice because of its versatility and low material costs. However, a steel bridge shall also be considered as a candidate depending on the span lengths. Regarding the scale of a bridge, bridge length and span length shall be decided using the results of the hydrological survey and analysis of the survey results, and the bridge width shall be the same as the Chiromo Road Bridge. The following three alternative bridge types shall be compared.

Alternative 1: PC 6-span connected post-tensioned T-girder bridge

Alternative 2: PC 3-span continuous box-girder bridge

Alternative 3: Steel 3-span continuous truss bridge

Alternative 2 is the most preferable bridge type because Alternative 2 is evaluated "a little less cost-efficient than Alternative 1 but no construction in the river", "the river cross-section reduction is under the standard value" and "this is the most desirable alternative in overall evaluation because of superior structural performance, construction efficiency, and river characteristics"

(5) Preliminary Cost Estimation

The project cost includes 10% contingency and engineering fee, and does not include tax in Malawi. Table 26 summarizes the estimated project cost for the reconstruction of S151 road between Makhanga and Bangula.

Table 26 Estimated Project Cost

Cost Item		Estimated Project Cost (US$ million)	
Improvement of Road between Makhanga and Bangula		14.52	
Chiromo Road Bridge	Superstructure works	15.64	22.08
	Substructure works	6.44	
New Shire Bridge	Superstructure works	12.80	19.48
	Substructure works	6.68	
Total Project Cost		56.08	

Source: Study Team

(6) Establishment of Road and Bridge Maintenance Plan

- The road maintenance activities are either cyclic or reactive and can be of a routine or periodic nature. Cyclic activities are those that are carried out at regular intervals. Reactive activities are those that are carried out in response to an occurrence or a condition defect exceeding values dictated by maintenance standards greater than a given value. When a double surface dressing (DBST) for design road are adopted, it is proposed to conduct slurry seal work as major maintenance at after 10 years form start of service.
- The bridge maintenance works after the completion of these projects is generally divided into those performed regularly every year and those performed at intervals of several years. Inspection and maintenance needed every year are such as removal of sand and dirt accumulating in bridge deck drain pipes, the areas around bearings, gutters and other drain facilities, cleaning of these areas, inspection and repair of bank protection and riverbed protection works, removal of boulders and driftwood after floods. Maintenance performed at intervals of several years are patching or overlaying of bridge deck pavement; at intervals of about 5 years and replacement of expansion joints; at intervals of about 10 years.

(7) Economic Analysis of Reconstruction of S151 Road between Makhanga and Bangula

In the economic analysis using the HDM-4 model, the capital costs, maintenance cost, traffic volumes and vehicle operating costs are defined as the difference between "Without the project" and "With the project" cases. In the "With the project" cases, the project road would be upgraded to a class 1 bitumen standard with an initial roughness of around 2 mm/km. The project road has three major components as follows.

- Reconstruction of S151road between Makhanga and Bangula (8.5km)
- Construction of the Chiromo Road Bridge
- Construction of the New Shire Bridge

Daily traffic volume in 2030 on S151 between Makhanga and Bangula, which is the targeted project area, is 1,606 vehicles per day based on traffic demand forecast analysis.

Table 27 Results of Evaluation of Basic Options

(SDR = 12.0%)

Engineering Option		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)
1	Without Project	0.547	0.0%	0.0	0.000
2	With Project (Option-1) (Road improvement and Construction of Chiromo Road Bridge and New Shire Bridge)	42.358	26.0%	1.697	71.876
3	With Project (Oprion-2) (Road improvement and Construction of only Chiromo Road Bridge)	28.005	50.0%	6.421	179.831

Source: Study Team

Based on the above analysis, Option-1, the improvement of road section between Makhanga and Bangula with the construction of the Chiromo Road Bridge and the New Shire Bridge, is technically and economically viable, but in the worst case scenario the EIRR is near marginal at 14.2%. This would therefore need further confirmation by robust economic evaluation at the full feasibility study stage to be conducted later.

(8) Implementation Programme for Reconstruction of S151 Road between Makhanga and Bangula

The implementation schedule for the rehabilitation of the S151 road between Makhanga and Bangula is shown in Table 28.

(9) Overall Evaluation of Reconstruction of S151 Road between Bangula and Makhanga

- Reconstruction of road sections as well as the construction of two bridges would provide several benefits to the national and local economy. Construction of the Chiromo Road Bridge will generate a very positive economic and social benefits for residents such as to bring and sell agricultural products in Bangula, the ability to commute to school and better health care services.
- Alternative routes are compared to minimize the necessity for resettlement of houses and shops, as well as to secure the function of an all-weather road by sufficient height of embankment to prevent damage to the road by frequent floods from the Ruo River and the New Shire River. The horizontal alignment in Makhanga area is planned to avoid resettlement of 16 houses/shops near the railway crossing and to avoid the high risk from the Ruo River bank erosion, where the existing road is only 30 m from the continuously eroding river bank.

Table 28 Implementation Programme for Reconstruction of S151 Road

Task		Duration (month)	Year: 1st	2nd	3rd	4th	5th	6th	7th	8th
Feasibility Study		6								
Decision on Investment		3								
Selection of Engineering Consultant		3								
Detailed Design		12								
Selection of Contractor (Tender Procedure)		6								
Execution of Project		60								
Phase I	Road between Makhanga and Bangula (7.7 km)	30						Start of Service		
Phase I	Chiromo Road Bridge								Start of Service	
Phase II	Approach Road to New Shire Bridge (0.8 km)	30								
Phase II	New Shire Bridge									

Source: Study Team

- The Chiromo Road Bridge is planned to cross the Chiromo washed away section by the best horizontal alignment not only from the geometric design point of view, but also to avoid negative influence on the planned railway line alignment. The Extradosed type 3 spans PC Box Girder Bridge was selected as the most suitable type.
- In order to avoid traffic confusion on this Kumuzu Truss Bridge after completing the improved road section between Makhanga and Bangula, and construction of the Chiromo Railway Bridge, as well as reconstruction of the railway between Makhanga and Bangula, construction of the New Shire Bridge only for road traffic is evaluated as a priority project for the medium term project.
- In the economic analysis, all the values of the evaluation index are in good standard and this project is considered to be economically feasible from the viewpoint of the national economy, even though this is a full scale project, including road improvement as well as construction of two new bridges
- According to the scoping results of the project, executing the project will generate various positive impacts particularly for the local economy and social lives of local residents, while

negative effects under the environment and social consideration is very limited. Mitigation measures for these limited negative impacts should be studied under the feasibility study stage.

9. Pre-Feasibility Study on Rehabilitation and Reconstruction of the Railway between Limbe and Border (Marka)

(1) Justification of Rehabilitation and Reconstruction of Railway between Limbe and Border

In the Master Plan study, rehabilitation and reconstruction of the railway between Limbe and Border (Marka) was evaluation as generating several benefits, such as, reduction of transport cost by connecting to Beira Port, positive economic and social effects for people living along the railway line, reduction of CO_2 emissions, and foreign currency savings by diesel consumption. Responses from business society were very positive about connecting the railway to Beira Port in order to reduce transport costs and raise the reliability of railway operation. Responses toward revival of the Branch Line of the Sena Railway by relevant authorities in Mozambique were also very positive, because of the increase of cargo handling capacity of Beira Port. With this background, the Study Team considers that carrying out the Pre-F/S for the rehabilitation and reconstruction of the railway between Limbe and Border (Marka) is justified.

(2) Basic Transportation Plan

a) Freight Trains

From the yearly cross sectional transportation volume of freight calculated based on the demand forecast, the daily average transportation volume is calculated and the number of trains able to transport freight multiplied by the undulate rate due to the seasons is settled. The transportation volume and the number of trains operated are shown in Table 29.

Table 29 Transportation Volume and Number of Trains Operations

Type of Commodity	Freight Transport Volume (tonnes/day/direction)		Type of Rolling Stock	Number of Rolling Stock Required	
	2020	2030		2020	2030
General	686	1,682	DL	1	2
			Wagon	20	60
Fuel	297	1,093	DL	0	1
			Wagon	10	30
Ore	860	1,720	DL	1	2
			Wagon	30	60
Total	1,843	4,495	DL	2	5
			Wagon	60	150

Source: Study Team

b) Passenger Train

The sections between Limbe and Makhanga, Limbe and Bilila and Balaka and Nayuchi are in remote regions with no road traffic or where the roads are in poor condition. In addition, passenger trains are operated only as a domestic service. For the convenience of residents along the line in the Study Area, at least two passenger trains should be operated weekly. The passenger train will be

operated at the section between Limbe and Bangula in the medium-term plan. For the long-term plan, the section will be extended to Border.

(3) Rehabilitation/Reconstruction Plan for Railway Infrastructure

a) Earthworks

According to the results of the inventory survey, three major places at the Chiromo Washaway section and near Sankhulani are found to be necessary of major earthworks as shown in Table 30.

Table 30 Summary of Earthworks

Item	unit	Border–Nsanje	Nsanje–Bangula	Bangula–Makhanga	Makhanga–Luchenza	Luchenza–Limbe	Total
Fills	m^3	7,132	6,147	44,470	26,131	5,940	89,819
Cuttings	m^3	0	0	0	0	0	0
Culverts	lot	1	2	2	10	25	40
Revetment (Riprap)	m^3	-	-	12,000	-	-	12,000

Source: Study Team

b) Bridge Rehabilitation and Reconstruction Plans

1) Summary of Bridge Works

The bridges between Border and Limbe which should be rehabilitated or reconstructed are identified according to the inventory survey and visual check. Combination of a Steel Truss bridge and 5-spans PC bridge is selected for the Chiromo Railway Bridge, and PC Girders, RC Girders and RC Slab bridges are applied to the remaining sections.

Table 31 Summary of Bridge Works

Type	unit	Border–Nsanje	Nsanje–Bangula	Bangula–Makhanga	Makhanga–Luchenza	Luchenza–Limbe	Total
Steel Truss Bridge	m	0.0	0.0	80.0	0.0	0.0	80.0
PC Bridge (20 to 30 m)	m	220.0	75.0	190.0	48.0	89.0	622.0
RC Bridge (10 to 20 m)	m	15.0	15.0	0.0	38.0	14.0	82.0
RC Slab Bridge (5 to 10 m)	m	5.0	13.0	0.0	0.0	0.0	18.0
RC Box Culvert (less 5 m)	m	9.0	4.0	0.0	0.0	0.0	13.0

Source: Study Team

2) Preliminary Design of Chiromo Railwaye Bridge

The best bridge construction position shall be selected among the three alternatives mentioned below using the results of a comparative study on the bridge construction positions and access road of the three alternatives. In the comparison, the three alternatives are analysed comprehensively, with bridge length, cost-efficiency of bridge construction, alignment of the access road, impact of the New Shire River on the approach embankment sections, flood control measures, land acquisition, construction efficiency and impact on the natural and social environments taken into full consideration, and the best alternative shall be identified from the results of the comprehensive analysis. Alternative 2 is the most preferable bridge construction position in terms of “best horizontal alignment”, “no significant impact from flooding of the New Shire River”, and “lowest construction cost”.

Alternative 1: Existing alignment position

Alternative 2: Using the existing road embankment

Alternative 3: Matching the new road alignment

Three types are compared for the bridge to be constructed at the best position selected in the pervious section. A combination of steel truss bridge and concrete T-girder bridges shall be the first choice because of its suitability for long span to cross the washaway section and best cost performance. Regarding the scale of a bridge, bridge length and span length shall be decided using the results of the hydrological survey and analysis of the survey results..

The following three alternative bridge types shall be compared.

Alternative 1: Steel 8-span plate girder bridge

Alternative 2: Steel 3-span continuous truss bridge

Alternative 3: Steel simple truss bridge + PC 5-span post-tensioned T-girder bridge

Alternative 3 is the most preferable bridge type because Alternative 3 is evaluated “appropriate for long spans and does not need any construction in the river” and “best cost performance” and “this is the most desirable alternative in overall evaluation because of superior structural performance, construction efficiency, and river characteristics”

3) Rehabilitation Plan for the Existing Kamuzu Truss Bridge

- It is necessary to repaint the whole truss structure as early as possible
- Anti-corrosion paint must be applied for the open grating floor.
- It is necessary to separate pedestrians and bicycle traffic from other vehicle traffic on the Kamuzu Truss Bridge. Therefore, all the metal flooring is planned for replacement by the open grating floor to minimize the static load on the simple sidewalk structure.
- Routine inspection and maintenance, as well as periodic maintenance are deemed necessary.

c) Track Rehabilitation and Reconstruction Plans

To secure safe and stable transportation, all tracks should be replaced and the outline of the track works is summarised in Table 32.

Table 32 Outline of Track Works

Item	Unit	Border–Nsanje	Nsanje–Bangula	Bangula–Makhanga	Makhanga–Luchenza	Luchenza–Limbe	Total
Track Length (Main line)	km	25.6	45.4	8.7	76.6	44.0	200.3
Track Length (Sidings)	km	1.5	1.0	1.9	1.0	1.1	6.5
Total Track Length	km	27.1	46.4	10.6	77.6	45.1	206.8
Rail (Main line)	ton	2,600	4,600	900	7,700	4,400	20,200
Rail (Sidings)	ton	200	100	200	100	100	700
Total Rail	ton	2,800	4,700	1,100	7,800	4,500	20,900
PC Sleeper	Set	42,300	72,400	16,500	121,100	70,400	322,700
Fastening	Set	84,600	144,800	33,000	242,200	140,800	645,400
Turnouts	Set	7	4	8	4	9	32
Ballast	m3	36,200	62,100	14,200	103,800	60,300	276,600

Source: Study Team

(4) Signalling and Telecommunication System Installation Plans

a) Signalling System

The signalling system will consist of a combination of signals, interlocking devices, electric switch machines and track circuits. The electronic logic and interlocking devices will be installed in the signals of each station.

As to the system to be introduced on the railway, the "Train Control System for Secondary Lines using Radio Communications in Specific Area (TCS/SL/RC)" developed by the Railway Technical Research Institute (RTRI) of Japan for intermittent and continuous control would be suitable for the line. Because there are not many trains, the traffic density is low and the train operation control does not require the latest advanced technology.

b) Telecommunication System

The railway telecommunication network consists of a combination of transmission networks deployed along the rail line using voice cables, multiplex carriers, radio systems, or other forms of transmission media, which are suitable for transmission between terminals, and voice/data exchange equipment, data processing equipment, etc. Dedicated transmission lines or direct transmission lines should be installed on the whole line. The radio communication system between the OCC and trains will be another requirement unique to the railway operation.

(5) Rolling Stock

At present, only 4 out of 10 diesel locomotives (DL) are operated on the whole route. When the section between Border and Limbe is reopened, additional DLs, freight wagons and passenger coaches are required. As to the choice of diesel locomotive for the section, it should be determined to meet the overall traffic requirements for present and future at maximum efficiency and minimum overall cost to the system.

(6) Preliminary Cost Estimate

An estimate of the cost of rehabilitating/reconstructing the railway has been prepared to enable a decision to be made. However, before making a decision on the actual investment, a detailed feasibility study including a geotechnical investigation and development of the preliminary design should be conducted. The project costs are summarized in Table 33.

(7) Establishment of Railway Maintenance Plan

The railway facilities which are to be rehabilitated or reconstructed should be maintained properly by limited human resources and utilized longer to provide safe and stable railway transport services. To achieve this, a reliable and efficient maintenance plan should be established.

The present maintenance system involves assessing the soundness of the structure by periodical inspection, identification of deteriorated or deformed parts, detailed inspection of identified parts, and implementation of required measures (observation, repair, reinforcement). It is recommended that the railway operator in Malawi should establish a maintenance system by referring to the one in Japan and consider the following:

Table 33 Summary of Preliminary Cost Estimate

Unit: US$ million

Section / Route Length / Item	Border–Nsanje 25.6 km	Nsanje–Bangula 45.4 km	Bangula–Makhanga 8.7 km	Makhanga–Luchenza 76.6 km	Luchenza–Limbe 44.0 km	Total 200.3 km
Earth Works	0.186	0.161	0.789	0.683	0.155	1.974
Bridge	10.232	4.480	17.550	3.911	4.407	40.579
Chiromo Railway Bridge	-	-	15.350	-	-	15.350
Other bridges	10.232	4.480	2.200	3.911	4.407	25.229
Track	13.243	21.764	5.674	36.028	21.486	98.195
Station	0.138	0.275	0.413	0.688	0.688	2.200
Level Crossing	0.000	0.125	0.250	0.000	0.250	0.625
Signal & Telecommunication System	0.651	1.205	1.070	2.533	7.126	12.585
Sub-Total	24.449	28.009	25.746	43.841	34.112	156.158
Rolling Stock	0.000	0.000	0.000	0.000	46.500	46.500
Diesel Locomotive	0.000	0.000	0.000	0.000	30.000	30.000
Freight Wagon	0.000	0.000	0.000	0.000	13.500	13.500
Passenger Coach	0.000	0.000	0.000	0.000	3.000	3.000
Engineering Cost (10%)	2.445	2.801	2.575	4.384	3.411	15.616
Contingency (10%)	2.445	2.801	2.575	4.384	3.411	15.616
Total	29.339	33.611	30.895	52.610	87.434	233.890
Average Cost per km excluding Rolling Stock	1.146	0.740	3.551	0.687	0.930	0.936

Source: Study Team

- Verification of performance
- Applicability to related railway operators such as CDN
- Consistency for all types of structure
- Few major changes from the maintenance system during the Malawi railway era

(8) Economic and Financial Analyses of Rehabilitation/Reconstruction of Railway between Limbe and Border (Marka)

a) Economic Analysis

The objective of the economic analysis is to analyse and evaluate the viability of implementing this 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. Economic Internal Rate of Return (EIRR), Benefit and Cost Ratio (B/C Ratio) and Economic Net Present Value (ENPV) are estimated as the evaluation indices. The results of the economic evaluation based on the above conditions are summarized in Table 34.

Table 34 Results of Economic Evaluation

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)
198.81	17.40 %	1.53	72.43

Source: Study Team

b) Financial Analysis

The objective of the financial analysis is to evaluate the financial adequacy of the project and management soundness by the operation body. Financial Internal Rate of Return (FIRR) and Financial

Net Present Value (FNPV) are applied as evaluation indices. The results of the financial evaluation based on the above conditions are summarized in Table 35. As a result, the FIRR is found to be 2.05% and is considered financially viable compared with 1.53% of WACC.

Table 35 Results of Financial Analysis

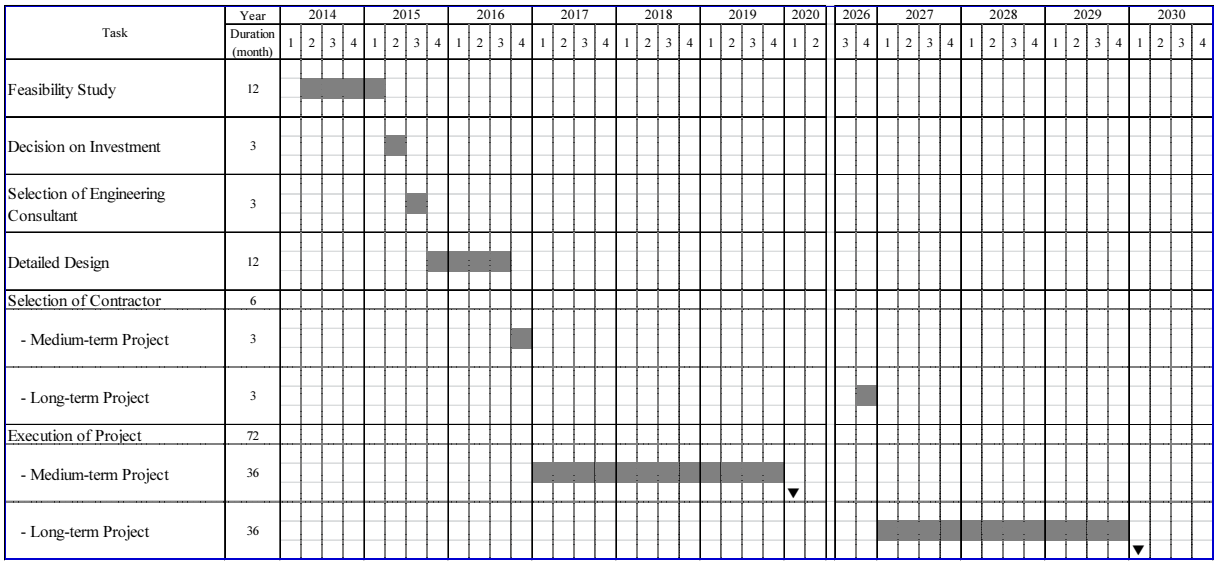
Financial Internal Rate of Return (FIRR)	Weighted Average Cost of Capital (WACC)	Financial Net Present Value (FNPV)
2.05 %	1.53 %	22.70 US$ million

Source: Study Team

(9) Implementation Programme for Rehabilitation/Reconstruction of Railway between Limbe and Border (Marka)

The implementation schedule for the whole project is shown in Table 36.

Table 36 Construction Schedule (Whole Project)



Source: Study Team

(10) Overall Evaluation of Rehabilitation and Reconstruction of Railway between Limbe and Border (Marka)

- The rehabilitation and improvement of the railway between Limbe and Border would provide several benefits on the national and local economy, positive economic and social benefits for residents along the railway line between Luchenza and Makhanga, reduction of CO_2 emissions, and foreign currency saving.
- The revision of the design standard, particularly axle loads, should be carefully considered at the detailed design stage taking into account the future freight demand. The biggest matter to increase the axle load is a replacement of Kamuzu Truss Bridge which will incur a high cost and long construction period.
- The current embankment which is about 80 years old would not have enough soil bearing capacity due to inadequate compaction work during its construction. Therefore, the compaction work for the new embankment should be carefully executed.

- The Chiromo Railway Bridge over New Shire River is planned as a steel truss bridge from a viewpoint of vertical alignment and easiness of the construction. Other small bridges are planned as RC or PC bridges which are popular these days.
- It is recommended to upgrade to heavy rails, i.e. 50 kg rails with PC sleepers which would achieve stable operation, track durability and the reduction of noise.
- A new signalling system should be implemented on the line. Regarding compatibility with the signalling system of Nacala Railway where Vale is planning to construct a new line and rehabilitate the existing line, it is important and inevitable to secure mutual compatibility. A new railway telecommunication network is to be established by the combination of a transmission network deployed along the rail line using voice cables, multiplex carriers, radio systems, or other forms of transmission media.
- It is necessary to introduce new diesel locomotives. New locomotives with similar specifications should be procured.
- After rehabilitation or reconstruction of the section, the railway facilities should be maintained properly by limited human resources and utilized longer to provide safe and stable railway transport service. To achieve this, a reliable and efficient maintenance plan should be established.
- In the economic analysis, all the values of the evaluation index are in good standard and this project is considered to be economically feasible from the viewpoint of the national economy. Also, this project is evaluated as financially feasible. It is inevitable to arrange governmental subsidies for the infrastructure portion of the project.
- According to the scoping results of the project, executing the project will generate various positive impacts particularly for the local economy and social lives of local residents along the railway line. Mitigation measures for these limited negative impacts should be studied in detail under the feasibility study stage.

10. Social and Environmental Considerations

(1) SEA Methodology

At the Master Plan stage, the SEA methodology is normally required to assess environmental and social impacts from an early stage, according to the JICA guidelines for Environmental and Social Considerations. In this study, the proposed nine options, including the zero option, are regarded as regional transport programmes. The Study applies the SEA methodology to evaluate qualitatively the environmental, social, and economic impacts of the regional transport development programme for the Sena Corridor.

(2) Scoping of Proposed Projects and IEE for the Sena Corridor Master Plan

Each proposed project is screened using the EAD guidelines and the SEA methodology. Since all projects are under List B, less significant environmental and social impact is expected, and all projects are expected to contribute to the objectives of the Sena Corridor Master Plan.

Based on the results of the scoping matrix for the proposed projects of the three transport network

alternatives, the Study evaluates each project in terms of economic, social, and environmental impacts in order to integrate environmental considerations into economic and social aspects. The results of each alternative are then cumulated at the programme level in order to compare three alternatives for the Sena Corridor Master Plan. The option of no investment on the Sena Corridor (zero-option) is also evaluated for comparison.

The rehabilitation of the railway line is expected to change the transport mode from truck/car to railway, which will reduce total emission of air pollutants emissions. The landslides, slope failures, and soil erosion that currently occur along the railway line are expected to be improved by stabilising the slopes and soil while the occurrence of floods and overflow of water on the road is expected to be minimized.

The overall cumulative results for the Sena Corridor's Master Plan are summarised in Table 37. Regarding Alt. 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, which will benefit the local population in terms of access to agricultural products, schools and health posts.

Table 37 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

(3) Environmental and Social Conditions along Selected Projects for Pre-F/S

a) Existing Social Infrastructure and Services

- Due to the disconnection at the Chiromo washaway in 1997, local residents on the eastern side of the Chiromo washaway section have difficulty selling agricultural products to the major market in Bangula as well as having to spend extra money to cross the Chiromo washaway section by boats when they go to a market, school or hospital.
- Local residents along the railway line between Makhanga and Luchenza face more serious problem as they have almost lost their opportunity to bring agricultural products by a train and sell at a major market, because train operation is limited to weekly or less often service since the disconnection of railway line at the Chiromo washaway section.
- Oarsmen, who were formerly fishermen, operate the boats rented from their owners and depend on income from the crossing fee.

b) Involuntary Resettlement

- The Study Team employs the policy in the selection of alternative road alignment to avoid involuntary resettlement, in line with the same policy adopted by MoTPI. However, the selected

road alignment described in Section 12.1.1 may affect about 20 huts and shops with grass structures in Makhanga.

- There are few huts which illegally occupy the unused railway line between Makhanga and Border.

c) Hazards

- There are serious erosions on the right-side bank of the Ruo River near Makhanga and this can cause a negative impact if the existing road alignment, which passes only 30 m from the river bank, will be selected for improvement.
- There is a risk of frequent flooding at the narrow river section caused by the existing road embankment on Bangula side of the Chiromo washaway.
- There is a difficulty of not being able to drain flooded water from on the land between the existing railway embankment and the planned road embankment from the Chiromo washaway towards the Shire River. This will have a negative impact on land used for cultivation.

d) Forests Biodiversity and Social Condition

- The proposed project passes the edge of wetland called Elephant Marsh, which is not a protected area by law in Malawi.
- The railway line between Border and Limbe does not pass through an ecologically sensitive area and the impact on biodiversity is considered to be negligible.
- It is expected that no forest cutting will be necessary for the Projects.
- Historical and cultural heritages, including the World Heritage Sites, are not found along the selected roads.
- There are no indigenous people in Malawi. However, there are minority people living in the country since Malawi is a conglomerate state that consists of multi-ethnic groups and religious sects.

(4) Possible Environmental and Social Impacts of the Projects

- When the proposed Chiromo Road Bridge will be constructed, the positive impacts for those local residents will be significant for improving mobility to the market in Bangula and social services, as well as saving unnecessary expenditure to cross the Chiromo washaway section.
- When the proposed rehabilitation and reconstruction of the railway line will be completed, the positive impact for those local residents along the railway line will be significant for getting much more opportunity to bring and sell agricultural products to a major market by frequent service of trains.
- When the proposed Chiromo Road Bridge will be constructed, negative impacts for those oarsmen are expected because they will lose their main income source.
- The selected road alignment may affect about 20 huts and shops with grass structure in Makhanga. This is a negative impact from the improvement of the road section between Makhanga and Bangula.

- Relocation of huts illegally occupying the railway track will be a negative impact on the reconstruction of the railway line between Makhanga and Border.
- The expected difficulty to drain flooded water on the land between the existing railway embankment and planned road embankment will be a negative impact on the cultivated land.
- During construction, the air quality around project sites will temporarily change due to the emission of pollutants. Dust and diesel emissions will be major pollutants.
- Trucks and heavy equipment working along the road will be noisy and cause vibration.
- Solid waste will be produced during the road improvement process, starting with surplus soil and rocks which will derive from the excavation work and also metallic parts, cut wood from road side and slopes and food waste from construction workers.
- Sewage will be discharged from toilets and food courts of the construction camp into surrounding water flows if appropriate treatment is not taken. Construction workers could increase the prevalence of HIV/AIDS.
- There are potential pollution sources of surface and groundwater flows in the Project. Those are 1) runoff soil from the construction site, 2) surface soil erosion with rain water from excavation site, 3) accidental leakage of fuel/oil and 4) structure, such as drains and bridges, connected to or placed in/under surface water flow.
- During the construction process there will be an increased intensity of heavy vehicle traffic, which may increase the risk of traffic accidents.
- The high velocity and increment of traffic can cause traffic accidents between vehicle and pedestrians or bicycles after completion of reconstruction work.
- Resume operation of train with higher frequency than at present between Limbe and Border can cause accidents between a train and a vehicle, bicycle or pedestrian at level crossing and on the Kamuzu Truss Bridge.

(5) Mitigation Measures to be taken

In order to avoid or alleviate the possible impacts by the Projects, mitigation measures should be taken during construction and operational phases of the Projects.

- When the number of huts and temporary shops to be relocated is identified in the feasibility study stage, particularly in Makhanga, the proper compensation according to government regulations should be paid to those affected residents or alternate plots of land should be provided as well.
- The oarsmen, who will lose their source of income after construction of the Chiromo Road Bridge will be given job opportunities as unskilled labour during the construction. In addition, a mitigation measure to create a source of income will be prepared by consultation during the F/S.
- In order to minimize environmental impacts from the construction activity, the contractor should consider the possibility of establishing the construction camp as far as possible from the residences of the villages where the road and railway pass, and also as far as possible from the water sources and agricultural, pastures or forestry land. The contractor should prepare the environmental management plan and to mitigate negative impacts during construction. The

contractor should also instruct workers about the risks and preventive measure for HIV/AIDS and other infectious disease under the environmental management plan.

- The noise protection efforts shall mainly be focused on the road segments passing through inhabited centres of the communes and villages. Treatment of solid waste shall follow the GoM's regulation.
- Temporary yards and construction camps should be chosen from locations, far away from sources of surface water, in non-productive lands, at an acceptable distance from village houses where the road and railway pass through.
- The protective measures for the pollution of surface water and groundwater need to follow the GoM's regulation. In particular, special care needs to be taken when workings near the water flows or bridges.
- Traffic safety devices (warning signs, sidewalks and pedestrian crossings, humps to reduce vehicle speed, etc.) will need to be installed in populated areas and near schools to prevent traffic accident. Also, traffic safety education at primary schools will be necessary.
- Warning signs and barriers will need to be installed for the approach sections of roads at major level crossings to prevent train accidents with vehicles, bicycles or pedestrians. Also, traffic safety education at primary schools will be necessary.
- Guard personnel will need to be assigned at level crossings and the Kamuzu Truss Bridge to control vehicle traffic.

(6) Consultation with Stakeholders

The consultation with stakeholders aims to encourage stakeholders to understand the project needs, the project design, and the adverse impacts on the environment and society. In the Study, consultations with stakeholders were held according to the following schedule:

- April 2011: First Technology Transfer Seminar in Lilongwe and Blantyre
- October 2011: Second Technology Transfer Seminar in Lilongwe and Blantyre
- November and December 2011: Consultation with related District Councils
- January 2012: Third Technology Transfer Seminar in Lilongwe and Blantyre

(7) Environmental Management and Monitoring Plan

An Environmental Management and Monitoring Plan is to provide the environmental standards for rehabilitation, operation, and routine maintenance of the proposed projects. The executing agencies of the project should prepare an EIA during the feasibility study phase. The results of EIA should be incorporated in the Environmental Management and Monitoring Plan, which is mandatory in Malawi.

11. Institutional Arrangements for Implementing the Master Plan Programme

(1) Institutional Arrangements for the Road Sub-sector

Since several road improvement projects, including projects proposed in the Master Plan, will be implemented in the Study Area within the next 10 years, MoTPI and Road Authority (RA) should focus on the operation and maintenance of road assets, by routine and periodic maintenance by the

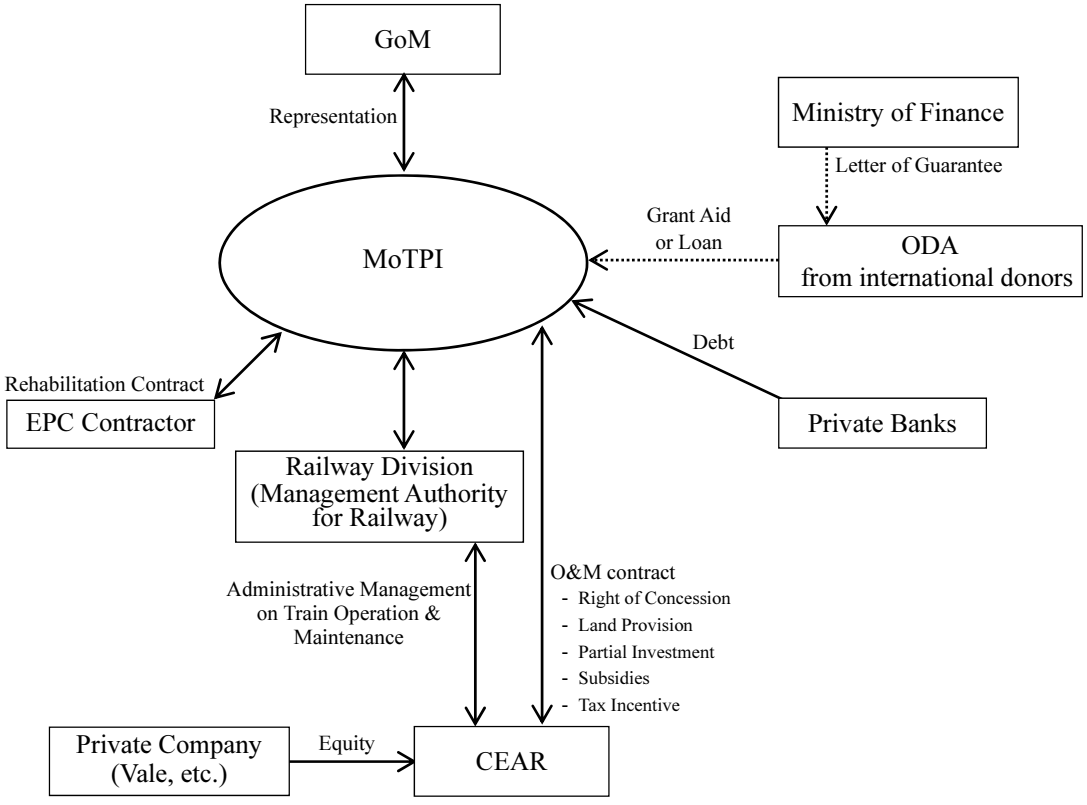
following programmes.

- Routine maintenance work should be carried out according to the O&M programmes.
- Periodic maintenance works should be carried out according to the O&M programmes for priority road sections identified by the Highway Development and Maintenance Model 4 (HDM-4).
- Inspection and maintenance of drainage structures and bridges should be carried out annually to identify and repair/clean disorderly parts of structures.

(2) Institutional Arrangements for the Railway Sub-sector

The institutional arrangements for the railway sub-sector range from information sharing and consensus building to rehabilitation/reconstruction project plans and their implementation. In order to secure smooth implementation of the Master Plan, the authority of the Railway Division of MoTPI must be strengthened to supervise CEAR's operation and maintenance performance.

MoTPI acts as an implementing organization of the rehabilitation project. It should exchange a revised concession contract with CEAR and implement financing, EPC (engineering, purchase, and construction), and O&M of the Branch Line of the Sena Railway. The project implementation structure of the rehabilitation is shown in Figure 38.



Source: Study Team

Figure 38 Project Implementation Structure

To decide the freight tariff, a tariff policy is required. The tariff policy should be established based on a system of definite unified principles and priorities, rules and methods of the operator regarding rolling stock, freight cars handled, and transit by freight tariff. The main objective of the tariff policy

is to preserve the balance between the operating company and service consumers. Regarding international freight traffic, the railway administrative bodies of Malawi, Mozambique and Zambia should establish a tariff policy for such traffic.

The current concession with CEAR will expire in 2019. According to the concession agreement, both parties should discuss revision or extension of the agreement 5 years before expiration of the contract. Therefore, the discussion will start within 3 years from now. From a macroeconomic perspective, Malawi faces important structural changes to maintain sustained economic growth and improve living standards. It requires more transport services to import and export products. To provide stable transport services, operation and maintenance of the railway were shifted from public to private operation by CEAR as a concession. However, this concession has not worked well. There are problems and issues in the current concession between MoTPI and CEAR. These matters should be considered in the course of discussing the concession revision work.

12. Capacity Development Programme

(1) Capacity Development Programme in the Study

Personnel in the executing agency, MoTPI, and other related agencies have had limited experience of being involved in the preparation of transport master plans in the past and it was desirable for them to learn the process of formulating a transport master plan and understanding its contents for implementation in the near future.

The capacity development was planned to be carried out mainly through on-the-job (OJT) training while Japanese experts were carrying out their studies in Malawi. The main activities of performed capacity development programme are as follows:

- Accompanying field surveys (between November 2010 and November 2011)
- Discussion in the Working Group meetings (five working group meetings)
- Peer review of draft reports (Progress, Interim and Draft Final Reports)
- Preparation of materials for technology transfer seminars (1st, 2nd and 3rd technology transfer seminars)
- Presentation at technology transfer seminars (1st and 2nd technology transfer seminar)

In addition to the capacity development in the Study, JICA selected one counterpart personnel for one of the Training and Dialogue Programmes entitled “National and Regional Development Policy”.

(2) Evaluation of Capacity Development Programme in the Study

During the course of the Study from commencement up to the end of December 2011, six counterpart personnel actively worked together with the Study Team to improve their ability to prepare the transport master plan and pre-F/S for both the road and railway projects, even though the number of personnel in the executing agencies is limited and they have their existing duties.

These counterpart personnel have their own knowledge and experience in their own specialities. However, their ability to prepare the transport master plan and pre-F/S for both the road and railway

projects has definitely been improved, particularly the process of study carried out by JICA through OJT and preparation/presentation in technology transfer seminars.

In order to secure the sustainability of capacity development in MoTPI and other agencies, it is recommended to assign one transport field expert (engineer) in MoTPI.

13. Conclusions and Recommendations

Conclusions and recommendations of the Master Plan and the Pre-F/S are as follows:

(1) Conclusion

- The Basic Policy for development of the Sena Corridor is proposed in line with the national development policy for sustainable economic growth and poverty alleviation in three main areas: Southeastern Africa, Malawi and the Study Area.
- Based on the Basic Policy, development of the Sena Corridor is examined in terms of the international north-south axis, the domestic north-south axis and arterial transport networks in the study area, and then the targeted international transport corridor and arterial transport network in the study area are identified. The development of transport infrastructure in Mozambique is defined as an external factor and it is assumed that both the road and railway will be developed up to 2030.
- Master Plans for the road and railway sectors are proposed divided into three terms, i.e. short-term (2015), medium-term (2020) and long-term (2030), followed by the Development Concept and Strategy for both sectors. Among the three alternatives, the entire transport network including both the road and railway connecting to Beira Port is evaluated as the most desirable for the Master Plan in terms of economic evaluation (EIRR=17.1%), environmental impact and transportation.
- The proposed projects for the Master Plan in the Study, which consist of four road projects (M1, S151, S152 and D379) and three packages (railway line rehabilitation and reconstruction, procurement of rolling stock, and installation of signal and telecommunication system) of railway projects, are judged as technically and economically feasible. Hence, it is necessary to start preparing an investment programme for the Master Plan.
- The projects in the Master Plan will greatly contribute to sustainable economic growth, poverty alleviation and improvement of living conditions in the Study Area by improving access to rural growth centres from local communities, particularly from isolated communities with very limited access at present.
- These projects will also contribute to sustainable economic growth, improving international competitiveness of export products, and strengthening redundancy of transport network in Malawi by improving access to ocean ports and international markets for exporting cash crops and importing fuel and fertilizer from a view point of Malawi.

- These projects will contribute to strengthen the international north-south axis in the region by creating alternative international transport corridor to/from Beira Port from a view point of Southeastern Africa.
- The Selected road project for the Pre-F/S, i.e., ”Reconstruction of S151 Road between Makhanga and Bangula”, is judged as technically and economically feasible, based on the preliminary design for improvement of the road section between Makhnaga and Bangula, and construction of the Chiromo Road Bridge and the New Shire Bridge for the short term and medium term programme.
- The Selected railway project for the Pre-F/S, i.e., ”Rehabilitation and Reconstruction of the Railway between Limbe and Border (Marka)” is technically and economically feasible, based on the preliminary design of rehabilitation and reconstruction of railway line, including tracks and road bed, bridges, including the Chiromo Railway Bridge, installation of a signalling/ telecommunication system, and procurement of rolling stock. Financial analysis results also indicate that the project will also be feasible.
- Results of IEE for both road and railway projects identified minimal negative environmental and social impact as a result of these projects.

(2) Recommendations for the Project Implementation

- The GoM will have to continue dialogs with counterparts in the GoMZ after the first dialogue in November 2011, since it is necessary to coordinate with the GoMZ for implementing projects in the Master Plan. The main topics to be discussed are reconstruction of the branch line of the Sena Railway between *Villa Nova de Frontera* and *Dona Ana* and improvement of the secondary roads N300 and N322 between *Villa Nova de Frontera* and Caia via Mutarara.
- MoTPI can inform the outcome of the Master Plan as well as the Pre-F/S, particularly “Reconstruction of S151 Road between Makhanga and Bangula and “Rehabilitation and Reconstruction of Railway between Limbe and Border (Marka)”, to development partners for possible assistance with project implementation.
- MoTPI should carry out the F/S of priority projects identified as feasible under the Pre-F/S at an early stage. Also, MoTPI should carry out a full-scale EIA, including public consultations, during the course of the F/S for both the road and railway projects.
- MoTPI should allocate sufficient budget to the compensation for resettlement and land acquisition necessary for executing the projects based on the results of the F/S.

(3) Recommendations for the Institutional Arrangements

- RA can consider changing the classification of S151 to “Main Road” after the completion of upgrading to create complete arterial network in the Study Area.
- MoTPI needs to secure adequate budget for operation and maintenance of the road sub-sector to maximise use of existing road assets.
- MoTPI needs to strengthen the organisation of the Railway Division and develop capacity of personnel, and revise Railway Act to supervise and check the performance of CEAR.

- MoTPI will have to review the present concession with CEAR starting from 2014. The past performance of CEAR in management and operation of railway lines in Malawi will require carefully checking.