CHAPTER 3

3. Medium/long-term Port Development Plan (Target Year: 2030)

3.1. Development potential of Nacala Corridor and Nacala Port

In this section, the development potential of Nacala Port and Nacala Corridor is analyzed.

3.1.1 Development targets

The Port and the Corridor are expected to play an important role in realizing the following two important targets for the development of the regional socio-economy:

(1) Industrial development of northern Mozambique

Northern region of Mozambique, which consists of three provinces, i.e. Nampula, Cabo Delgado, and Niassa, is less developed compared to the southern and the central regions; while 33.5 % of the country's population is found in the northern region, the GDP share of this region accounts for only 12.8%. Therefore, it has been a priority policy of the Government to eradicate poverty by promoting industries in this region.

The major industry in northern Mozambique is agriculture in which potential is high due to the rich and fertile land of the region. However, commercialized agriculture has not been developed and the productivity of the agricultural sector is very low, which is the principal reason for the low economic performance of the region. The Government has been making efforts to develop the agricultural sector in the region, and international development partners including Japan have been proactively providing technical and financial aid to promote agricultural production. The Port and the Corridor are expected to guarantee efficient and reliable access to the world market, and to improve the competitiveness of the agricultural sector in northern Mozambique. The Port and the Corridor are also expected to become a low-cost supply route of fertilizers.

Thus, the Port and Corridor should contribute to the development of agricultural sector in northern Mozambique. And at the same time, the Port and Corridor should be developed in line with the growth of the agricultural sector; in other words, a synergistic relationship between the agricultural sector and the Port and Corridor will be formed.

In 2007, GOM established Special Economic Zones in two districts surrounding the Port, Nacala and Nacala a Velha, with the aim of developing the areas along the Corridor. Export processing industry which imports raw materials from overseas and exports products to the foreign market is the most promising industry in the SEZ adjacent to the international sea port. The deepest port in the region makes the export processing zone (EPZ) in Nacala SEZ very unique and competitive. The SEZ is expected not only to be a pure export processing zone but also to be a "gateway processing zone of the Corridor". Agricultural, forestry and mineral products produced in the corridor area shall be manufactured in the gateway processing zone, and exported to world markets, or imported raw materials, such as wheat and other cereals, shall be manufactured in the gateway processing zone and be delivered to the corridor area.

Private investments in mining and afforestation are increasing. For these industries, provision of efficient mass transport service is crucial. In mining development, in particular, the capacity of the Port and Corridor is the decisive factor of the production capacity. Therefore, the Port and the Corridor are expected to increase their capacity in order to play an important role in the promotion of these investments.

The Port and Corridor should be the catalyst to industrial development of northern Mozambique, and should guarantee the sustainable development of the region.

(2) Trade and transport facilitation for LLCs and landlocked region in Mozambique

Trade and transport facilitation through provision of efficient international transport routes is crucial for economic development of LLCs and landlocked regions, which is the one of the most important issues in the context of African development.

The Port has historically been the principal gateway port of a greater hinterland area including Malawi and Zambia as well as the northern part of Mozambique. During the 1970s, about 95 % of import and export cargoes of Malawi were handled at the Port. However, once the Corridor was damaged during the civil war, no transit cargo was shipped at the Port. Though the cargo volume at the Port has been recovering in recent years, the Port handles only 14% of the transit cargoes to and from Malawi, while almost all the cargoes to and from Zambia are hauled all the way to South Africa or Tanzania and shipped there.

The Port and the Corridor can provide the shortest access from Malawi to the international maritime transport network, and a competitive transport route from Zambia to the Middle East or Asia.

The Port and the Corridor are expected to resume and to strengthen the gateway function by being rehabilitated and upgraded. The Port and Corridor can bring a large benefit to LLCs. And at the same time increased volume of transit cargoes will bring a large benefit to the Mozambican transport sector and related industries. The increased volume attracts a larger number of container vessels and this enables the local industry to enjoy frequent and competitive liner service.

3.1.2 SWOT analysis

SWOT analysis is conducted to evaluate the potential of the Port and the Corridor to realize the above mentioned development targets. The results of the SWOT are shown below:

(1) Industrial development of northern Mozambique

Strengths	Weaknesses
• Well-sheltered deep-water port • On-going road rehabilitation project • Remaining capacity of the Port if it is properly operated • Direct liner service to Asia and Middle East • Possibility of inclusion into East African Port group on the maritime network • Existence of railway link to the Port • Less congested road • Geographical proximity to Nacala SEZ • Geographical proximity to the prospective agricultural center of the country • Possibility of synergetic effects of Port, Corridor, SEZ, and agriculture • Possibility of operational improvement of port and railway • Possibility of strengthening of financial structure of CDN	• Inefficient container operation • Inefficient land use in the Port • Shortage of water depth for bulk cargo handling • Insufficient investment in port and railway • Weak financial structure of CDN • Distance from the international container trunk route • Absence of modernized dry bulk terminal in the Port • Burden of scanning • Absence of strategic port development plan • Less active domestic maritime transport • Insufficient water and energy supply in Nacala • Possibility of collapse of port facilities due to deterioration • Shortage of spatial resources in the existing footprint of the Port for future development • Capacity of urban road network in Nacala • Relatively small area of basin when port facilities are constructed on the Nacala-a-Velha side
Opportunities	**Threats**
• Increased number of factories located in the SEZ • Establishment of IFZs in the SEZ • New international airport • On-going and planned projects in agriculture sector, forestry sector and mining sector • Possible assistance from international development partners • Political stability	• Possibility of delay of improvement of investment climate (human resources, corruption, water and energy supply, telecommunication etc.) • Possibility of delay of simplification of customs procedures • A downturn in world economic activity • Environmental sustainability of Nacala Bay • Absence of well coordinated spatial plan of SEZ considering port development • Absence of dedicated IFZ • Relatively small amount of FDI in the SEZ

(2) Trade and transport facilitation for LLCs and landlocked region in Mozambique

<table>
<tr><th>Strengths</th><th>Weaknesses</th></tr>
<tr><td>

Good geographical position to serve Zambia and Malawi
Existence of direct railway link between the Port and LLCs
Well-sheltered deep-water port
On-going road rehabilitation project
Planned new railway line construction and improvement of existing railway tracks by Vale
Existence of a single entity operating both port and rail
Direct liner service to Asia and Middle East
Possibility of inclusion into East African Port group on the maritime network
Remaining capacity of the Port if it is properly operated
Less congested road
Possibility of operational improvement of port and railway
Possibility of strengthening of financial structure of CDN

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Inefficient container operation
Inefficient railway operation
Inefficient land use in the Port
Long dwell time for transit cargoes via railway and weak interface between rail and sea
Insufficient investment in port and railway
Weak financial structure of CDN
Absence of strategy to attract transit cargoes
Distance from the international container trunk route
Absence of modernized dry bulk terminal with deep-water quays
Deposit system of import duty for transit cargoes
Burden of scanning
Absence of pipeline connection to LLCs
Deteriorated rail tracks especially in Malawi
Absence of rail link connecting Copperbelt
Delay of introduction of OSBP
Absence of strategic port development plan
Possibility of collapse of the port facilities due to deterioration
Shortage of spatial resources in the existing footprint of the Port for future development
Relatively small area of basin when port facilities are constructed on the Nacala a Velha side

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<tr><th>Opportunities</th><th>Threats</th></tr>
<tr><td>

Political stability and continued economic growth in LLCs
Relatively good political relations between Mozambique and LLCs
Possible assistance from international development partners
Overall improvement in the competitiveness of Mozambican port network through fair competition between Nacala and Beira

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Possibility of delay of simplification of customs procedures
Planned increase of port capacity in Tanzania (Bagamoyo Project) and efficiency improvement of TAZARA railway
Planned development of Durban Port
Aggressive sales of Walvis Bay Port
Possibility of change of Durban's strategy focusing on transit cargoes to utilize increased capacity by the port development and Ngqura Port construction
Improvement of corridors connecting LLCs with Durban, Dar es Salaam and Walvis Bay
Restriction of the capacity of the railway for general cargoes due to increasing demand of coal transport
A downturn in world economic activity

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3.2. Issues of the Port

To become a driving force of the socio-economic development of the Northern Provinces of Mozambique or greater Nacala Corridor area, the Port must:

- be competitive, and
- be sustainable.

At present, however, the Port is neither competitive nor sustainable for numerous reasons as described below:

(1) Sustainability

1) Damaged pier structure of the container terminal

The 372m long container wharf is the busiest wharf in the Port. However, the pier structure of the container terminal is seriously damaged and deteriorated. Considering the age of concrete, the deterioration will be accelerated, and continuation of container operation on the pier will become impossible. Once the container operation is suspended, container handling function of the Port will be lost completely because there is no alternative facility for container handling in the Port. Since the repair would not be easy and it would take very long time, the suspension of container operation will seriously affect the regional economy and employment. Thus, the Port is not sustainable physically.

2) Shortage of functional capacity

By the development of the Corridor and its surrounding area, the Port will be required to provide new types of services such as mass transport of mineral products, sophisticated logistics services as the major component of supply chain of SEZ. However, the present port function cannot meet these requirements. Thus, the Port is not sustainable functionally.

3) Shortage of spatial resources in the existing footprint of the Port for future development

At present land use of the Port is quite inefficient. There are many underused or unnecessary sheds and shunting rail lines in the Port. In addition, functional allotment in the port area is not clear. If they remain as they are, the port operation will be paralyzed when the cargo volume increases. Even when all unnecessary facilities are demolished and the land use is rationalized, the existing footprint of the Port doesn't have enough space for future development of the Port to meet increasing cargo demand induced by the growth of the Corridor. The area of the basin will also become rather small when port facilities are constructed on the Nacala-a-Velha side. Thus the Port is not sustainable spatially.

4) Increase of traffic impedance of urban road network

Although the port traffic is separated from urban traffic to some extent, and the port traffic bypasses current Nacala CBD, the capacity of the bypass road is not enough to meet increasing port traffic demand and urban traffic demand in the future. In particular, the capacity of the urban road network will become a major bottleneck for the synergetic development of the Port and the SEZ. Thus the urban road network is not sustainable to accommodate increased port traffic.

5) Lack of a growth strategy and updated master plan

The Port doesn't have a growth strategy. Consequently, it doesn't have an updated master plan to materialize growth. Without a strategy and updated master plan, it would be very difficult for the Port to achieve sustainable growth utilizing synergism with the economic development of the Corridor area.

6) Managerial and financial problems of CDN

Financial performance of CDN has been very poor. CDN has not been able to make a profit to invest in rehabilitation of port infrastructure and acquisition of handling equipment. The U.S. Overseas

Private Investment Corporation provided infrastructure fund for port rehabilitation. However, the fund has disappeared without being invested leaving large amount of debt. The top management of CDN is fully responsible for the poor financial performance. Almost all issues of the Port listed above and below are directly or indirectly caused by inadequate management of CDN. CDN is not sustainable financially due to managerial problems.

7) Inadequate concessional framework

The framework of the current concession is so designed as to give the right of port operation to the concessionaire exclusively in return for imposing the responsibility of rehabilitation and development of the Port. The framework presumes that the concessionaire sincerely makes the utmost effort to discharge its duty. CDN, however, has never intended to rehabilitate the port facilities on the pretext of financial difficulty. The current concessional framework cannot cope with such occasion, and effective measures to force CDN to comply with the concession agreement have not been able to be taken.

Furthermore, the provision of priority right of port development in all areas of Nacala Bay and Fernao Veloso Bay to the concessionaire, which the concession agreement prescribes, would spoil the competitiveness of the Port, even if a concessionaire were competent and trustworthy. A lot of examples prove that fair competition among operators in a port is the source of the competitiveness of the port.

With such a concessional framework, it would be very difficult to expect sustainable growth of the Port. Thus, the current concessional framework is not sustainable.

8) Imperfect institutional framework for port sector

For achieving sustainable growth of the port sector, establishment of an institutional framework of the sector is essential. However, Mozambique doesn’t have a fundamental law on ports which prescribes basic framework of the sector including establishment of basic port policy, scheme of national and regional port planning, procedure of port development, functions of port authority, usage of land and basin in ports, and collaboration with stakeholders.

9) Shortage of human resources and knowledge

Considering the vital importance of sustainable growth of the port sector in the country’s development policy, quantity of qualified human resources is insufficient at all levels of the sector.

(2) Competitiveness

1) Low productivity of container handling

For the container shipping lines, it is most important to deploy their fleet in accordance with the schedule. For the consignees, it is also vital to export or import on schedule. The container handling operation at Nacala Port sometimes requires container ships to stay at the port for a week when they bring a large number of containers. It is quite inconvenient for both shipping lines and consignees that their schedules cannot be maintained. Unless the port improves productivity to the levels seen in other container terminals in the world, it will not be able to attract either shipping lines or consignees. The average productivity of loading and unloading containers of 8 units per hour per ship is quite low compared with the world’s standard. The low productivity of overall operation is caused by a lot of factors such as:

- Insufficient investment in handling equipment.
- Lack of knowledge and skill for modernized container operation.
- Mixed operation of containers and bulk cargoes.
- Insufficient computerization of terminal operation.
- Insufficient capacity of terminal gate and inefficient gate operation.
- Inadequate layout of the terminal.
- Conflict of traffic flow in the Port, even in the container terminal.

- Unclear definition of the perimeter of container terminal.
- Lack of desire on the part of CDN to improve productivity

2) Shallowness of basin alongside quays for bulk cargo handling

No renovation has made to adapt the Port to the change in the world’s maritime transport system for bulk cargoes since its inauguration. The berth used for petroleum tankers has a depth of only -10 meters, and large tankers cannot dock with full load. The depth of the basin alongside the conventional terminal is also insufficient, and bulk carriers frequently dock at container quays hampering container operation. Since the Port is not furnished with modern bulk unloaders, occupation of container quays by bulk carriers lasts a very long time. Nacala Bay is a deep-water bay; however, Nacala Port is not a deep-water port in terms of bulk cargo handling at present.

3) Long dwell time

The dwell time of containers in the Port is excessive especially for imported transit containers to Malawi via railway. The average dwell time of 27.5 days for Malawian cargoes is far from competitive. The service is not predictable at all. This is mainly caused by shortage of locomotives and railway wagons; however, the Port is also to blame for the inefficient sea and rail interface.

4) Burden of scanning inspection

The Customs requires all trucks carrying containers (laden and empty), dry bulk, break bulk, or liquid bulk, and even empty chassis or tank trucks to be scanned. After the scanning, many containers are opened and visually inspected. The scanning fee is extraordinarily high (100 USD per laden container, for example). Though this kind of business is sometimes observed in developing countries, this can cancel out the benefit generated by the improvement of the Corridor, and impairs competitiveness of the Port and the Corridor.

This also causes traffic congestion around the port entrance despite the relatively small cargo volume handled in the Port.

3.3. Development strategy of the Port

In this section, the Study Team proposes development strategies which will enable the Port to achieve the development targets by fully utilizing the potential of the Port and the Corridor while overcoming the issues of the Port. The proposed development strategies corresponding to each development target are summarized in Table 3.3-1.

Table 3.3-1 Development strategies of the Port

Target 1. Trade and transport facilitation for LLCs and landlocked region in Mozambique
(1) Regeneration of container logistics function Relocation and expansion of the container terminal to the North Wharf Demolishing of sheds and spur lines of the railway Relocation of the oil and general cargo terminal from the North Wharf Separation of container handling and bulk cargo handling Modernization and computerization of container operation Upgrading and increase of container handling equipment Construction of a transit cargo terminal in the vicinity of the Port Capacity building (2) Creation of mega port function for bulk cargoes Expansion of port to the north, to the south and to Nacala-a-Velha Construction of a deep water terminal Introduction of efficient bulk cargo handling equipment (3) State of the art sea and rail interface Construction of a multimodal terminal equipped with modernized operation systems Concentration of the function of multimodal terminal on sea and rail transfer Construction of a marshalling yard and a station for regional cargoes outside the Port Demolishing of all rail tracks along quays Construction of a branch rail line linking Nacala-a-Velha (4) Strengthening maritime link through introduction of container transshipment function Improvement of overall efficiency of container handling Installation of a sufficient number of quay gantry cranes Reform of customs regulation Introduction of incentive policy of port tariff Revival of domestic container network
Target 2. Industrial development of northern Mozambique
(5) Seamless supply chain between the Port and the SEZ Establishment of a basic policy of integration of the Port and the SEZ Construction of the Port Expressway linking the Port, the SEZ and the Corridor Simplification of procedure for cargo movement between the Port and IFZs Integration of operation system of the Port and IFZs (6) Port for agricultural development Efficiency improvement of the Port aiming at improving market access of the sector Quality improvement of cargo handling for sensitive agricultural products Formation of a gateway processing function by integrating the Port and the SEZ Establishment of a reliable cold chain Provision of economical route of fertilizer import Strengthening of incentive policy of port tariff for agricultural products (7) Creation of grain-hub function Construction of a grain terminal with deep water berth and modern equipment Formation of a wheat processing complex in the SEZ

Source: Study Team

(1) Regeneration of container logistics function

Since the productivity of container operation in the Port is far below the world's standard, the current container operation shall be completely changed. If it remains unchanged, it would be impossible for the Port to provide the most efficient and economical access from the domestic hinterland and LLCs to the world's maritime network, even after the improvement of the Corridor.

First of all, the location of the container terminal shall be changed. The existing terminal was originally designed as a conventional terminal, and therefore, the dimensions of the terminal are not suitable for container handling. The inland depth is too shallow for container operation. But it is very difficult to expand it because of the existence of the rail transfer facility which is located at sole available place in the Port due to topographical restriction. Southward expansion is not preferable due to shallowness of the water. Seaward expansion would not be economically viable. Therefore relocation of the container terminal to the North Wharf is the only realistic option. All sheds and spur lines of the railway on the North Wharf shall be demolished when the container terminal is relocated. The current liquid bulk handling function on the North Wharf shall also be relocated to an appropriate location considering maritime safety and environmental protection.

The perimeter of the new container terminal shall be clearly defined and fenced, and the area inside the perimeter must be exclusively used for container operation. All movements of vehicles and containers in a container terminal must be controlled and monitored by an operation center using a terminal operating system. Instructions from the operation center to trucks shall be informed automatically or semi-automatically at a dedicated container terminal gate.

Upgrading the container handling machinery of the Port is strongly required for efficiency improvement. For vessel/quay operation, the number of reach stackers shall be increased urgently. By simply doing this, the vessel/quay productivity will be doubled or tripled. In the medium-long run, introduction of quay gantry cranes will be necessary for further productivity improvement. For yard operation, the current forklift system shall be replaced by a more productive system such as RTG system, considering relatively small area of the terminal even after the relocation. Upgrading of the terminal operation system is crucial.

At present, vanning or devaning of transit cargoes is carried out inside the port perimeter; however, this is not preferable for efficient use of the port area. Therefore a dedicated transit terminal (CFS) shall be constructed outside the port perimeter. Dar es Salaam Port has such facilities for Malawi and Zambia outside the port area.

Capacity building of personnel of container operation at every level is also important for sweeping reform of the container operation.

(2) Creation of mega port function for bulk cargoes

For bulk cargo transport, very large vessels are preferred to take advantage of the economies of scale, and deep-water ports are required to accommodate very large bulkers. Durban Port, the largest of the ports in the southern African Region, has wharves having water depths of only -12 m or shallower. At present the only mega bulk port in South-eastern Africa is South Africa's Richards Bay Port with -19 meter quays. However, the port serves mainly for the eastern provinces of South Africa, since long distance land transport of bulk cargoes is not economically viable by nature. Consequently Mozambique cannot enjoy the benefit of the deep water port of Richards Bay.

Nacala Bay, where the Port is located, has a well sheltered water area that makes it possible to construct a berth deeper than -20 meters with minimum investment. Utilizing this high potential, the Port shall become the second mega bulk port in the region, which handles mineral products and other minor bulk cargoes generated in Tete Province, Northern Provinces, and LLCs.

In order to become a mega bulk port, the port area is required to be expanded to the Nacala-a-Velha side, to the north, and supplementarily to the south, because the existing footprint of the port is too small to handle a large amount of bulk cargoes. The Nacala-a-Velha side would have very high potential as a development area for a mega bulk terminal due to its proximity to the deep basin and a wide stretch of vacant flat land; however, due socio-environmental consideration is required when developing this area.

Then, new terminals with deep water quays shall be constructed. The new terminals shall be equipped with highly productive bulk cargo loaders or unloaders.

(3) State of the art sea and rail interface

Railway is an important mode for long distance inland haulage of seaborne cargoes such as transit to/from LLCs, or mass transport of bulk cargoes. The improvement of railway tracks in inland areas is important as a matter of course. But, at the same time, the improvement of sea and rail interface at ports is a crucial and decisive factor in the overall improvement of the railway system. The Port shall be furnished with a state of the art sea and rail interface, which enables the Port to become an efficient and competitive gateway for inland areas.

A new multimodal terminal equipped with modernized operation systems shall be constructed in the South Wharf. Since a container loading/unloading facility requires a long and straight area, it shall be located at the site currently used as the marshalling yard and main lines. The rail terminal in the Port shall be utilized only for loading or unloading seaborne cargoes, and shall not be used for handling regional cargoes or marshalling trains. In order to materialize this, a new marshalling yard and a freight station for regional cargoes shall be constructed outside the Port. Since the direct operation between ship and rail wagon is inefficient and old-fashioned, all rail tracks along quays shall be demolished.

The new mineral terminal in Nacala-a-Velha requires railway access. Therefore a branch line to the mineral terminal shall be constructed. For efficient coal handling, a loop line system will be preferable.

(4) Strengthening maritime link through introduction of container transshipment function

Acquisition of transshipment cargoes is an important policy not only for the business of the Port but also for strengthening the gateway function of the Port. Transship cargoes can increase frequency of liner services and numbers of ports directly linked with Nacala Port. This will benefit the economy of the hinterland of the Port by reducing transit time and the cost of international freight transport.

The amount of local cargoes is basically indifferent to the potential of a port as a container transshipment hub. Important factors to attract transshipment cargoes are geographical advantage and efficiency of container operation. Nacala Port, located at an intersection between the Eastern African loop and the Southern African loop on maritime network, has the geographical advantage, and the Port has been the sole Mozambican port which handles transship containers. Therefore it is expected that the Port will be able to attract more transship cargoes, and will become a regional container hub port when the efficiency of container handling becomes vastly improved. Possible scenario would be partial relocation of the hub function from ports in Indian Ocean Islands or Durban Port to Nacala, besides increase of the frequency of existing transshipment services.

Measures described in “Regeneration of container logistics function” are important; however, further strengthening of the strategy is required to form a regional container hub function in Nacala. Since efficiency improvement of vessel/quay operation is crucial, installation of a sufficient number of quay gantry cranes, introduction of an advanced terminal operation system, and capacity building of personnel are required. For transshipment to other Mozambican ports, resumption of domestic container line is necessary.

This is a very important strategy for functional enhancement of the Port, but this strategy is in the context of long term development.

(5) Seamless supply chain between the Port and the SEZ

With the incentive policy applied to the Special Economic Zone in Nacala District and Nacala a

Velha District, foreign and local investors are establishing factories. Nacala SEZ is the flagship project for industrial development of Northern Mozambique. The strategy of Integration of the Port and the SEZ is of paramount importance in strengthening the competitiveness of the Port and the SEZ. The integration will make the SEZ very unique in the region. Meanwhile, an abundant cargo flow to/from the SEZ will improve the status of the Port in the international maritime network. The Port and the SEZ shall be integrated physically, electronically, and institutionally. By the integration, the Port and the SEZ can form a single node in a supply chain. A company in the SEZ will be able to use the Port as if they had a private port in their plot. The Port and IFZs in the SEZ shall be regarded as a single bonded area, and the procedures required for the cargo movement between the Port and the IFZs shall be equivalent to those for movement within a single bonded area.

In order to form a seamless supply chain, the Port Expressway shall be constructed, which directly connects the SEZ including IFZs with the container terminal gate of the Port without passing through the urban area of Nacala. Although the Expressway will not be fenced and will be open to the public, the Expressway shall function as a virtual bonded area. Trucks should be able to come and go easily between bonded areas in IFZs and the Port with very simplified and computerized procedure.

The Expressway shall not be only for vehicles but also for electronic data. Optical fiber cables connecting IFZs and the One Stop Service Building in the Port shall be installed along the Expressway. The port administration system and administration system of IFZs shall be integrated.

(6) Port for agricultural development

Agriculture is the most important industry in Northern Mozambique. There is great potential for the agricultural sector in Northern Mozambique to further develop. The shift from current subsistent farming to commercial farming is oriented for the development of the sector. Efforts are being made in various fields to achieve this goal including cooperation with international development partners. The Port is also expected to contribute in the development and reform of the agricultural sector in Northern Mozambique.

Improvement of market access is of vital importance in the development of the agricultural sector in Africa, and ports can help it in terms of the efficiency improvement of physical distribution. Efficiency improvement discussed in “Regeneration of container logistics function” and “Creation of mega port function for bulk cargoes” is also essential in this context.

In addition to the efficiency improvement, quality improvement of cargo handling shall be accomplished for sensitive agricultural products. For instance, tobacco, which is one of promising products in the hinterland of the Port, requires accurate control of humidity and temperature. Improvement of reliability of port logistics can help increase the market value of these products.

The Port together with the SEZ shall also contribute in the increase of added value of agricultural products. A synergy effect of development of the agricultural sector, the SEZ, and the Port is expected to be generated. A gateway processing function shall be formed by integrating the Port and the SEZ, which provides a reliable processing and logistics function. Cassava, for example, is one of typical subsistent agricultural products in the region at present, but once this is processed into starch under strict quality control, additional value can be generated as an exported commodity. Towards the formation of a gateway processing zone, the establishment of a seamless supply chain is required as mentioned above. In addition, establishment of a reliable cold chain connecting the Port and the SEZ will enable generation of further added value. Strengthening of reefer function of the Port and improvement of logistics management will be required for this purpose.

The Port is also expected to provide economical route of fertilizer import by strengthening bulk cargo handling function.

(7) Creation of grain-hub function

The Port has a great potential to be a competitive bulk port as mentioned in “Creation of mega port function for bulk cargoes”. For grains, the Port has a greater potential to be a hub port serving all provinces in the country beyond its traditional hinterland (including LLCs) and even some part of Tanzania because cape-size bulkers, which have economic advantage, are generally selected for grain transport in the world, and the Port is the sole Mozambican port able to accommodate cape-size bulkers within realistic amount of investment.

Without a considerable amount of local consumption, the hub function cannot be formed no matter how advantageous it is in terms of water depth. In this context, increase of purchasing power of the people in the Northern Provinces through achievement of programs of poverty reduction will be the precondition.

A wheat processing complex shall be strategically invited to Nacala SEZ. Wheat will be transported from the Americas or Europe directly to Nacala by large bulkers, and be transshipped to smaller bulkers for Central and Southern Mozambique, or be processed into flour and be shipped by domestic or international container vessels.

Besides construction of a grain terminal with very deep water quays and productive unloaders such as pneumatic unloaders, all efforts described in “Regeneration of container logistics function”, “Creation of mega port function for bulk cargoes”, “State of the art sea and rail interface”, and “Seamless supply chain between the Port and the SEZ” shall be focused on in order to achieve this goal.

3.4. Forecast of future maritime and land transport network

3.4.1 Maritime transport network

(1) Container transport

Future traffic pattern of containers depends on the growth of cargo volume, improvement of operational efficiency at ports, global economic situation, and regulatory changes related to trade and customs.

When assuming a future pattern of maritime transport network for Mozambican ports, it is appropriate to consider the characteristic features of the existing network, as well as adding volume factors.

1) Decoupling from Durban

Currently substantial volume of cargoes are connected in Durban spending rather high cost for feeders. In future, once the cargo volume of Mozambican ports increases up to a certain level, shipping lines will ship them out by the main line vessels directly from those ports, without using feeders. This tendency will be more prominent at the ports remote from Durban, such as Nacala.

However, as mentioned in the previous sub-section of 2.4.2, those ports might remain combined with some other areas' ports for the time being, until the cargo volume of the port reaches the level to fill up whole capacity of main line vessels.

2) Forecast of future transport network

a) For East Asia, South Asia and Middle East

The future network pattern is depicted in Figure 3.4-1.

For the network for East Asia, Nacala would be decoupled from Durban and even from Maputo, then incorporated into main lines of a cluster combined with IOI ports or Tanzanian/Kenyan ports. For South Asia and Middle East, Nacala would be coupled with Tanzanian/Kenyan ports.

As Beira has a rich cargo source, it will have a chance to be incorporated into those clusters if its channel/quay depth and operational efficiency are both improved. However, in case of the trade lanes for Middle East, there will be some possibility for Beira to be feedered to and transshipped at Nacala, due to its remote position from the cluster of Mombasa/Dar es Salaam/Nacala.

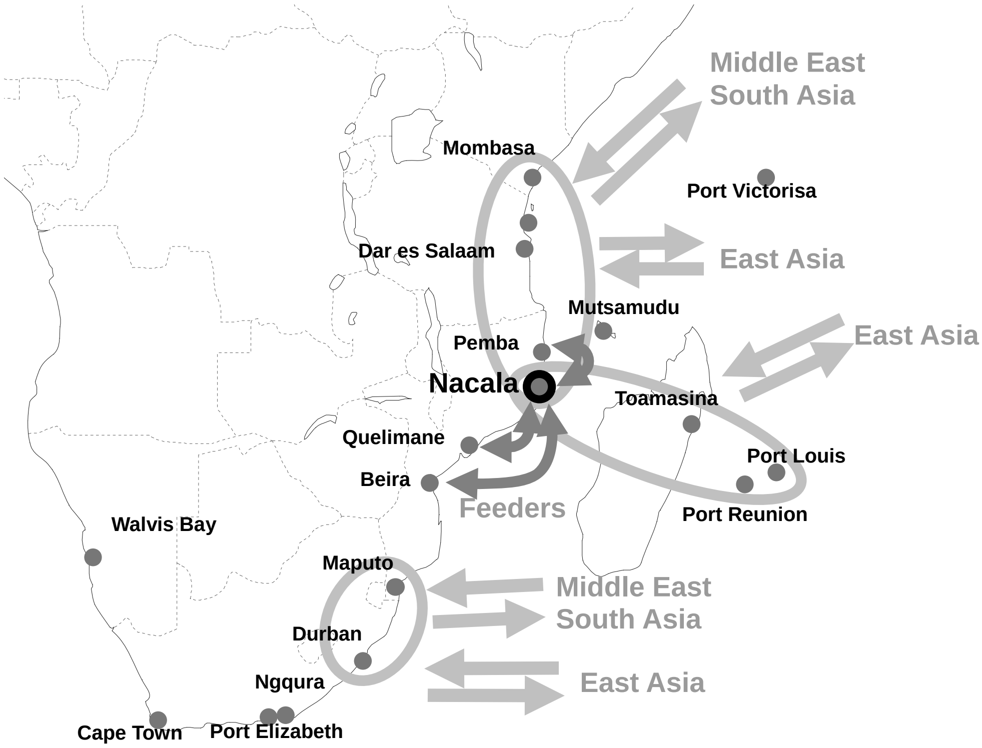
Since Maputo is geographically close to Durban, its current supplemental status to Durban would remain the same. Since sufficient cargoes can be secured by Durban & Maputo, discreet services from those 2 ports will be provided by the shipping lines, not involving Beira/Nacala.

b) For Europe, North America and South America

Future network pattern would be depicted in Figure 3.4-2.

For the network for Europe, North America and South America, more main line vessels would be calling at Maputo combined with South African ports including Ngqura. Walvis Bay might be incorporated in some main lines.

Nacala would still be covered by feeders due to the long distance from those trade lanes. There is some possibility for Beira to be covered by main lines, depending on its cargo volume and operational efficiency.



Source: Study Team

Figure 3.4-1 Future maritime transport network for Asia and Middle East

Source: Study Team

Figure 3.4-2 Future maritime transport network for Europe, North America & South America

3) Forecast of size of vessels calling at the Port

To make a future projection on the size of vessels to call at the Port, an appropriate scenario needs to be elaborated from the supply/demand and operational viewpoint.

As the demand of cargo volume increases in future at the Port and other neighboring ports combined, shipping lines will increase their supply of vessel capacity. To increase the capacity, shipping lines may take action in 2 different ways; to enlarge the size of vessels or to increase the frequency of calls.

If there is no operational restriction at the Port, they will firstly enlarge the size of vessels to seek the economy of scale. However, if there is any constraint at the Port such as stevedoring equipment, berth length or berth draft, they will increase the frequency of vessel calls.

For the demand side, cargo growth at the ports along the relevant trade lanes needs to be examined. Table 3.4-1 below indicates the growth of container cargoes at major ports to be combined with the Port in typical trade lanes.

Table 3.4-2 shows the growth of container cargoes in the hinterland of the Port (this will be discussed in detail in the next sub-section).

The average of the indices in Table 3.4-1 and Table 3.4-2 is given as 293 for the year 2020 and 566 for 2030.

Table 3.4-1 Forecast of container cargo growth at major ports combined with the Port

		Currently	Around 2020	Around 2030	Source
Nhava Sheva	Year	2008	2020	2026	JNPT Business Plan - Final Report (2006)
	Throughput (1000TEU)	4,430	17,630	25,450	
	Index	100	398	574	
Jebel Ali	Year	2008	2018	2030	Master Plan of Jebel Ali Port (Jun. 2008)
	Throughput (1000TEU)	10,620	27,260	58,380	
	Index	100	257	550	
Dar es Salaam	Year	2007	2018	2028	Tanzania Ports Master Plan - Final Report (Feb. 2009)
	Throughput (1000TEU)	334	1,554	4,719	
	Index	100	465	1,413	
IOI 6 major ports (import only)	Year	2009	2019	2029	Study on Maritime Sector in Indian Ocean (Dec. 2009)
	Throughput (1000TEU)	333	562	915	
	Index	100	169	275	
Index (weighted average)		100	299	569	

Source: Study Team

Table 3.4-2 Forecast of container cargo growth in the hinterland of the Port

(unit: MT)

	2008	2020	2030
Northern Mozambique	276,000	1,034,200	2,712,400
Malawi	520,000	1,124,000	2,016,000
Zambia	775,000	2,350,000	4,120,000
Total	1,571,000	4,508,200	8,848,400
Index	100	287	563

Source: Study Team

For the supply side, a possible scenario on how the shipping lines will increase their current capacity to cope with the increased demand for the year 2020 and 2030 is drawn.

Table 3.4-3 shows the scenario for the increase of vessel capacity toward 2020. The capacity of the vessels at the Port required for 2020 will be 2.93 times of the same for the current capacity. It is noted that there is no weekly service for the Port at present. Those services will sooner or later become weekly due to the shipping lines' behavior at all times. Entry of new shipping lines or services into the existing market is also assumed. Rest of the increment will be made by enlargement of vessel size.

Table 3.4-3 Possible scenario for the increase of vessel capacity for 2020

(unit: TEU)

Trade lane	Current capacity /year (as of Aug. 2010)	Increment of capacity by weekly services	New entry (40%)	Enlargement of vessel size	Total (increased capacity for 2020)
East Asia	85,834	35,137	48,389	82,134	251,494
Middle East/South Asia	116,690	59,277	70,387	95,547	341,900
Europe	33,893	33,893		31,520	99,306
Main line Total	236,416	128,307	118,775	209,201	692,700
Feeder	87,037	59,509	58,618	49,854	255,018
Total	323,453	187,816	177,394	259,056	947,719

Source: Study Team

Table 3.4-4 shows the scenario for the increase of vessel capacity toward 2030. The vessel capacity required for 2030 will be 5.66 times of the current capacity. 50% of 2020 capacity is assumed for new entry and more frequent calls such as twice a week or twin-loop operations. Rest of the increment will be made by enlargement of the vessel size.

Table 3.4-4 Possible scenario for the increase of vessel capacity for 2030

(unit: TEU)

Trade lane	Capacity /year for 2020	New entry or more frequent calls (50%)	Enlargement of vessel size	Total (increased capacity for 2030)
East Asia	251,494	125,747	108,580	485,820
Middle East/South Asia	341,900	170,950	147,612	660,463
Europe	99,306	49,653	42,874	191,834
Main line Total	692,700	346,350	299,067	1,338,117
Feeder	255,018	127,509	110,102	492,630
Total	947,719	473,859	409,169	1,830,747

Source: Study Team

Based on above, enlargement of vessel size is assumed as per Table 3.4-5 below. As the Port is not equipped with gantry cranes, the vessels to call the Port are all required to have self loading gears. As the container vessels with gears are generally below 3,000 TEU capacity, the assumption below is within that range. If the Port had a gantry crane, the larger vessel (Panamax or above) might be deployed by the shipping lines who seek the economy of scale.

Table 3.4-5 Forecast of size of vessels calling at the Port

(unit: TEU/vessel)

Trade lane	Current average vessel size (as of Aug. 2010)	Average vessel size for 2020	Average vessel size for 2030
East Asia	1,160	1,723	2,218
Middle East/South Asia	1,676	2,325	2,995
Europe	1,300	1,905	2,453
Main line Total	1,408	2,017	2,597
Feeder	569	707	910
Total	1,198	1,648	2,123

Source: Study Team

(2) Bulk cargo transport

The decisive factors of future bulk cargo transport network are cargo demands and port capacity. In this sub-section future port capacity will be estimated qualitatively. The forecast of cargo demands will be described in the following section.

In Nacala, a large coal shipment terminal with a deep-water quay (more than 20 meters) is planned by Vale Mozambique. Vale explained to the Study Team that the terminal would start operation in 2015 at the earliest. Although there may be some uncertainties as to the implementation schedule in the short run, Nacala will be functioning as the largest coal port in the country in 20 years' planning horizon.

Whether Nacala can become a bulk hub for imported bulk cargoes such as cereals or not depends on cargo demands in Mozambique (not only its northern part), Tanzania and neighboring landlocked countries. When a sufficient demand materializes, the Port is likely to have enough capacity as a regional bulk hub, making good use of its advantage of the deep-water bay.

Maputo and Beira are shallow ports, therefore they are unlikely to become bulk hubs. Their capacities will increase in accordance with the growth of cargo demand of their direct hinterlands.

In Ponta Techobanine, 70 kilometers south-east of Maputo and 40 kilometers to the national border with South Africa, a new deep-sea port development is planned. The port is planned to import fuel to Mozambique, Botswana, South Africa and Zimbabwe and to export coal, iron ore and other minerals from Botswana, South Africa, Swaziland and Zimbabwe. The handling volume is estimated to be 10 million tons in the initial stage and will eventually reach 200 million tons. Although the plan has been agreed upon between the GOM and the Government of Botswana, the feasibility of the project has not been confirmed. Therefore the new port will not be included in the forecast of the bulk network in this Study.

In Tanzania, shortage of container handling capacity is the most urgent issue to be coped with, and the construction of a new container terminal in Dar es Salaam and the development of a new container port in Bagamoyo are planned. For bulk cargo handling, a new port development is planned in Mwambani, located in the north of the country. However, the feasibility of the project has not been confirmed, and the project requires large scale development of roads and railways in an environmentally very sensitive area. Therefore Mwambani Port will not be included in the forecast of the bulk network in this Study. Bagamoyo project may be implemented within 20 years, but their capacity for bulk cargo handling will be very limited. Therefore, the new port will not become a bulk hub in the region.

In the master plan of Richards Bay, the main focus is on the further increase of exporting capacity of bulk cargo. Therefore the port is unlikely to become an importing hub of bulk cargoes.

Port development in Durban, including the construction of the new port at the airport site, focuses on increasing container handling capacity. The increase of bulk cargo handling is forecasted to be less than 40% in 20 years, and therefore no major infrastructure development for bulk cargoes is planned. Thus, the port is unlikely to become a bulk hub.

As a result, the following two scenarios can be developed:

Scenario 1: Continuation of current pattern

When the bulk cargo demands in Mozambique, Tanzania and neighboring landlocked countries don't grow greatly, the current "milk run" pattern of bulk cargo flow, in which handymax or smaller bulkers call multiple ports in the region as described in 2.4.3, would continue, and a bulk hub would not be created in the region.

Scenario 2: Creation of bulk hub function at Nacala

When the bulk cargo demands in Mozambique, Tanzania and neighboring landlocked countries grow, and appropriate infrastructure development and its efficient management is realized in Nacala, the Port of Nacala would become a bulk hub in the region. Larger bulk carriers would be deployed to transport cargo from its origin to Nacala Hub, and the cargoes would be transshipped at the hub to smaller feeder vessels bound for the ports in the region.

3.4.2 Land transport network

(1) Roads

ANE has been implemented and is planning the road project by using the domestic and international fund. On-going and planned road projects are listed in Table 3.4-6 and Table 3.4-7. Note that the hatched projects are located in the northern Mozambique.

Table 3.4-6 On-going road projects by ANE

Sr.No	Description	Location / Province	Funding
1.	Maputo – Marracuene	Maputo	IDA/GOM
2.	Marracuene- Manhica	Maputo	IDA/GOM
3.	Manhica – 3 de Fevereiro	Maputo	IDA/GOM
4.	Incoluane – Chicumbane	Gaza	IDA
5.	Chissibuca – Maxixe	Inhambane	IDA/GOM
6.	Maxixe – Massinga	Inhambane	IDA & GOM
7.	Nhanchengue-Pambara	Inhambane	IDA & GOM
8.	Muxungue-Inchope	Sofala	IDA & GOM
9.	Namacuraa-Nampevo	Zambezia	EU
10.	Nampevo-Alto Molocue	Zambezia	EU
11.	Incoluane-Zandamela 71.1 Kms	Gaza	IDA/GOM
12.	Alto Molocue - Rio Ligonha	Zambezia	EU
13.	Nampevo-Rio Ligon	Zambezia	
14.	Namitil-Angoche	Nampula	IDA/GOM
15.	Litunde-Marrupa	Naissa	SIDA

Source: ANE

Table 3.4-7 Planned road projects by ANE

Sr.No	Description	Location / Province	Funding
1.	Cuamba– Lichinga	Niassa	
2.	Lichinga- Litunde & 7 Bridges	Niassa	AFDB, JBIC, GOM
3.	Monteouez - Ruaea	Cabo-Delegado	AFDB, JBIC, GOM
3.	Jardim– Benfica	Maputo	WB, GOM
4.	Xai Xai– Chissibuca	Gaza	WB, GOM
5.	Massinga– Nhachengue	Inhambane	WB, GOM
6.	Vanduze–Changara	Tete	
7.	Beira-Inchope	Sofara	
8.	Nampula-Cuamba	Nampula	
9.	Chimuara-Nicuadala	Zambezia	
10.	Rio Ligonha-Nampula	Nampula	
11.	Namialo-Namapa	Nampula	
12.	Namapa-Metoro	Cabo Delgado	
13.	Chissano-Chibuto	Maputo	
14.	Gurue-Maguigue	Zambezia	
15.	Milange – Mocuba	Zambezia	
16.	Mussacama-Colomo		

Source: ANE

The development of Nacala Corridor road is one of the priority projects of the Southern Africa Development Community (SADC) Region to support economic growth and foster regional integration through reliable, efficient and seamless transport infrastructure to improve the competitiveness of the region. Under this background, the design works for the section between Nampula-Cuamba and Cuamba-Lichinga were carried out from 2006 to 2009 by JICA, then based on the result, African Development Bank (AfDB) approved the loans amounting to US$ 181 million to Mozambique and Malawi to finance the construction of the first phase of the Nacala Road Corridor, which links from Nampula to Cuamba.

In fact, the Nacala Road Corridor project comprises 1,033 km of road works and two one-stop border posts between Mozambique and Malawi and the other between Malawi and Zambia and is divided into 3 phases. Remaining 2 phases might also be approved in the near future. The contents of Nacala Corridor road project are as follows.

Table 3.4-8 Contents of Nacala corridor road project

Phase	Project contents	States Quo
1	361 km (35% of the road) works in Mozambique and Malawi.	Approved by AfDB
2	360 km (34.9% of the road) works in Zambia	Not approved yet
3	312 km (30.1% of the road) works in Mozambique and Malawi and two one-stop border posts between Mozambique and Malawi and Malawi and Zambia	Not approved yet

Source: Study Team

There are also some bridge construction and rehabilitation projects in progress. The construction of new bridge at Caia on Zambezi River was completed in 2009 by the fund from EU. As the only ferry was operated to cross the river at this location, the accessibility between south and north has been improved by the new concrete bridge with 2-lane carriageway. Moreover, two other major bridge projects are described as follows.

Tete Bridge

On the Zambezi River, there is another bridge in Tete, the Samora Machel Bridge, of which the rehabilitation work was completed in 2010.

The Mozambican government has awarded the construction contract for a new US$ 132 million bridge across the Zambezi River in July 2010. The new bridge will cross the Zambezi River at Benga in the inland province of Tete, about 6 km downstream from the Samora Machel Bridge.

Unity Bridge

Between Tanzania and Mozambique, the Unity Bridge was supposed to be constructed at near the confluence of Rovuma and Lugenda Rives by the end of 2008. In fact, the project has been suspended due to no donor being interested in funding. However, it is announced in May 2010 that the construction cost about 35 million US dollars for the bridge with 750 m length will be shared equally between the two countries.

Source: Study Team

Figure 3.4-3 Overview of Tete Bridge

Source: Study Team

Figure 3.4-4 Rehabilitation work of Tete Bridge

(2) Railways

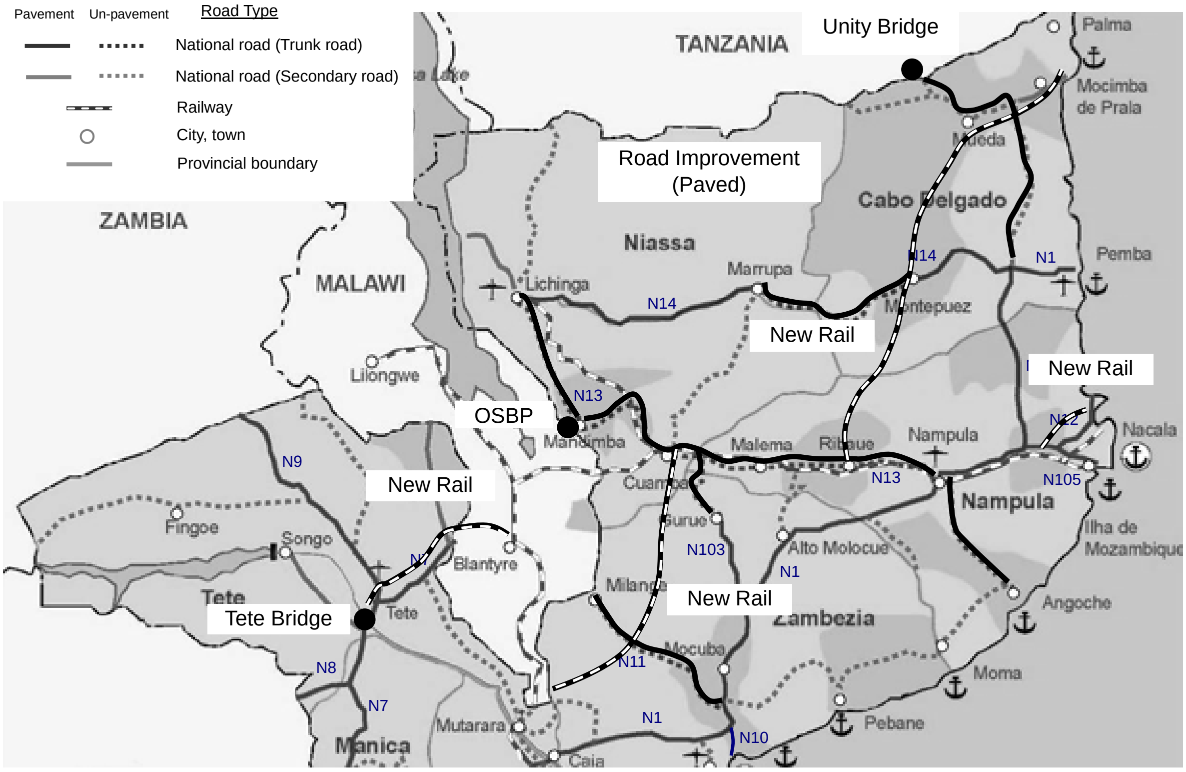
Coal mining development in Tete

November 2004, Vale, Brazilian mining company, was selected to research one of the largest carboniferous reserves in the world, located in Moatize, Tete province. According to Vale, the development plan for coal mining is divided into two phases and the coal produced in Moatize will be transported by Sena-Beira rail link with 600 km to a new seaport terminal in the port of Beira in first phase. The production of coal will be commenced in 2011 and the volume will be forecasted at 12 million ton per year. However, given the limitations of Sena-Beira rail transport facilities, it is now examining the possibility of laying a new rail link from Moatize to Nacala. The annual amount of coal in phase 2 has not been confirmed but the new terminal will be completed in 2014 at the earliest. Vale acquired a 51% share of SDCN in 2010, which holds a 51% share of CDN. The scales of railway development plan by Vale are as follows.

- 200 km branch line linking the coal mines of Moatize to Malawi
- Rehabilitation of existing railway in Malawi and Mozambique
- New railway line to Nacala-a-Velha, adjacent to existing Nacala port
- Rehabilitation of the branch line from Cuamba to Lichinga (Depend on the results of coal exploration in Niassa Province)

North-South railway

The plan of the new railway from north to south is introduced in the strategic vision for the development of transport published from MTC in May 2009. This will connect the existing railway, Limpopo line from Maputo, Sena line from Bira and Nacala railway. By opening of this railway, the inland transportation for goods and passengers to north-south direction will be facilitated.



Source: Study Team

Figure 3.4-5 Future land network plan

(3) Influence of the improvement of land transport network on Nacala Port

Based on the above information for both of the road and railway, the future land transport network is shown in Figure 3.4-5. The influence of the improvement of the land transport network on Nacala Port is summarized as follows:

- As the most of arterial roads will be developed as the pavement road, it is expected to shorten the travel time through the road. Especially, the international transportation between Malawi and Nacala Port will become considerably efficient by improvement of the Corridor.
- The congestion of the existing Tete Bridge is one of the major bottlenecks for transportation from/to Malawi. The completion of the rehabilitation and construction of the new bridge will accelerate the international transportation between Malawi and Beira, or Durban.
- The cross border traffic will get a lot of advantages such as the simplification of border process and shortening of passing time by the establishment of OSBP at Mandimba.
- The coal development area in Tete and the new coal terminal in Nacala-a-Velha will be directly connected by a rail through Blantyre, Cuamba and Mandimba. By the rehabilitation of existing railway, it is expected that the internal and regional railway transportation will also be improved.

(4) Pipelines

The only long distance oil pipeline currently operated in Mozambique is Beira-Harare Pipeline constructed in 1960, with the annual capacity of 1.2 million tons. Considering its important role, the pipeline would be kept operated in the future. Furthermore, the extension of the pipeline to Botswana is planned. The plan is also included in the future network in this Study.

There are currently no pipeline connections from Nacala Port to any of the landlocked countries. Feasibility Studies were done in 2004 on a pipeline connecting Nacala with the inland port of Liwonde in Malawi. These plans proved unsuccessful. New plans are being considered in which a pipeline would be built from Nacala to Nsanje inland port (at the southern most point of Malawi), reducing the pipe distance with over 200km. However, the feasibility has not been confirmed, therefore the plan is not included in the future network in this Study. There is a plan to install a pipeline between Beira Port and Nsanje inland port. Since the feasibility of this pipeline has also not been confirmed, the Study Team doesn’t include it into the future network.

A 500 km fuel pipeline connecting Maputo (Matola) Port with Kendal in South Africa is planned. The pipeline will be linked to South Africa’s Transnet Pipeline Network. The initial capacity of the pipeline will be 6 million cubic meters of oil per year. The project is behind schedule due to environmental procedures. However, at least in the long run, the project will be implemented, and therefore the plan is included in the future network in this Study.

There are two gas pipelines in the country. One is the pipeline connecting Pande and Temate Gas Fields in central Mozambique with a petrochemical plant in South Africa. The other is its branch line from the main line at Ressano Garcia, the border city along Maputo Corridor, to the industrial zone in Matola. In addition, some gas pipeline projects are being studied. However, none of them is directly related to seaborne trade to/from Mozambican ports.

In conclusion, pipeline networks to be considered as a basis of the demand forecast in this Study are:

1) The pipeline connecting Beira Port with Zimbabwean pipeline network with extension to Botswana
2) The pipeline connecting Maputo Port with South African pipeline network which is also linked to Botswana.

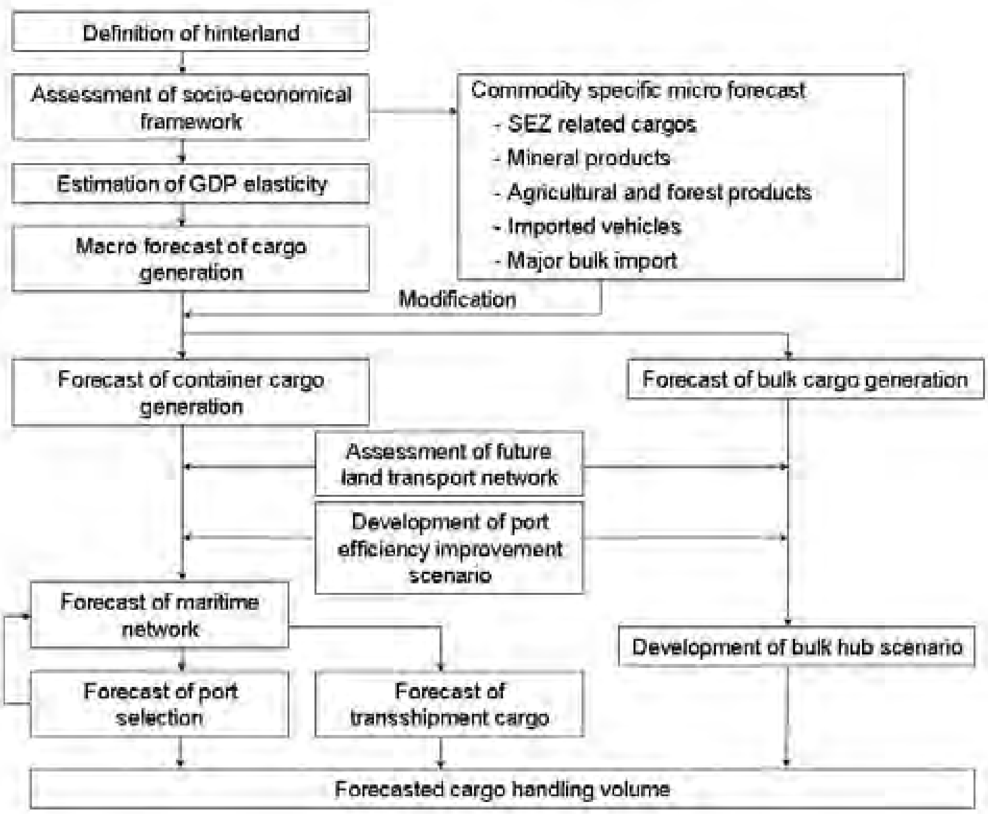
3.5. Demand forecast

In this section, the cargo demand in Nacala Port in the target year of 2030 is forecasted. The cargo volume in 2020, which is the target year of the short term development plan, is also estimated here. The flowchart of the demand forecast is shown in Figure 3.5-1.

First, the future hinterland of the Port will be defined considering improvement of the road and railway network.

Then, the cargo generation in the hinterland in the target years will be forecasted. The cargo volume will be estimated mainly by macro forecast using the past trends of GDP elasticity of cargo generation. The result of the macro forecast will be modified by micro forecast which considers market perspectives of major commodities.

Finally cargo handling volume in the Port will be estimated. The handling volume of containers will be estimated by employing a mathematical model which simulates competition among ports in the region taking account of behavior of both shippers and carriers. The handling volume of bulk cargoes will be estimated by developing a bulk hub scenario as well as by analogy with the container model.



Source: Study Team

Figure 3.5-1 Flowchart of the demand forecast

3.5.1 Cargo generation

(1) Future hinterland of Nacala Port

At present, the hinterland of Nacala Port is Northern Provinces of Mozambique (Nampula, Cabo Delgado, and Niassa) and Malawi. As mentioned in the Section 3.4.2, projects for improving road and railway network are ongoing in this region. Substantial improvement of port and railway operation is expected and must be realized. These improvements are expected to expand the hinterland of the Port as described below.

Mozambique

Table 3.5-1 shows the time required for land transport from each Mozambican province to the three major ports in the country in 2010 and in 2030. The light-tinted columns indicate the nearest port from each province in terms of transport time. Although the road improvement leads to significant reduction of transport time in some sections, such as Lichinga to Nacala and Tete to Nacala, the basic demarcation of the three ports is likely to remain unchanged.

At present, considerable amount of tobacco, cotton and timber produced in Niassa is sold to Malawi, and is re-exported overseas. These cargoes will be diverted to direct transport through Nacala Port after improvement of the road network.

Currently, Nacala Port doesn’t serve Tete Province. Even after the improvement of road and railway network connecting Tete and Nacala, Beira Port still has a competitive advantage in terms of the time required for transport. However, some part of coal will be transported from Tete to Nacala Port via the new railway to be constructed by Vale, since the Port will become able to accommodate large bulk carriers which provide economical measures of transport.

For imported grain, Central and Southern Provinces can become a part of the hinterland of the Port due to the availability of a deep basin in Nacala Bay.

Pemba Port handles around 10% of cargoes in Northern Provinces. The port is mainly used for the export of timber from Cabo Delgado to China. But the sustainability of this trade is doubtful. Although the road improvement between Pemba and Niassa can expand its hinterland, the Study Team nevertheless evaluates that the share of Pemba port will be unchanged since the port capacity is very limited and there is no large-scale expansion plan of the port.

In conclusion, the Study Team assessed that future domestic hinterland of the Port would be basically the same as at present. The cargoes to/from this basic hinterland will be forecasted in the macro forecast. Then the increased share in Niassa and the newly acquired cargoes in Tete will be estimated in the micro forecast.

Table 3.5-1 Time required for land transport from each province to the three major ports in Mozambique in 2010 and in 2030

(Unit: hr)

	2010			2030		
	Nacala	Beira	Maputo	Nacala	Beira	Maputo
Nampula (Nampula)	3	29	60	3	29	60
Niassa (Lichinga)	48	58	104	26	52	83
C.Delgado (Pemba)	7	48	79	7	48	79
Zambezia (Quelimane)	25	8	51	25	8	51
Tete (Tete)	53	11	50	31	11	50
Manica (Chimoio)	34	3	31	34	3	31
Sofala (Beira)	32	0	32	32	0	32
Inhambane (Inhanbane)	56	25	8	56	25	8
Gaza (Xai-Xai)	60	29	3	60	29	3
Maputo (Maputo)	75	32	0	75	32	0

Source: Study Team

Malawi

Malawi is the only LLC which Nacala Port serves currently. Around 70% of transit cargoes to/from Malawi are transported by railway. But the condition of the rail track is very poor especially on the Malawian side, which lowers the competitiveness of the Corridor. The shortage of locomotives also causes delays in delivery. The road is in poor condition as well, and trucks have to detour to Milange border in Zambezia Province.

The road and railway network between Malawi and Nacala will be improved dramatically in the target year as mentioned in the previous section, and this will increase the share of Nacala Port in the

Malawian market. The impact of the improvement of land transport network will be assessed in the following sections.

Zambia

Zambia is a mineral rich country, and is a prospective market for port business. Although Nacala Port doesn't serve Zambia at present, the improvement of road and railway network will enable the Port to access the Zambian market. Therefore, the Study Team considers that Zambia will become part of the port's hinterland.

Tanzania

Southern Tanzania can be a possible hinterland of the Port by the completion of the Friendship Bridge at the border point of the two countries. However the Study Team placed it out of the scope of the macro forecast, because the Tanzanian Government plans to develop Mtwara Corridor and the deep-water port of Mtwara to serve the region, and the volume of Tanzanian cargoes transported through Nacala Port will be very small compared with the cargo volume to/from Northern Mozambique, Malawi and Zambia through the upgraded Nacala Corridor. Tanzanian cargo to be handled in Nacala Port is estimated in the commodity based analysis of the micro forecast.

(2) Macro forecast

In the macro forecast, the volume of seaborne cargoes to be generated in the basic hinterland of Nacala Port, namely Northern Mozambique, Malawi and Zambia, is estimated based on macroeconomic data. Tanzanian macroeconomic framework is estimated also in this section.

The base year of the forecast is 2008 due to the availability of statistical data on the third countries. Although the Lehman Shock is not considered fully in the baseline data, its impact on long term cargo demand would be very small.

1) Macroeconomic framework of the hinterland

The World Population Prospects (the 2008 revision) by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat forecasts the annual growth rate of the population in Mozambique, Malawi, Zambia and Tanzania as shown in Table 3.5-2.

Table 3.5-2 Forecast of the population growth

	2006-2010	2011-2015	2016-2020	2021-2025	2026-2030
Mozambique	2.5%	2.2%	2.0%	1.9%	1.7%
Malawi	3.0%	2.9%	2.8%	2.6%	2.3%
Zambia	2.6%	2.6%	2.6%	2.3%	2.1%
Tanzania	3.1%	3.1%	2.9%	2.6%	2.4%

Source: UN

IMF has developed scenarios of GDP growth of the four countries in the course of debt sustainability assessments for them. The growth scenarios are summarized as follows:

Mozambique

Real GDP growth is projected to approach 8 percent over the next few years and stabilize around 7.5 percent in the longer term. This includes the impact of higher infrastructure investment raising growth by 1 to 1.5 percentage points in the medium term and by about 0.3 percentage points in the longer term.

This represents a deceleration from the annual average of above 8 percent over the past decade in which growth was supported by large aid flows, as well as high private capital inflows, mainly to the natural resource sector, that together averaged about 20 percent of GDP. But growth has been trending down and requires an ambitious agenda of structural reforms and infrastructure investment to be sustained. The government is therefore aiming to temporarily raise public investment from an average of 11 percent of GDP during the past decade to about 15 percent of GDP over the medium term (or to 17 percent of GDP including the Portuguese credit lines).

Malawi

The Kayelekera uranium mine is expected to act as a major driver for GDP growth. The mine is adding to overall economic growth while production is being ramped up during the first four years, but will then detract from overall growth as production is wound down at the end of the mine’s life. At its peak, the mine could add 10 percent to Malawi’s overall GDP and 25 percent to exports. Additional mining projects are expected to come on stream as Kayelekera winds down, reflecting considerable interest in Malawi’s natural resources, including uranium and niobium, with projects expected to be viable at current prices.

The real GDP growth is projected to average 6.7 percent over 2009–14, thereafter averaging 5.4 percent. Growth is slightly higher than the 4.5 percent average over the past decade, which reflected poor macroeconomic management in the earlier period and a sequence of negative shocks, including a food crisis in 2005, but lower than the average over the last five years.

Zambia

The medium-term outlook remains relatively favorable due to productivity increases in recent years on account of high investment in the mining sector. The Zambian economy is expected to diversify as non-mining activity expands in response to improvements in the business environment and infrastructure. There is considerable untapped potential in agriculture and tourism but much remains to be done with respect to investment in infrastructure, particularly in the energy sector.

The growth of real GDP is estimated at 6.0 percent by 2011, and 6.4 percent by 2014, supported primarily by activity in mining and construction. While investment in energy is expected to benefit all sectors over time, the mining industry is expected to be the immediate beneficiary. Diversification is, however, necessary in order to make up for the eventual decline in mining activity. But investment in tourism and agriculture are not expected to be as resource intensive as mining and energy. Hence, once the near-term investment and construction impact slows, growth is expected to stabilize at a rate slightly below 6 percent in the long-run. An average growth rate in the order of 5.4 percent in the period 2015–19 is envisaged.

Tanzania

Tanzania’s macroeconomic outcomes improved substantially over the last decade with sustained high rates of growth and relatively low inflation. Prior to the global financial crisis, growth had been accelerating (averaging 7 percent per year during 2002-2009). Growth slowed as the global crisis hit, but the government’s economic recovery program cushioned the impact on the economy. Economic indicators suggest that growth began to accelerate in the second half of 2009, stemming from good performance in agriculture, construction, and, transport and communication.

A gradual recovery in private sector activity over the next three years from the current slowdown caused by the global crisis is forecasted. Growth in 2010/11 is projected to be 6.5 percent, increasing from 5.8 percent in 2009/10. The growth rate will increase to 7.1 percent in 2011/12 before reaching 7.5 percent in 2012/13 and thereafter. The high growth path over the long term reflects the stepping up of infrastructure investment financed via additional domestic and external borrowing on less concessional terms. Inadequate infrastructure is considered a key constraint to higher growth in the country. The authorities have developed a list of priority high return infrastructure projects, which are expected to produce synergistic growth effects on vital sectors.

Based on the above mentioned scenario, the percentage change of real GDP is given in Table 3.5-3. Figure 3.5-2 shows the result of the calculation of real GDP growth index, where the real GDP of each country in the base year is 100. Linear interpolation is applied in the calculation. It is estimated that the Mozambican real GDP of the target year of 2030 is 4.8 times larger than that of the base year of 2008, whereas Malawian and Zambian GDPs are 3.4 times and 3.2 times larger than the baseline

GDPs respectively. Tanzania's GDP growth is almost the same as that of Mozambique.

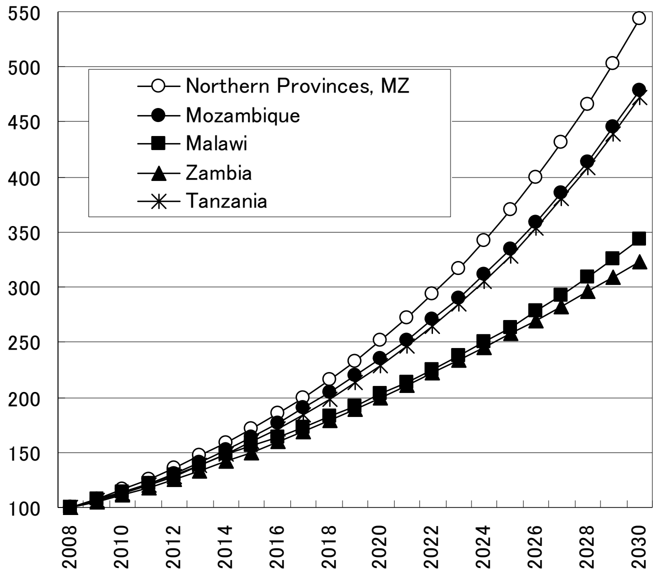
Mozambique's Northern Provinces are less developed and acceleration of its development is expected. The development of the Northern Provinces is one of the priority policies of GOM. The annual GDP growth of Nampula Province, which is the most populated province in the Northern provinces (and in the country), is estimated at 8.0% from 2010 to 2020 in the Strategic Plan of Nampula. Assuming that this growth rate will continue up to 2030, and the GDP of other Northern provinces will grow at the same rate, the GDP growth of the Northern Provinces is calculated as shown in Figure 3.5-2.

In the Study, the above mentioned economic growth scenarios are adopted as a basis of the forecast of cargo generation in the hinterland of the Port.

Table 3.5-3 Assumption of percent change of real GDP by IMF

	2008	2009	2010	2011	2012	2013	2014	2015	2019	2020	2025	2029	2030
Mozambique	6.7	6.3	6.5	7.5	7.6	7.9	7.8	7.8		7.2			7.5
Malawi	9.8	7.6	6.0	6.3	6.6	6.8	7.1	5.4		5.4	5.4		5.4
Zambia	5.7	5.3	5.5	6.0	6.2	6.3	6.4		5.7			4.5	
Tanzania	7.3	6.4	5.8	6.5	7.1	7.5	7.5	7.5		7.5			7.5

Source: IMF Country Report (2009, 2010)



Source: Study Team (based on the Data provided by IMF)

Figure 3.5-2 Forecasted growth of real GDP in the hinterland countries

2) GDP elasticity of seaborne cargoes

The Study Team assumed that the GDP elasticity of seaborne cargoes of Northern Mozambique was equal to that of total seaborne cargoes in the country, and used it in the cargo forecast in Northern Mozambique due to availability of data and statistical fluctuation. Since all seaborne cargoes generated in Mozambique are handled in Mozambican ports, the statistics on imported and exported cargoes through Mozambican ports provided by CFM give time series of seaborne cargo volume generated in the country as shown in Table 3.5-4. Then the GDP elasticity can be calculated from the time series of the cargo volume and GDP.

Table 3.5-4 Time series of seaborne cargoes generated in Mozambique

(tons)

	2003	2004	2005	2006	2007	2008
Export	1,019,600	1,196,400	1,423,500	1,671,500	1,688,400	2,044,300
Import	3,214,000	3,521,300	3,634,700	4,122,400	4,322,600	4,271,800
Total	4,233,600	4,717,700	5,058,200	5,793,900	6,011,000	6,316,100

Source: CFM

The estimation of time series of seaborne cargo volume generated in Malawi and Zambia is rather complicated because Durban Port, which handles a considerable amount of cargoes to/from LLCs, doesn't disclose statistics of transit cargoes. The Study Team tried to acquire the data from South African Revenue Authority and Transnet Port Authority, but was unsuccessful. Therefore the time series of cargo generation in Malawi and Zambia is estimated based on the trade statistics provided by the Global Trade Atlas.

The database provides information on cargo volume, but the counting unit is not unified in metric tons. Some commodities are counted by pieces. Therefore, the time series data in monetary terms are used in the estimation. Cargoes to/from countries listed in Table 3.5-5 are eliminated from the estimation, since they are unlikely to be seaborne cargoes. Table 3.5-6 shows the time series of seaborne trade (current US dollar terms) of the two countries as well as Mozambique. In the estimation of the GDP elasticity, the time series of trade data will be modified by the Unit Value Index of export and import listed in Table 3.5-7 to remove the influence of price escalation.

Although UVI for seaborne trade may be different from that for the total international trade, the Study Team had no choice but to use the UVI for total trade in the estimation due to availability of data. This can cause some errors in the estimation. The fact that the trade data includes air cargoes may also cause minor errors. Therefore, the Study Team examined adequacy of utilization of trade data in the estimation of cargo volume elasticity by using Mozambican trade and cargo data. Figure 3.5-3 shows the correlation between the cargo data by CFM and the trade data modified by UVI from 2004 to 2008. Although the fluctuation remains, the correlation factor of 0.96 indicates that the time series of trade data can be assumed to be proportional to that of cargo volume data, and that the GDP elasticity of cargo volume are approximated by the GDP elasticity of trade value.

Table 3.5-5 Destination/origin of non-seaborne transport

Mozambique	Swaziland	Namibia
South Africa	Tanzania	Rwanda
Zimbabwe	Botswana	Burundi
Malawi	Lesotho	Kenya
Zambia	Uganda	

Source: Study Team

Table 3.5-6 Time series of seaborne trade

(Unit: 1000 US$)

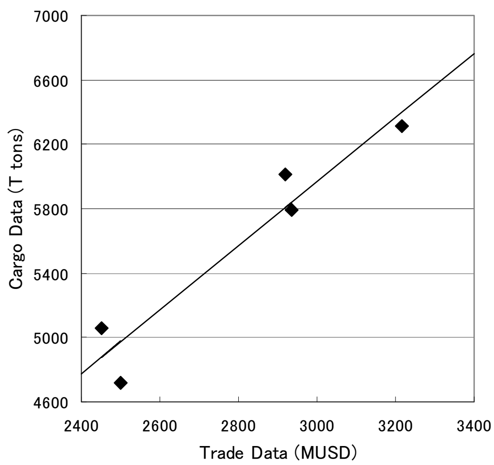
		2003	2004	2005	2006	2007	2008
Mozambique							
Export	Seaborne		1,199,595	1,362,744	1,902,261	1,887,704	2,242,319
	Regional		304,251	382,512	478,871	524,375	410,941
	Total		1,503,846	1,745,256	2,381,132	2,412,079	2,653,260
Import	Seaborne		1,301,531	1,344,639	1,836,781	2,016,236	2,762,622
	Regional		733,141	1,063,556	1,032,546	1,033,510	1,245,141
	Total		2,034,672	2,408,195	2,869,327	3,049,746	4,007,763
Total	Seaborne		2,501,126	2,707,383	3,739,042	3,903,940	5,004,941
	Regional		1,037,392	1,446,068	1,511,417	1,557,885	1,656,082
	Total		3,538,518	4,153,451	5,250,459	5,461,825	6,661,023
Malawi							
Export	Seaborne	358,147	316,287	351,487	451,189	550,264	674,182
	Regional	144,283	142,416	144,003	215,028	318,295	204,817
	Total	502,430	458,703	495,490	666,217	868,559	878,999
Import	Seaborne	323,754	379,853	427,318	461,469	607,161	869,596
	Regional	461,622	548,805	737,874	745,227	770,684	1,334,092
	Total	785,376	928,658	1,165,192	1,206,696	1,377,845	2,203,688
Total	Seaborne	681,901	696,140	778,805	912,658	1,157,425	1,543,778
	Regional	605,905	691,221	881,877	960,255	1,088,979	1,538,909
	Total	1,287,806	1,387,361	1,660,682	1,872,913	2,246,404	3,082,687
Zambia							
Export	Seaborne		802,091	1,077,825	3,015,357	3,529,412	4,066,515
	Regional		773,536	731,938	755,013	1,088,042	1,032,173
	Total		1,575,627	1,809,763	3,770,370	4,617,454	5,098,688
Import	Seaborne		924,516	1,060,514	1,249,134	1,650,634	2,015,670
	Regional		1,227,556	1,497,496	1,825,127	2,356,346	3,044,813
	Total		2,152,072	2,558,010	3,074,261	4,006,980	5,060,483
Total	Seaborne		1,726,607	2,138,339	4,264,491	5,180,046	6,082,185
	Regional		2,001,092	2,229,434	2,580,140	3,444,388	4,076,986
	Total		3,727,699	4,367,773	6,844,631	8,624,434	10,159,171

Source: Global Trade Atlas, Study Team

Table 3.5-7 Unit Value Index for export and import

		2000	2001	2002	2003	2004	2005	2006	2007	2008
Mozambique	Export	100.0	94.3	89.9	100.4	115.6	131.5	166.4	169.2	187.9
	Import	100.0	97.6	98.1	106.5	116.1	124.4	132.1	143.6	174.6
Malawi	Export	100.0	98.1	90.8	91.8	94.9	100.1	109.2	120.9	134.8
	Import	100.0	97.0	97.7	104.2	113.0	122.0	127.9	142.6	176.9
Zambia	Export	100.0	91.6	90.4	99.7	129.2	155.8	260.4	275.8	279.7
	Import	100.0	97.9	99.2	104.8	114.8	124.3	131.8	142.3	163.9

Source: UNCTAD



Source: Study Team

Figure 3.5-3 Correlation between trade statistics and port statistics of Mozambique

Table 3.5-8 summarizes the GDP elasticity of cargo volume generated in Mozambique, Malawi, and Zambia obtained from Mozambican port statistics and Malawian and Zambian trade statistics. The time series of real GDP growth (USD terms) was obtained from IMF database. The calculated elasticity for Zambian exported cargo was extraordinarily large due to the influence of accidental increase of copper export in 2006. Therefore, for Zambian export, the GDP elasticity calculated from the time series of Export Quantity Index provided by UNCTAD is used for the cargo forecast expediently, though EQI includes non-seaborne cargoes. The GDP elasticity calculated from the time series of EQI is also shown in Table 3.5-8.

Generally, the GDP elasticity is large in the earlier stage of development of the economy, and with the development, the elasticity tends to decrease. In developed economies, the elasticity is less than 1.0. Considering this tendency, the Study Team developed a scenario in which the GDP elasticity converges on 1.0 from the historical average toward the target year of 2030. Table 3.5-9 shows the assumption of GDP elasticity based on this scenario. The listed elasticity will be used in the cargo forecast.

Table 3.5-8 GDP elasticity of cargo volume generated in Mozambique, Malawi, and Zambia

		2003	2004	2005	2006	2007	2008	Average	Elasticity
Based on Port Statistics (CFM)									
Mozambique	GDP Growth Rate		8.8%	8.7%	6.3%	7.3%	6.7%	7.6%	
	Export Cargo Growth Rate		17.3%	19.0%	17.4%	1.0%	21.1%	15.2%	2.0
	Import Cargo Growth Rate		9.6%	3.2%	13.4%	4.9%	-1.2%	6.0%	0.8
	Total Cargo Growth Rate		11.4%	7.2%	14.5%	3.7%	5.1%	8.4%	1.1
Based on Trade Statistics (Global Trade Atlas)									
Malawi	GDP Growth Rate		5.4%	3.3%	13.6%	1.2%	9.4%	6.6%	
	Export Cargo Growth Rate		-14.6%	5.3%	17.7%	10.2%	9.9%	5.7%	0.9
	Import Cargo Growth Rate		8.2%	4.2%	3.0%	18.0%	15.5%	9.8%	1.5
Zambia	GDP Growth Rate			5.3%	6.2%	6.2%	5.7%	5.8%	
	Export Cargo Growth Rate			11.4%	67.4%	10.5%	13.6%	25.7%	4.4
	Import Cargo Growth Rate			5.9%	11.1%	22.4%	6.0%	11.4%	1.9
Based on Export/Import Volume Index (UNCTAD)									
Malawi	GDP Growth Rate	5.7%	5.4%	3.3%	13.6%	1.2%	9.4%	6.4%	
	Export Cargo Growth Rate	27.2%	-10.2%	-1.7%	21.8%	17.8%	-9.2%	7.6%	1.3
	Import Cargo Growth Rate	6.7%	9.5%	15.6%	-0.9%	2.4%	28.7%	10.3%	1.8
Zambia	GDP Growth Rate	5.1%	5.4%	5.3%	6.2%	6.2%	5.7%	5.6%	
	Export Cargo Growth Rate	-7.1%	24.0%	-4.8%	24.7%	14.4%	7.2%	9.7%	1.7
	Import Cargo Growth Rate	35.1%	24.9%	9.8%	13.3%	19.7%	7.8%	18.4%	3.2

Source: Study Team

Table 3.5-9 Assumption of the GDP elasticity

		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Mozambique	Export	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.5
	Import	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9
Malawi	Export	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	Import	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3
Zambia	Export	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.4	1.4	1.4	1.3
	Import	1.9	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.5	1.5
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Mozambique	Export	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.1	1.1	1.0	1.0
	Import	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0
Malawi	Export	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Import	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.0	1.0	1.0
Zambia	Export	1.3	1.3	1.3	1.2	1.2	1.2	1.1	1.1	1.1	1.0	1.0
	Import	1.4	1.4	1.4	1.3	1.3	1.2	1.2	1.1	1.1	1.0	1.0

Source: Study Team

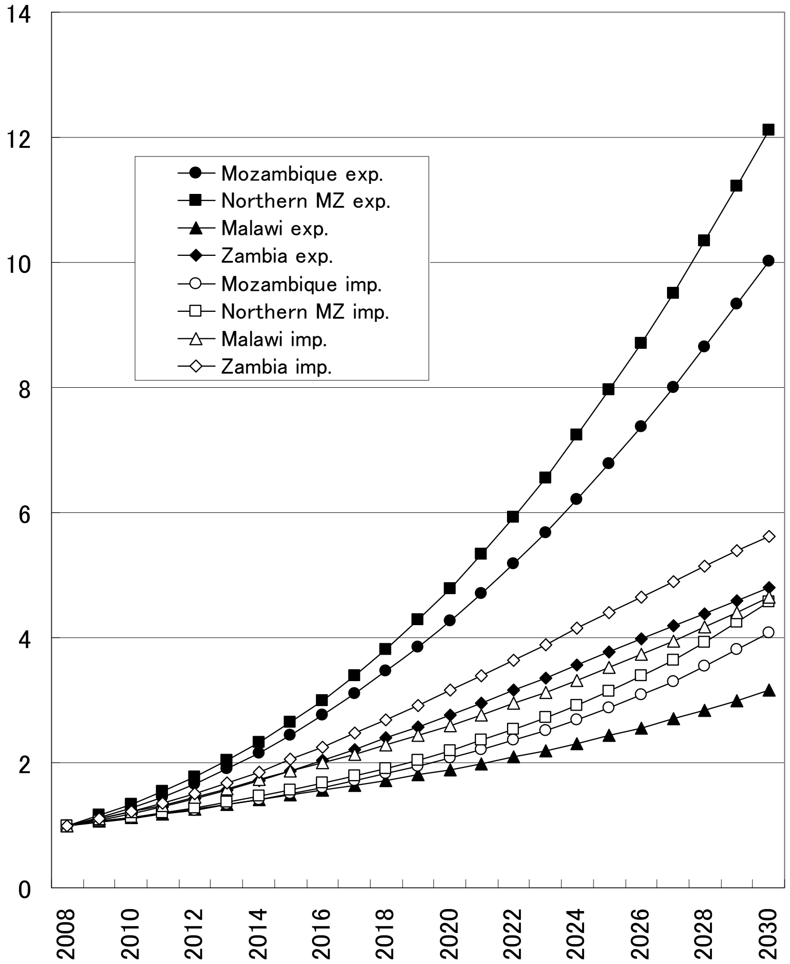
3) Result of the macro forecast

Figure 3.5-4 shows the forecasted growth ratio of seaborne cargoes generated in Mozambique (average in the country and Northern Provinces), Malawi, and Zambia, which is calculated from the above mentioned GDP growth scenario and the GDP elasticity.

Mozambican export cargo is forecasted to grow very rapidly reflecting the higher growth of the economy. The import is forecasted rather modestly since the GDP elasticity of import is small. In Northern Provinces, larger cargo generation is forecasted than the country's average due to higher growth rate of their economy.

The growth in Zambia and Malawi is smaller than that of Mozambique, since their GDP growth rate is forecasted to be lower than Mozambique.

Table 3.5-10 shows the comparison between the average annual growth rate of the trade value forecasted by IMF (US dollar terms) and of the seaborne cargo volume forecasted by the Study Team from 2010 to 2030. Since the two forecasted growth rates are on a different basis, namely monetary terms and volume, and total flow and seaborne flow, they cannot correspond with each other. However, overall tendency in which Mozambique shows the highest growth followed by Zambia is consistent.



Source: Study Team

Figure 3.5-4 Forecasted growth ratio of seaborne cargoes generated in Mozambique, Malawi, and Zambia

Table 3.5-10 Comparison between the average annual growth rate of the trade value forecasted by IMF and of the seaborne cargo volume forecasted by the Study Team from 2010 to 2030

		Growth of cargo volume forecasted by the Study Team	Growth of trade value forecasted by IMF
Mozambique	export	11.0%	11.4%
	import	6.7%	10.4%
Zambia	export	7.3%	8.5%
	import	8.1%	8.3%
Malawi	export	5.3%	7.5%
	import	7.0%	5.0%

Source: Study Team, IMF

The result of the macro forecast in any year can be obtained from the growth ratio shown in Figure 3.5-4 by multiplying the cargo volume in the base year. The forecasted volume of cargo generation in the target years is shown in Table 3.5-11. Since almost all cargoes handled in the Port except dry bulk and liquid bulk are already containerized, and there is no significant difference between the historical growth rate of total cargoes and containerized cargoes, the Study Team assumed that the future growth rate of containers was the same as that of total cargo volume.

The cargo volume of Northern Mozambique in the base year was obtained from cargo statistics of Nacala Port by eliminating tare weight of containers (2.3 tons per TEU). As the share of Pemba Port was assumed to be unchanged, the forecasted volume represents the cargo volume generated in Northern provinces, and handled in Nacala Port.

The cargo volumes of Malawi in the base year were estimated from trade statistics provided by the Global Trade Atlas, by eliminating non-seaborne trade, multiplying the conversion factor listed in Table 3.5-12 to the commodities which are not recorded in weight, and finally converting from net weight to gross weight which includes the weight of packages (the conversion factor is 1.01 for bulk cargo, and 1.30 for containerized cargo).

The cargo volumes of Zambia in the base year were estimated from SADC trade statistics in 2006 by eliminating non-seaborne trade, multiplying Import Volume Index in 2008 provided by UNCTAD, and converting from net weight to gross weight.

Some kinds of cargoes cannot be captured in the above mentioned macro forecast. For example, EPZs adjacent to ports generate more cargo volume per economic output than average, and the volume of these kinds of cargoes can be underestimated by the macro forecast because the historical time series of cargoes don't reflect these characteristics. On the other hand, some specific commodities may be overestimated since the macro forecast doesn't take future change of individual market structure into account. Therefore, the forecasted volume will be modified by the micro forecast described below.

Table 3.5-11 Forecasted volume of cargo generation in the target years by the macro forecast

(ton)

			2008	2020	2030
Northern Mozambique	Export	Containers	152,000	726,000	1,840,000
		Bulk	28,000	134,000	339,000
		TOTAL	180,000	860,000	2,170,000
	Import	Containers	124,000	272,000	567,000
		Bulk	311,000	683,000	1,430,000
		TOTAL	435,000	954,000	1,990,000
	TOTAL	Containers	275,000	998,000	2,400,000
		Bulk	339,000	817,000	1,760,000
		TOTAL	615,000	1,810,000	4,170,000
Malawi	Export	Containers	192,000	364,000	606,000
		Bulk	68,200	129,000	215,000
		TOTAL	260,000	493,000	821,000
	Import	Containers	328,000	851,000	1,570,000
		Bulk	694,000	1,800,000	3,320,000
		TOTAL	1,020,000	2,650,000	4,890,000
	TOTAL	Containers	520,000	1,210,000	2,180,000
		Bulk	762,000	1,930,000	3,540,000
		TOTAL	1,280,000	3,150,000	5,720,000
Zambia	Export	Containers	246,000	680,000	1,140,000
		Bulk	579,000	1,600,000	2,690,000
		TOTAL	825,000	2,280,000	3,830,000
	Import	Containers	529,000	1,670,000	2,980,000
		Bulk	772,000	2,440,000	4,340,000
		TOTAL	1,300,000	4,110,000	7,320,000
	TOTAL	Containers	775,000	2,350,000	4,120,000
		Bulk	1,350,000	4,040,000	7,030,000
		TOTAL	2,130,000	6,390,000	11,100,000

Source: Study Team

Table 3.5-12 Conversion factors into weight for Malawian cargoes

Malawi Export

HS Code	Commodity	Unit	KG/Unit
06	Live Trees and Plants	NO	2.0
40	Rubber	NO	10.0
44	Wood	NO	300.0
44	Wood	M3	500.0
61	Knit Apparel	NO	0.7
62	Woven Apparel	NO	1.0
82	Tools, Cutlery, Etc.	NO	1.0
84	Machinery, Reactors, Boilers	NO	10.0
85	Electrical Machinery, Etc.	NO	5.0
90	Medical Instruments	NO	0.3
93	Arms and Ammunition	NO	10.0
94	Furniture and Bedding	NO	30.0
96	Misc. Manufacturing Articles	NO	5.0

Malawi Import

HS Code	Commodity	Unit	KG/Unit
01	Live Animals	NO	100.0
06	Live Trees and Plants	NO	2.0
40	Rubber	NO	10.0
42	Leather Art; Saddlery, Etc.	NO	1.0
44	Wood	M3	500.0
61	Knit Apparel	NO	0.8
62	Woven Apparel	NO	0.8
65	Headgear	NO	0.5
66	Umbrella, Walking Sticks, Etc.	NO	2.0
69	Ceramic Products	NO	2.0
69	Ceramic Products	NO	2.0
70	Glass and Glasswares	NO	1.0
73	Iron and Steel Products	NO	100.0
82	Tools, Cutlery, Etc.	NO	5.0
84	Machinery; Reactors, Boilers	NO	5.0
85	Electrical Machinery, Etc.	NO	5.0
87	Vehicles, Not Railway	NO	1,800.0
88	Aircraft, Spacecraft	NO	40,000.0
89	Ships and Boats	NO	2,000.0
90	Optical, Medical Instruments	NO	0.5
92	Musical Instruments	NO	5.0
93	Arms and Ammunition	NO	10.0
94	Furniture and Bedding	NO	30.0
95	Toys and Sports	NO	1.0
96	Misc. Manufacturing Articles	NO	0.1

Source: Study Team

(3) Micro forecast

1) Potential export commodities in domestic hinterland and LLCs

Based on the investigations by the Study Team, potential export commodities in domestic hinterland and LLCs are summarized as shown in the Table 3.5-13. Agricultural and forestry products will become major export commodities in the Northern Provinces in the year 2030. Mineral resources such as coal in Tete Province and copper in Zambia will also be major export commodities.

Table 3.5-13 Potential export commodities in domestic hinterland and LLCs

No	Commodity		Origin	Estimated Annual Production Volume in Year 2030 (ton/year)	Remarks
	Type	Item			
1	Forestry products	Raw lumber (Wood chip) (Sawed timber)	Niassa	4,300,000 (384,000) (3,916,000)	2 plant x 80t/hour
2	Agricultural products	Tobacco	Mozambique	100,000	Niassa and Nampula province will share the half of this amount
3			Malawi	179,000	
4		Cotton	Nampula	50,000	
5		Sugar	Malawi	100,000	Only 79% is related to the exports through Beira and Nacala port
6		Cashew	Nampula	46,000	
7		Maize (Corn)	Nampula	400,000	
8		Sorghum	Nampula	180,000	
9		Millet	Nampula	21,000	
10		Rice	Nampula	100,000	
11		Soybean	Nampula	150,000	
12		Cassava	Nampula	6,000,000	
13	Mining products	Coal	Tete province	40,000,000	MMR comment
14		Iron ore/Phosphate	Northern provinces	20,000,000	MMR comment
15		Zircon	Nampula	56,000	Moma project
16		Illuminate	Nampula	800,000	Moma project
17		Rutile	Nampula	21,000	Moma project
18		Copper	Zambia	1,500,000	

Source: Study Team

2) Forestry products

In 2006, the Mozambican Ministry of Agriculture issued the “National Reforestation Strategy”, which aims at promoting the establishment of industrial tree plantations using fast-growing species, not only for economic development, but also for job creation and poverty eradication in rural areas. This strategy identified about 7 million hectares with potential for reforestation in five provinces of the Central and the Northern Provinces. During 2005 to 2009, about 35,000 hectares were planted nationwide, resulting in the generation of about 8,000 jobs. Several projects were approved for the establishment of commercial forest plantations at large scale in the provinces of Niassa (2.4 mil. ha), Nampula (1.5 mil. ha), Zambezia (2.1 mil. ha), Manica (0.86 mil. ha) and Sofala (0.12 mil. ha).

The province of Niassa, which has the largest potential for reforestation, is located along the Nacala Corridor and has received SIDA support since 1998. SIDA established a non-government organization, the “Malonda Foundation”, as its implementation body in 2005. The Malonda Foundation has provided business development services in order to attract foreign and domestic investment. Existing forest projects in Niassa Province are being driven by 5 companies as shown in the table below.

Table 3.5-14 Existing forestry projects in Niassa

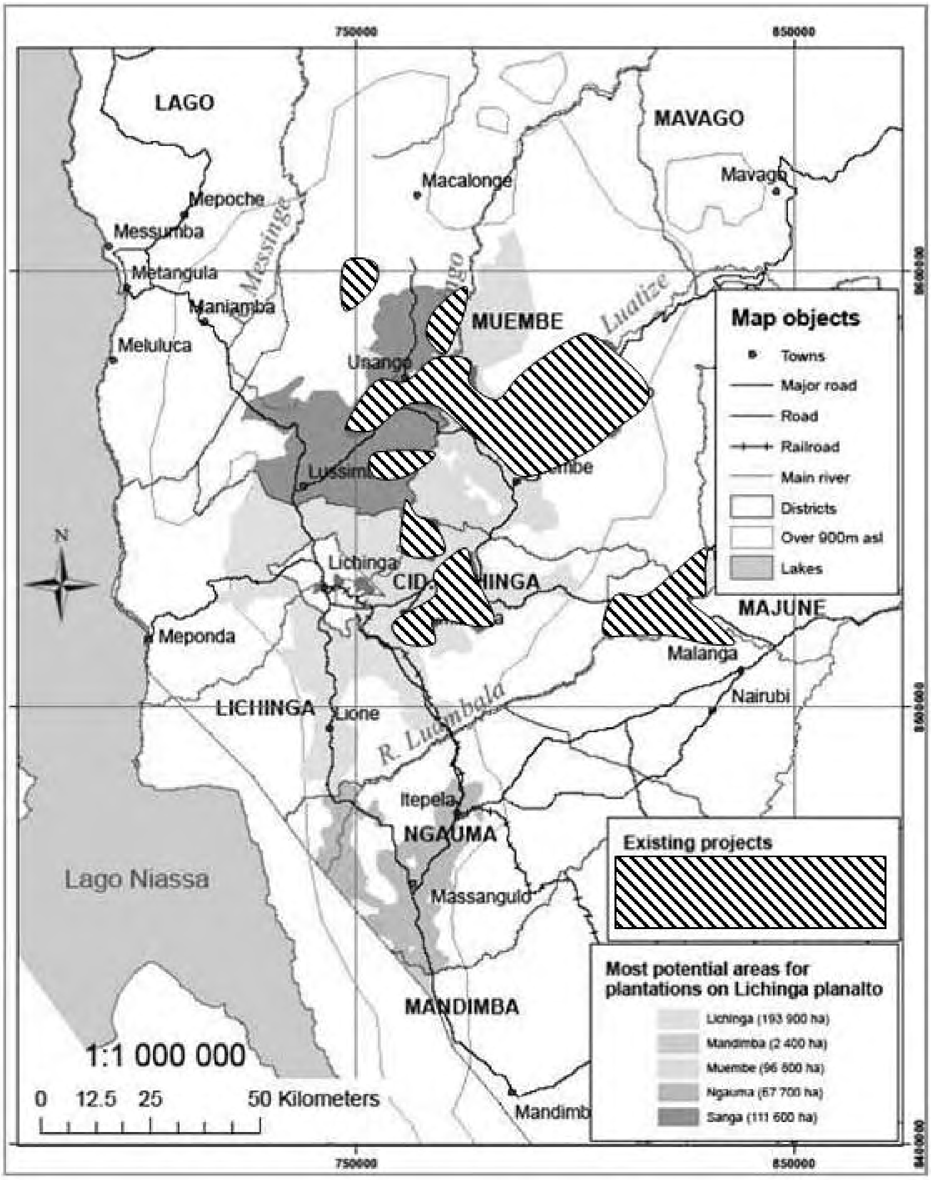
No	Company	Main Investors	Planned Plantation Area (ha)	Planned Conservation Area (ha)	Total Projected Area (ha)
1	Chikweti Forest of Niassa	Global Solidarity Forest Fund (Sweden)	68,500	71,500	140,000
2	Florestas de Niassa	Rift Valley Forestry (German & Norway), Malonda Foundation	120,000	90,000	210,000
3	Florestal de Massangulo	Global Solidarity Forest Fund (Sweden)	50,000	50,000	100,000
4	New Forest Malonda	New Forests Company (UK), Malonda Foundation	60,000	27,000	87,000
5	Malonda Tree Farms Mozambique	Green Resources (Norway), Malonda Foundation	24,000	36,000	60,000
Total			322,500	274,500	597,000

Source: Study Team

Current status of planned projects for pine, eucalyptus and other species and estimated production volumes (sawn timber and pulp chips) are as follows;

- Area planted to-date :13,545 ha
- Number of Employees :5,332 (2009), 9,950 (2015) and 18,330 (2025) [22,000 at peak year]
- Production (ton/year) :57,775 (2015) and 2,376,000 (2025) [4,300,000 at peak year]

Figure 3.5-5 shows the identified area for recommended forestry development by the Ministry of Agriculture based on the geological and metrological criteria by GIS tool.



Source: Zoning and Identification of Areas for Investment in the Agrarian Sector and Socio-Environmental Analysis for Niassa Province, Volume 3: Forestry Plantations, Ministry of Agriculture, May 2007

Figure 3.5-5 Areas with high potential for forestry development in Lichinga plateau

Although the export of forestry products from Lichinga plateau has not yet been commenced, it is anticipated that a substantial amount of wood chip and sawed timber will be produced and be exported in the near future. Forestry projects are also being carried out in Cabo Delgado Province, and natural wood products have been already exported to China through Pemba Port. Table 3.5-15 shows the forecasted export volume of forestry products from the northern regions.

Table 3.5-15 Forecasted export volume of forestry products

(1000 tons)

		2015	2020	2025	2030	Remarks
Norhern MZ	Raw lumber	58	1,000	2,376	4,300	
	Wood chip	0	96	192	384	2 plants of 80ton/hour chip factory
	Sawed timber	58	904	2,184	3,916	

Source: the Study Team

Since the trend of GDP elasticity for the export of forestry products must have been reflected in the overall GDP elasticity to some extent, the total cargo volume forecasted in the macro forecast shall not be modified based on the result of the forecast of exported forestry products. However, the total amount of exported containerized cargoes shall be decreased and the volume of bulk cargoes shall be increased in accordance with the volume of the exported wood chip.

3) Agricultural products

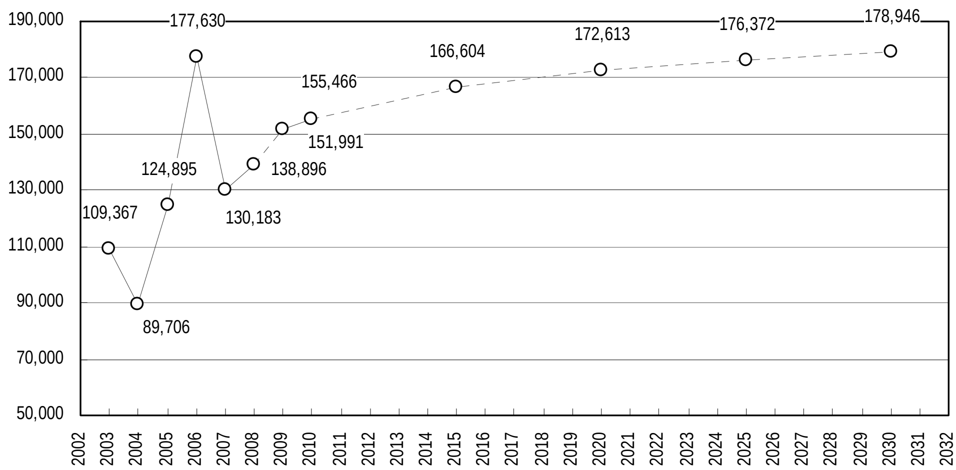
Perspectives of export of agricultural products from the hinterland of the Port are described below. Since it is expected that there is no significant change in the trend of the elasticity between economic output and export volume of agricultural products in the future, the forecasted volume by the macro forecast shall not be modified by the result of micro forecast on agricultural products.

a) Tobacco

Tobacco has been largest export crop of Malawi and is vital to the Malawi economy. In 2006, according to the National Statistical Office (NSO), exports of tobacco accounted for 61 per cent of the total export value, and 6.2 per cent of total GDP. The tobacco sector grew rapidly in the early ‘90s, however, it has not increased since that time. According to statistical trade data of “Global Trade Atlas”, the tonnage based export volume is around 130,000 tons per year.

Most of Malawian tobacco is exported to countries in other continents rather than African nations. Malawi Transport Cost Study in 2004 shows that 71 per cent of the tobacco is exported through Durban Port and 29 per cent through Beira Port. Since tobacco requires sensitive control of temperature, Durban Port would have an advantage at present. However it is expected that Malawian tobacco will become one of the most important cargoes in Nacala Port with the improvement of quality of the Port and the Corridor.

The future volume of tobacco export is estimated at approximately 170,000 tons per year based on the export trend of tonnage and cost from 2003 to 2008.

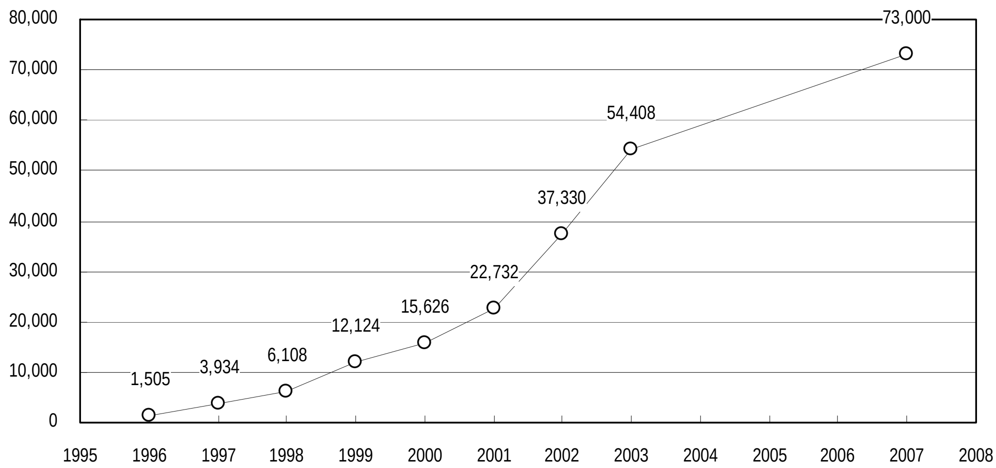


Source: Global Trade Atlas (2003~2008), the Study Team (2009~)

Figure 3.5-6 Trends of tobacco export from Malawi (2003-2008: result, 2009-: forecast)

Tobacco production is increasing at a rapid pace in Mozambique. The production of tobacco in 1997 was 1,505 tons. Production reached 54,408 tons in 2003 and 73,000 tons in 2007. This increasing trend is expected to continue. The Study Team found that the production of tobacco in Niassa province along the Nacala Corridor has been booming in smallholder contract farming schemes. According to the statistics in 2003, only 7,692 tons were produced in Niassa Province. But it is estimated that the amount of tobacco export will reach about 100,000 tons within the planning horizon of the port development.

on will reach 17,833 tons in PLANO ESTRATÉGICO PROVINCIAL (PEP) in 2017. As well as in Malawi, most of tobacco produced in Mozambique is exported to countries in other continents.



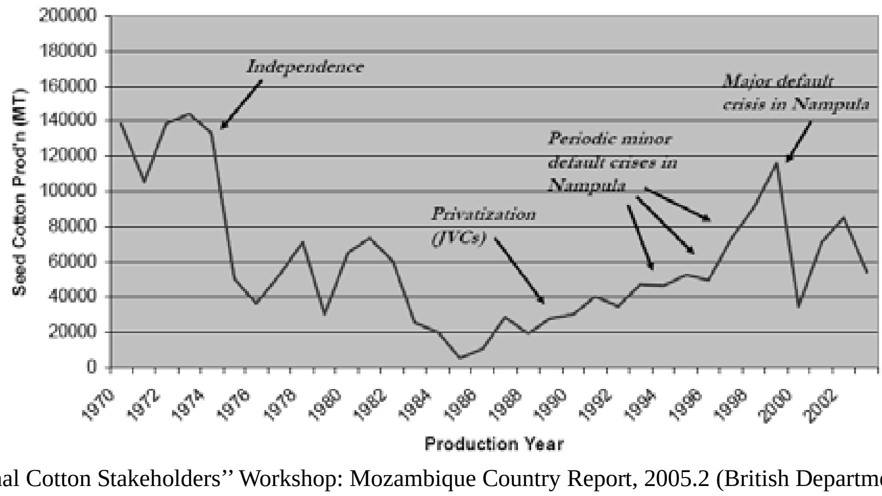
Source: The Economics of Smallholder Households in Tobacco and Cotton Growing Areas of the Zambezi Valley of Mozambique (Ministry of Agriculture), 2005

Figure 3.5-7 Raw tobacco production in Mozambique（1996 -2003, 2007）

b) Cotton

Nampula Province has been producing cotton along the so called "Cotton Belt". Although inefficient manual labor has led to lower harvest than expected, dynamic growth of cotton production has been seen in Cabo Delgado, Tete, Sofala, Manica and Zambezia provinces.

Figure 3.5-8 shows the variation of cotton production after 1970.



Source: Regional Cotton Stakeholders'' Workshop: Mozambique Country Report, 2005.2 (British Department for International Development)

Figure 3.5-8 Variation of cotton production

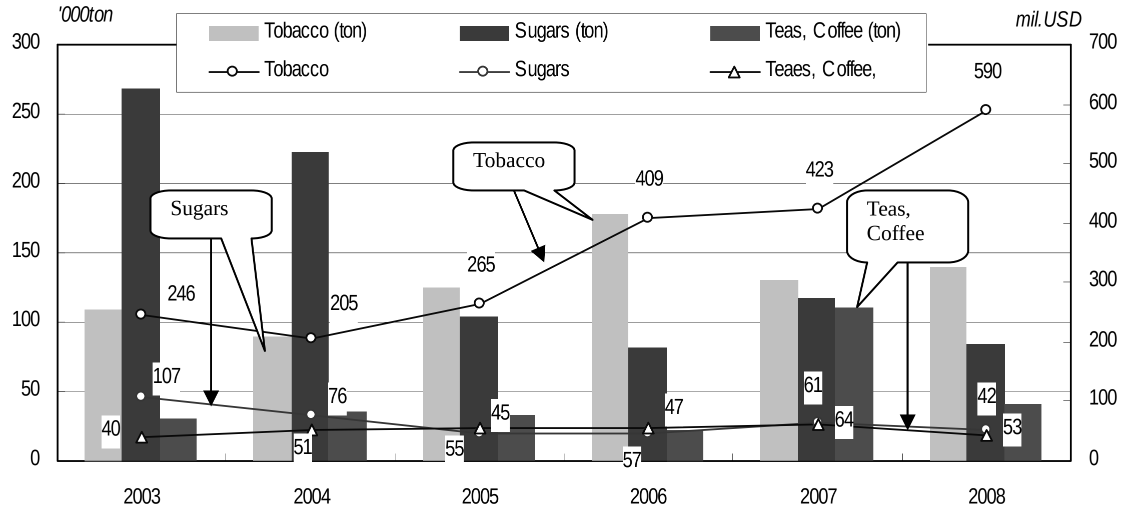
As shown in the Figure 3.5-8, the present production is about 80,000 tons per year which is less than that in the colonial period. The export volume varies from 20,000 to 40,000 tons, less than half of the total production. Thus, the future export volume is expected to be about 50,000 tons.

There is a possibility that exports could increase by improved productivity. The current unit production rate of 100 kg/ha is about one third of that in neighboring countries.

c) Sugar

Sugar is an important crop in Malawi. It accounts for nearly 10 per cent of total export earnings and employs about 11,100 permanent employees and 5,700 casual employees according to the Malawi Economic Growth Strategy.

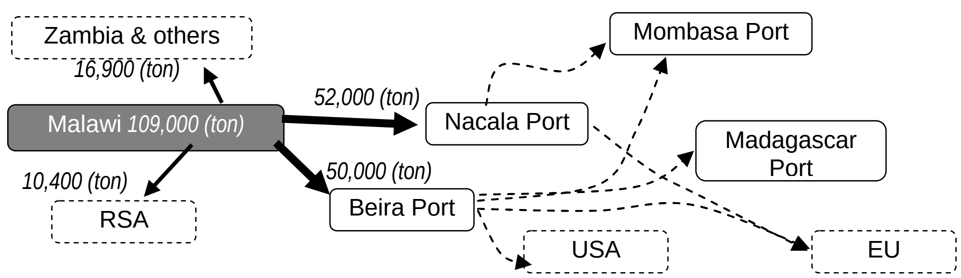
Sugar is the third ranking commodity following after tobacco and tea in terms of export value. Approximately 100,000 tons of sugar is produced per year, ranking second behind tobacco in terms of volume after 2005.



Source: Global Trade Atlas

Figure 3.5-9 Historical trend of Malawi top-3 export commodities (volume, value) 2003-2008

In accordance with the Malawi Transport Cost Study in 2004, 21% of the total sugar production is exported to neighboring countries such as South Africa and Zambia and the remaining 79% is exported to other nations through ports in neighboring countries.



Source: Malawi Transport Cost Study, 2004

Figure 3.5-10 Export route for sugar from Malawi (2003)

The volume of sugar export varies depending on the fluctuation of international sugar prices and the situation of preferential markets. In the last 6 years, the volume of sugar fell from 268 thousand to 87 thousands tons. Considering the recent trend and based on an interview with the ILLVO sugar group, which is Malawi's sole sugar producer, it is assumed that the export of sugar from Malawi will be around 100,000 tons.

At present, there is no sugar refinery in Northern Mozambique; however it is expected that sugar refining will be started there in the planning horizon. Sugar refinery is one of the prospective industries in Nacala SEZ.

4) Mining products

a) Coal

Currently, companies from Brazil, Australia, China and India are conducting or planning coal mining activities in Tete province as shown in the table below. In Moatize, they will produce 12,000,000 tons of coal annually in Phase-1 from year 2011. The coal will be transferred to Beira and shipped onto an off-shore self loading vessel. In Phase-2, they will use Nacala bay since Beira port will reach full capacity. Accordingly, a branch railway to Nacala-a-Velha and a coal loading jetty will be constructed by the year 2014 at the earliest.

Table 3.5-16 On-going coal development projects in Tete Province

No	Project	Company	Production Volume (Million tons/year)	Remarks
1	Moatize I	Vale	12.0	
2	Moatize II	Vale	-	
3	Benga	Riversdale	6.0 2.0	metallurgical thermal
4	Zambeze	Riversdale	-	9.0 billion tons of coal resources
5	Ncondezi	Zambezi Energy Corporation	10.0	4.3 billion tons of coal resources
6	Changara	JSPL Moz Minerals	2.5	1.65 billion tons of coal resources
7	Cahora Bassa	ENRC; Euroasian Natural Resources Corporation	-	1.03 billion tons of coal resources

Source: Study Team

Table 3.5-17 shows the result of forecast of coal export from Tete Province based on the interview with Ministry of Mineral Resources (MMR).

Table 3.5-17 Forecasted volume of coal export

(1000 tons)

	2008	2020	2030
Northern MZ	38	40,000	40,000

Source: Study Team

b) Other mining products to be exported from Northern Mozambique

In addition to the above coal, mineral products listed in the table below are expected to be exported from Northern Mozambique in near future. According to the information from the MMR, the export volume of iron ore and phosphate from the Northern Provinces is expected to grow up to 20,000 tons per year within the planning horizon.

Table 3.5-18 On-going development project for other minerals in Northern Mozambique

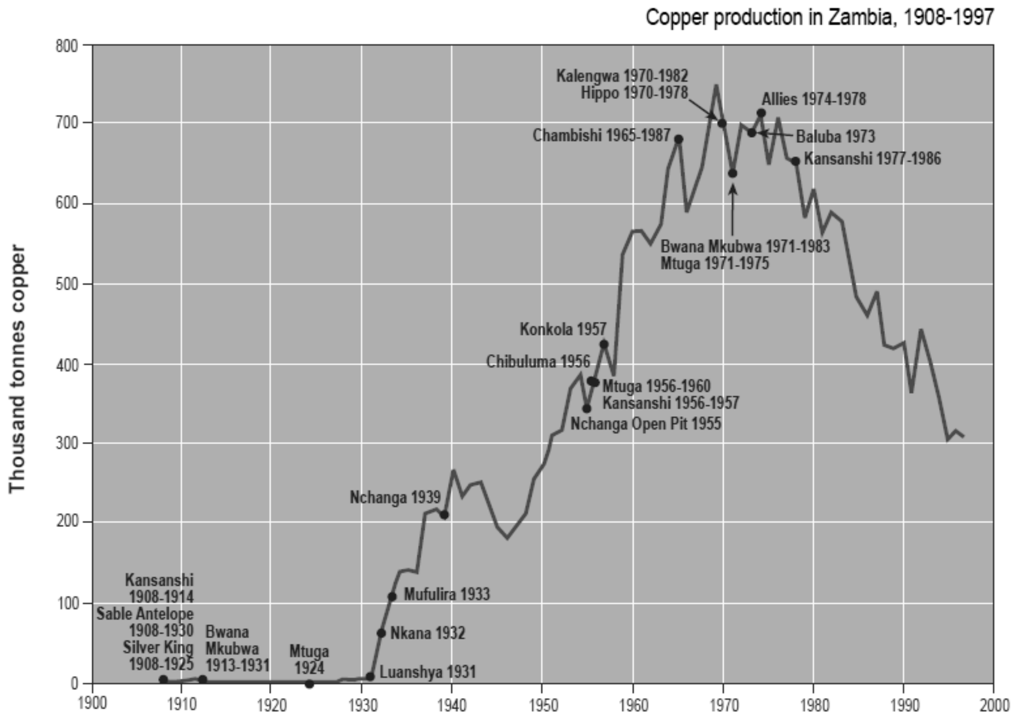
Province	District	Project name	Company	Type of mineral	Volume (mil.ton/year)
Zambezia	Ile	Marropino	Highland African Mining	Tantalite	0.5
	Gile	Muiane	Tantalum Mineral	Tantalite	-
	Pebane	Moebase	Naburi Mineral	Heavy minerals sands	-
Nampula	Monapo	Evate	Vale	Phosphate	3.5
				Iron	1.0
	Moma	Moma	Kenmare Resources	Heavy minerals sands	0.87
Cabo Delgado	Ancuabe	Ancuabe	Graphit Kropfnuhl	Graphite	-

Source: Study Team

c) Copper

Refined copper is a key of Zambian export. It currently accounts for 75.9% of the total export value.

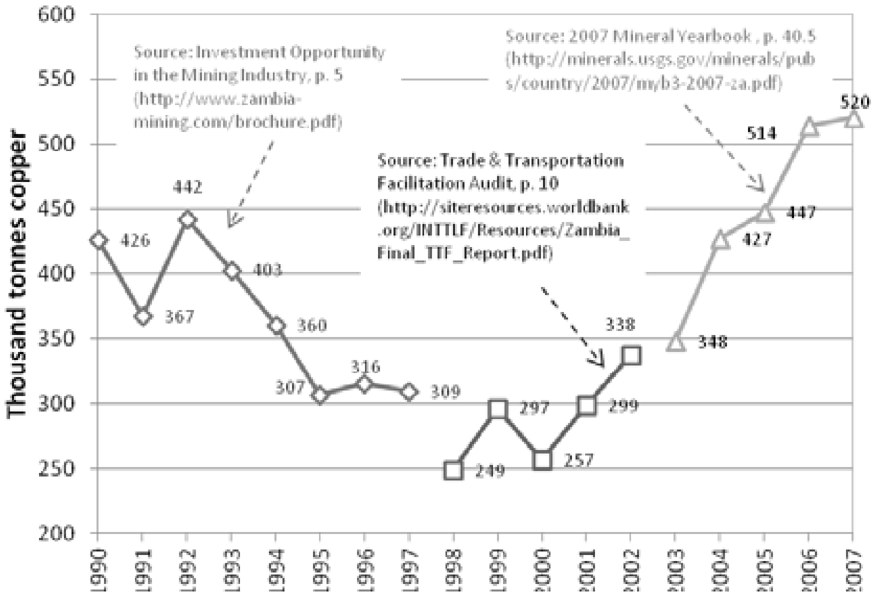
Copper production reached over 700 thousand tons per year in the 1970's, but production started to decline from the late 1970s and decreased to 300 thousand tons per year in the 1990s. Figure 3.5-11 shows the profile of copper production in Zambia from 1908 to 1997.



Source: Zambia Investment Opportunity in the Mining Industry

Figure 3.5-11 Production of copper in Zambia from 1908 to 1997

In 2002, Zambia's largest investors in copper mining announced their intention to withdraw their investment. However, due to rising copper prices from 2004, international interest in Zambia's copper sector returned, and China has now become a major investor in the Zambian copper industry. Currently, copper production has recovered to more than 500,000 ton. Figure 3.5-12 illustrates the recovery trend of copper production during 1990-2007 in Zambia based on a combination of three sources.



Source: Study Team

Figure 3.5-12 Production of copper in Zambia from 1990-2007

According to an article released by the Ministry of Finance, copper output in 2010 is expected to reach 740,000 tons compared with 696,900 tons last year due to increased production at several copper mines. It is also mentioned that Zambia's copper production is expected to reach 1 million tons by 2011-12 after the deep mining project at Konkola Copper Mine is completed.

Based on the above, the Study Team used a linear-regression to estimate future copper production and the results are as follows; 1,090,000 tons in 2020, 1,289,000 tons in 2025 and 1,488,000 tons in 2030.

About 60-70 % of copper production is exported to other continents from Durban by both the road and railway network. Although the freight rate by the railway used to be about half that of road transportation, nowadays railways have become much more expensive. Transport of copper from the Copper belt to South Africa cost US$75 per ton, which is 80% of the cost via the road network. Dar es Salam Port is also used for exportation of copper transported by Tazara railway but the transported volume has dropped due to inefficiency, excess employment, and low productivity. In addition, Walvis Bay already handles 10% of copper exports from the region.

5) Industrial Products and raw materials to/from IFZ of Nacala SEZ

Past experience of Special Economic Zones suggests that foreign investors are reluctant to step into unfamiliar countries. However, once some investments turn out to be successful, investment rapidly increases. Therefore, the volume of future cargo generation in Nacala SEZ cannot be forecasted from its historical cargo data.

For example, IFZ of Laem Chabang in Thailand has 570 ha of land in the hinterland of the port, and they generate 17,000 to 25,000 TEUs of seaborne containers per month. Assuming the same unit generation of containers, the cargo generated in the IFZ in Nacala would be 33,600 TEUs in year 2020 and 151,200 TEUs in year 2030 as shown in Table 3.5-19, when the IFZ is developed up to 450 ha, as planned by GAZEDA. Since the container generation per economic output is very large for IFZs in the vicinity of ports, and historical cargo data of Nacala Port scarcely includes this type of traffic, it is necessary to add the cargo volume forecasted here to the forecasted container volume by the macro forecast.

Nacala SEZ outside IFZs will also generate a considerable amount of seaborne cargoes, however this would be implicitly included in the result of macro forecast because it is assessed that the container generation per economic output is the same as that outside SEZ broadly. Accordingly, the modification of macro forecast is not necessary for this.

Table 3.5-19 Forecasted container cargo volume to/from Nacala SEZ

		Unit	2020	2030	Remarks
Nacala SEZ	Area of planned IFZs	ha	100	450	
	Area of tenanted IFZs	ha	80	360	80% of planned IFZs
	Production rate	TEU/ha/year	420	420	
	Total	TEU	33,600	151,200	
	Empty Container		16,800	75,600	Note 1)
	Loaded Container		16,800	75,600	Note 1)
	Loaded Container	tons	193,200	869,400	Note 2)

Source: Study Team

Note 1) Empty container ratio = 50%
Note 2) Cargo GW = 11.5 tons per 1 loaded TEU

6) Imported fuel oil and LPG

Table 3.5-20 shows the structure of supply and consumption of fuel oil in 2007 provided by IEA. Since there is no fuel oil refinery in Mozambique and Tanzania, all oil products consumed in these countries are imported. Zambia and South Africa have refineries, and they import crude oil as well as oil products. Though IEA doesn't provide data on Malawi, its supply and consumption structure seems to be the same as that of Mozambique, as it doesn't have a refinery.

Figure 3.5-13 shows the net trade flow of fuel oil in Southern Africa based on SADC trade database. Since there are yearly fluctuations, the data are indicated by the average of 2005 and 2006. Trade statistics of each country don't correspond with each other due to statistical errors. When the volume of export from A to B in the statistics of country A is different from the volume of import from A to B in the B's statistics, the larger volume is adopted since the error is likely to be caused by omission of reports. Malawian statistics tend to record larger volume in regional trade possibly because some transit cargoes are counted as regional cargoes. As only the monetary terms data are available for the statistics in Mozambique and Malawi, Mozambican data was converted into weight by the unit trade price in the littoral country of Tanzania, whereas Malawian data was converted by the unit price in landlocked Zambia. The trade volume indicated in the figure seems to deviate from that in Table 3.5-20 beyond the change in one calendar year due to statistical error. The figure shall be referred only for grasping the outline of trade pattern.

Mozambique imports oil products from South Africa and Western Asia. The imports from two origins are almost same amount. Since the total import volume roughly corresponds to the total handling volume in Mozambican ports, all imported fuel including that from South Africa is considered to be seaborne cargo.

SADC trade data for Malawi indicates that Malawi imports oil product mainly from Mozambique, but it doesn't correspond with Mozambican statistics. It may be transit via Nacala or Beira. Accordingly, all imported oil products are seaborne cargoes.

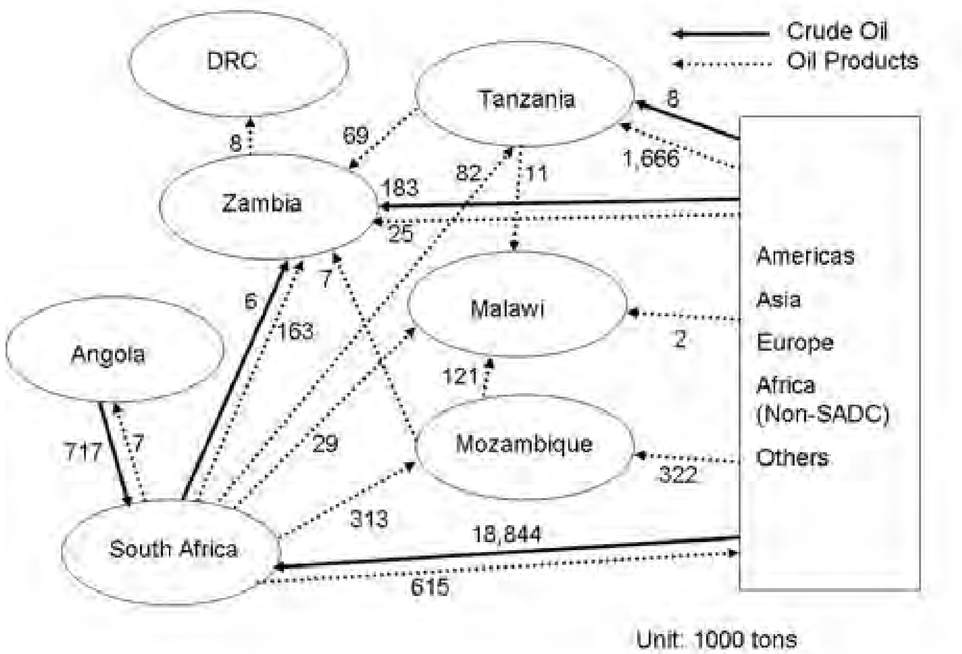
According to IEA statistics, around 85% of oil products consumed in Zambia are produced in a Zambian refinery, to which crude oil is transported mainly via Dar es Salaam Port and Tazara Pipeline. Smaller portion of oil products is imported from South Africa and Tanzania.

Table 3.5-20 Supply and consumption fuel oil in 2007

Unit - 1000tonnes

	Crude Oil	Natural Gas Liquids	LPG	Oil Products	Residual Fuel Oil	Crude Oil	Natural Gas Liquids	LPG	Oil Products	Residual Fuel Oil
	Mozambique					**Zambia**				
Production	0	0	0	0	0	0	0	3	475	95
Imports	0	0	14	676	1	654	0	0	109	0
Exports	0	0	0	0	0	0	0	0	-17	0
International Aviation/marine Bunkers	0	0	0	-63	0	0	0	0	-57	0
Stock Changes	0	0	0	-29	0	0	0	0	0	-21
Domestic Supply	**0**	**0**	**14**	**584**	**1**	**654**	**0**	**3**	**510**	**74**
Total Transformation	**0**	**0**	**0**	**1**	**0**	**654**	**0**	**0**	**7**	**3**
Electricity Plants	0	0	0	1	0	0	0	0	7	3
Petroleum Refineries	0	0	0	0	0	654	0	0	0	0
Energy Sector	0	0	0	0	0	0	0	0	0	6
Total Final Consumption	**0**	**0**	**13**	**577**	**1**	**0**	**0**	**3**	**503**	**65**
Industry	0	0	0	87	1	0	0	3	117	65
Transport	0	0	0	439	0	0	0	0	336	0
Residential	0	0	13	29	0	0	0	0	14	0
Commercial and Public Services	0	0	0	16	0	0	0	0	28	0
Agriculture / Forestry	0	0	0	6	0	0	0	0	8	0
	South Africa					**Tanzania**				
Production	1,027	146	293	16,393	4,118	0	0	0	0	0
Imports	18,589	0	0	3,456	99	0	0	7	1,252	174
Exports	-379	0	0	-827	-1,479	0	0	0	0	0
International Aviation/marine Bunkers	0	0	0	-1,130	-2,276	0	0	0	-95	-22
Stock Changes	0	0	0	0	0	0	0	0	0	0
Domestic Supply	**19,237**	**146**	**293**	**17,892**	**462**	**0**	**0**	**7**	**1,157**	**152**
Total Transformation	**19,237**	**146**	**0**	**276**	**0**	**0**	**0**	**0**	**0**	**11**
Electricity Plants	0	0	0	276	0	0	0	0	0	11
Petroleum Refineries	19,237	146	0	0	0	0	0	0	0	0
Energy Sector	0	0	0	0	0	0	0	0	0	0
Total Final Consumption	**0**	**0**	**291**	**17,623**	**462**	**0**	**0**	**7**	**1,157**	**141**
Industry	0	0	8	881	4	0	0	0	0	141
Transport	0	0	0	15,120	0	0	0	0	964	0
Residential	0	0	283	522	0	0	0	7	172	0
Commercial and Public Services	0	0	0	28	417	0	0	0	0	0
Agriculture / Forestry	0	0	0	1,072	41	0	0	0	0	0

Source: IEA



Source: Study Team

Figure 3.5-13 Net trade flow of fuel oil in Southern Africa (average of 2005 and 2006)

Hydrocarbon exploration is ongoing in the Mozambican basin, and a considerable amount of crude oil or natural gas is expected to be found.

GOM approved the construction of an oil refinery in Nacala-a-Velha, and it was expected to start operation in 2015. The installation of a pipeline was also planned to export products to landlocked Malawi, Zambia and Zimbabwe. However, the plan was postponed. GAZEDA explained to the Study Team that it would not be implemented in the near future.

Therefore the Study Team assumed that basic structure of supply and consumption of fuel oil would be unchanged within the 20 year planning horizon. Mozambique will continue to import oil products even after the increase of gas production or the commencement of crude oil production. Huge amount of gas or crude oil will be exported from the country. However the products will be transported to South Africa via pipeline, or be loaded at a dedicated facility. They will not be handled in the commercial ports. Accordingly, exported crude oil or natural gas is excluded from the demand forecast in this chapter.

Although the deep-water port of Nacala is advantageous in bulk cargo handling, the Study Team nevertheless assumed that the hinterland of the Port for oil cargoes would be unchanged except the acquisition of oil products to Zambia which would be connected with the Port by the rehabilitated Nacala Railway. Since Mozambique imports a large amount of oil products from South Africa for which the Port is unlikely to serve as a transport hub, the domestic hinterland would be unchanged. Dar es Salaam plans to expand oil unloading facilities, and it is not realistic to assume that a large amount of oil cargoes would divert from Dar es Salaam to Nacala.

Table 3.5-21 shows the time series of fuel import from 2004 to 2008. As the yearly fluctuation of the imported volume is rather large (probably because of change of stock volume), it is difficult to use these time series as a basis of the demand forecast. Table 3.5-22 shows indicators for fuel consumption in 2007. The consumed volume in Malawi was estimated from the average import volume between 2004 and 2008. For other countries, consumed volume is provided by IEA database. The table indicates that there is no significant difference in fuel consumption per GDP regardless of the size of economy, though Zambia, whose economy is dominated by minerals, is the only exception. This means that the GDP elasticity of fuel consumption is around 1.0 (or slightly less than that considering the difference of the consumption per GDP between South Africa and the rest of the countries). Despite the efforts of industrial diversification by the Government of Zambia, it is anticipated that its economy will continue to be dominated by the mineral sector. This results in unchanged consumption per GDP and the elasticity of around 1.0. Since the estimated GDP elasticity of Mozambican import for the macro forecast is less than 1.0 as shown in Table 3.5-9, the Study Team applies it in the forecast of fuel import to Malawi and Zambia, as well as Mozambique.

In the hinterland of the Port, production of biofuels from sugar cane, which is one of the most important and prospective agricultural products in the region, is expected to increase. For example, Mozambique adopted a National Policy and Strategy for Biofuels in 2009, and the Government plans to establish a mandatory 15 percent blend of biofuel to petrol and diesel in order to stimulate domestic consumption. Malawi plans to double production capacity of bio-ethanol, which at present covers around 3% of the country's fuel demands. The Study Team assumes that 15% of fuel demands will be covered by biofuels in the target year of 2030.

Table 3.5-23 shows the result of forecast of fuel import (seaborne) based on the above mentioned GDP elasticity and assumption of the introduction of biofuels. The import volume of Northern Mozambique in the base year was estimated from the handling volume of Nacala Port.

Since the time series of total cargo volume are scarcely affected by the introduction of biofuels, the total cargo volume by the macro forecast shall be modified to reflect it as shown in Table 3.5-24. GDP elasticity of oil import for Malawi and Zambia is different from the elasticity for total cargo volume in the macro forecast; however, modification for this is not necessary because the historical time series of total cargo volume must be affected by the low elasticity for fuel import.

GOM plans to commence the import of LPG through the three major ports in the country. Since the calorific value per kilogram is almost the same between LPG and fuel oil, it is expected that the total import volume (weight) of oil and gas will be basically unchanged after the commencement of LPG import. Therefore the above forecast is applicable even if LPG is imported.

Table 3.5-21 Time series of fuel import from 2004 to 2008

(ton)

	2004	2005	2006	2007	2008
Mozambique	826,621	121,778	848,046	481,105	754,571
Malawi	273,843	298,820	307,247	273,248	298,821
Zambia	1,224,361	523,945	1,244,131	629,356	884,643

Source: Global Trade Atlas

Table 3.5-22 Indicators for fuel consumption in 2007

	Consumption (1000 tons)	Consumption per GDP (kg/USD)	Consumption per capita (kg/person)
Mozambique	577	0.072	26.5
Malawi	290	0.081	20.3
Zambia	568	0.050	45.1
Tanzania	1,298	0.077	30.5
South Africa	18,376	0.065	377.3

Source: Study Team

Table 3.5-23 Forecasted volume of fuel import

(1000 tons)

	2008	2020	2030
Northern MZ	90	190	360
Malawi	290	490	760
Zambia	570	940	1,370

Source: Study Team

Table 3.5-24 Required volume for modification of macro forecast reflecting introduction of biofuels

(1000 tons)

	2020	2030
Northern MZ	-20	-60
Malawi	-50	-130
Zambia	-80	-240

Source: Study Team

7) Imported clinker

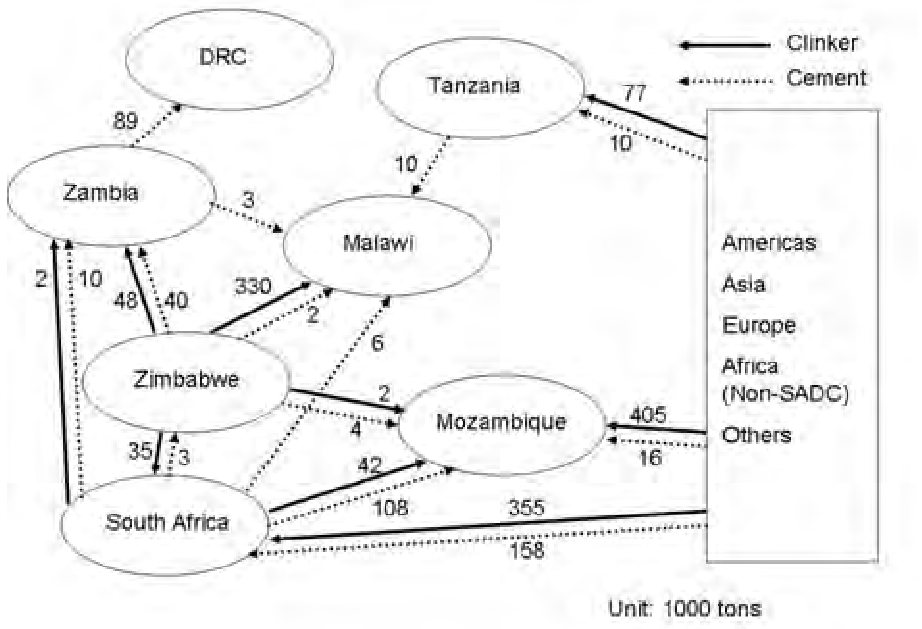
Table 3.5-25 shows Production of cement in Southern Africa from 2004 to 2008. Figure 3.5-14 shows the net trade flow of cement and clinker in Southern Africa based on SADC trade database. Assumptions of the calculation are the same as that of fuel flow. The figure illustrates both cement flows and clinker flows. Zimbabwe had been playing an important role in providing clinker to the region, especially to Malawi, however this flow has ceased due to disorder of the country, and Malawi have diverted import source of clinkers to Zambia and even Far East via Mozambican ports.

Table 3.5-25 Production of cement in Southern Africa

(1000 tons)

	2004	2005	2006	2007	2008
Mozambique	550	490	600	800	730
Malawi	120	166	187	185	240
Zambia	390	435	650	650	NA
South Africa	10,297	11,464	12,657	13,650	13,323
Tanzania	1,281	1,366	1,370	1,630	1,756

Source: USGS



Source: Study Team

Figure 3.5-14 Net trade flow of cement and clinker in Southern Africa (average of 2005 and 2006)

Mozambique

Mozambique has been struggling to meet cement demands as infrastructure construction is booming. The country is battling to restore more of its infrastructure which was lost to the combined effects of a long civil war and a series of natural disasters. In addition, the Government is increasing infrastructure investment in order to sustain the economic growth achieved in the last decade.

Production by domestic plants was insufficient to meet demand; the Government suspended the tariff on cement imports for a period of 2 years in December 2008. Cement shortages were particularly severe in the northern provinces of Mozambique; prices were more than twice as high in Niassa as in Maputo.

Mozambique’s largest cement production company, Cimentos de Mocambique Sarl, will double its output capacity to one million tons by 2011 up from the current production of 500,000 tons. The expansion project includes its branch in Nacala, which has an annual output capacity of 120,000 tons at present. The company believes that with the completion of the works, it will be able to meet the needs of cement in Mozambique until at least 2015.

The cement consumption in Mozambique is expected to reach one million five hundred thousand tons in 2014 from nine hundred tons in 2008 owing to a wide range of construction projects planned by the Government and private sector. The annual growth rate during this period is 8.9%, or a

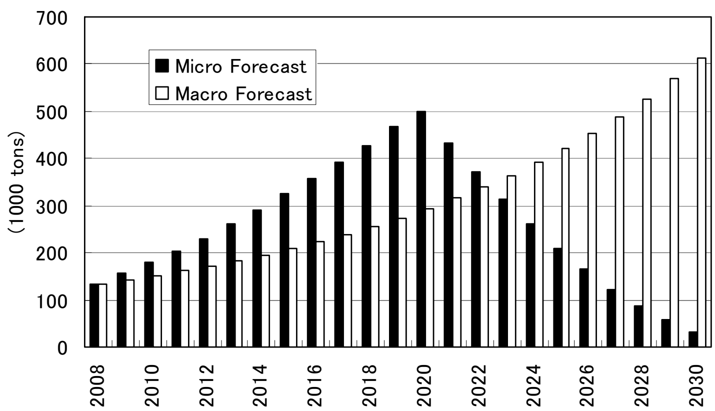
GDP elasticity of 1.2.

Mozambique produces around 1.5 million tons of limestone, however little of it is utilized for cement production probably due to insufficient supply of coal. Virtually all cement is produced from imported clinker mainly from Asian countries. This will continue for several years, and the import volume will increase in proportion to the rise of the cement demands for a short run. But the situation of coal supply will change. Mozambique has a huge amount of coal reserves, and it is expected that Mozambican cement producers will start production of cement from locally available limestone and coal instead of imported clinker. Vale Mozambique plans to export more than ten million tons of coal via Nacala from 2015 at the earliest, and Cinac, a cement producer operating in Nacala, explained to the Study Team that they had a plan to produce clinker from limestone in Nakharenghe located to the North of the Port.

Therefore, the Study Team developed the scenario as described below.

- Cement consumption grows with a GDP elasticity of 1.2 until 2015, and with the elasticity of 1.0 thereafter.
- Production of clinker starts in Nacala in 2020, and a self-sufficiency rate of clinker increases up to 97%, in the target year of 2030, which is equivalent to the current rate in South Africa.
- At present around 50,000 tons of cement is imported in Nacala. This is going to be substituted by local products ether made from limestone or imported clinker, and the cement import ceases in 2020. One ton of cement import is substituted by 0.965 tons of clinker production.

The result of the micro forecast of clinker import to Northern Mozambique based on the above mentioned scenario is depicted in Figure 3.5-15 compared with the result of macro forecast. In the macro forecast, the increase rate of clinker import is assumed to be equal to that of the total import cargo. The clinker import is forecasted to increase rapidly up to around 500,000 tons in 2020, thereafter to decline being substituted by domestic products.



Source: Study Team

Figure 3.5-15 Result of forecast of clinker import to Northern Mozambique

Malawi

Malawi produces cement mainly from imported clinker. The major source of import had been Zimbabwe, but the import has been diverted to other sources including Far East via Mozambican ports. At present around 50,000 tons of clinker is imported via Mozambique. However, this seaborne trade of clinker is going to cease due to stabilization of the Zimbabwean economy in several years.

In 2008, Portland Cement Company Ltd. (a subsidiary of LaFarge S.A. of France) was engaged in a drilling program at the Chenkumbi Hills limestone deposits in the Machinga District. Depending on favorable results, LaFarge could open a new limestone quarry at Chenkumbi Hills in 2011.

Domestic cement prices could decline by between 15% and 20% because of the use of lower cost local raw materials. By the local production of clinker, imported clinker would lose its competitiveness in the market.

Therefore, the Study Team estimates that seaborne cargo volume of clinker to Malawi in 2020 and 2030 is zero.

Zambia

Zambia produces cement using mainly local materials. At present, seaborne trade of clinker to Zambia is virtually zero, and there is no possibility that it will increase in the future. Accordingly, the Study Team estimates that seaborne cargo volume of clinker to Zambia in 2020 and 2030 is zero.

The result of forecast of imported clinker is shown in Table 3.5-26. The result of macro forecast shall be modified by the cargo volumes listed in Table 3.5-27 to reflect the change in the market structure of clinker. The volume includes the contribution from decreased import bulk cement.

Table 3.5-26 Forecasted volume of clinker import

(1000 tons)

	2008	2020	2030
Northern Mz	130	500	30
Malawi	50	0	0
Zambia	0	0	0

Source: Study Team

Table 3.5-27 Required volume for modification of macro forecast on clinker import

(1000 tons)

	2020	2030
Northern Mz	90	-810
Malawi	-130	-230
Zambia	0	0

Source: Study Team

8) Imported wheat

Since large bulk carriers have economic advantages in transport of wheat, this is a strategically important cargo for the deep-sea port of Nacala. Accordingly, the wheat cargo demands are forecasted for the larger hinterland including Tanzania.

Table 3.5-28 shows the balance of demand and supply of wheat in the hinterland of the Port. The data include processed products (flour etc.). In Mozambique the consumption (domestic supply) has been increasing rapidly in recent years, and almost all of it is imported. The consumption volume per capita in Mozambique is the largest among the four countries listed in the table. Malawi also imports the major part of its consumption, though the self sufficiency rate is higher than Mozambique. Its consumption volume per capita is the least among the four countries. Zambia produces a considerable amount of wheat, which can cover more than half of domestic consumption. Though the self sufficiency rate in Tanzania is much better than Mozambique and Malawi, it imports the largest volume among the four, since it has the largest population.

Increasing self-sufficiency in wheat production is an important issue to be coped with in the region. For example, in 2008 the Mozambican Government approved the Plan of Action for Food Production (PAPA) to offset the world food crisis that was affecting the country. The main objective of PAPA is to reduce imports of rice, wheat and potatoes through technical assistance. The country's yield of wheat doubled in a recent two-year period.

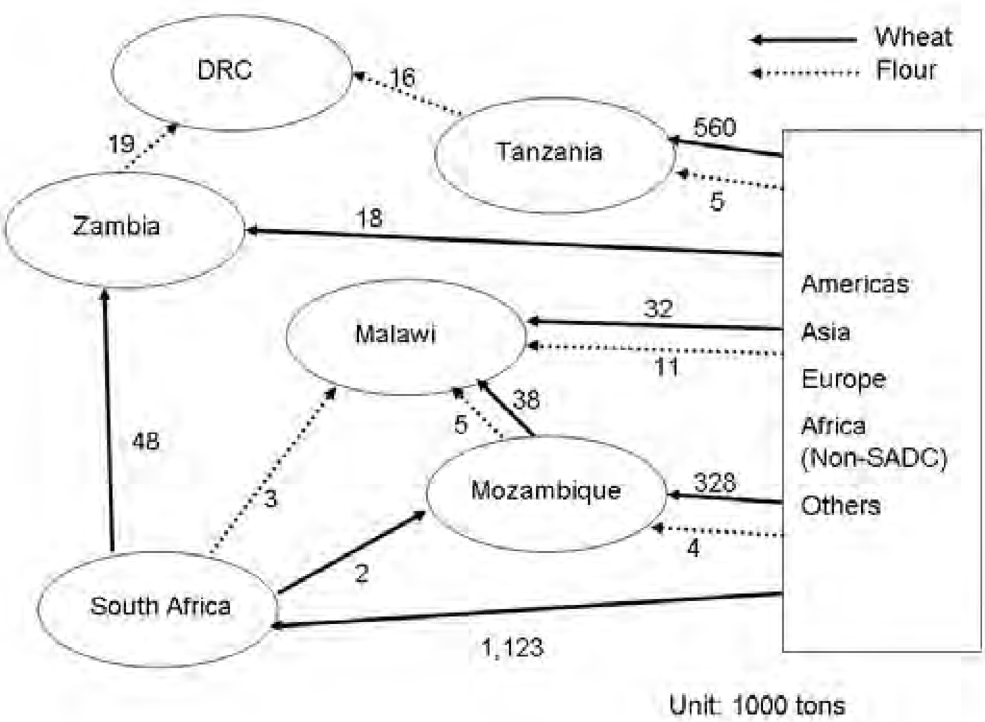
Figure 3.5-16 shows the net trade flow of wheat in Southern Africa. The figure indicates that the amount of flour flow is much smaller than that of wheat flow, and that a very small amount of wheat is traded among SADC countries. The import flow of wheat from Mozambique to Malawi must be a transit cargo flow.

Table 3.5-28 Demand and supply of wheat in the hinterland of the Port

(tons)

	2002	2003	2004	2005	2006	2007
Mozambique						
Production	2,000	2,000	2,100	2,100	2,000	2,500
Import Quantity	247,373	373,296	508,569	479,962	620,030	358,690
Stock Variation	0	-50,000	-100,000	-10,000	-100,000	200,000
Export Quantity	141	145	1,880	616	1,473	1,429
Domestic supply quantity	249,232	325,150	408,789	471,446	520,557	559,760
Malawi						
Production	1,520	1,502	1,668	1,730	1,999	4,605
Import Quantity	135,481	45,743	33,453	40,506	91,357	98,122
Stock Variation	-63,234	30,000	45,666	39,333	-2,667	2,667
Export Quantity	263	93	2,693	217	1,961	14,387
Domestic supply quantity	73,504	77,152	78,094	81,352	88,728	91,006
Zambia						
Production	75,000	135,000	82,858	136,833	93,958	115,843
Import Quantity	73,670	86,321	98,795	113,910	86,875	106,698
Stock Variation	313	-38,125	40,000	0	0	0
Export Quantity	3,122	5,887	8,908	19,774	28,236	25,039
Domestic supply quantity	145,860	177,310	212,745	230,969	152,598	197,502
Tanzania						
Production	77,000	74,000	67,000	102,000	110,000	82,800
Import Quantity	400,452	498,748	623,323	486,406	656,647	822,300
Stock Variation	-261	533	11	-31	-105,000	31
Export Quantity	27,709	168,686	196,779	12,909	53,589	208,853
Domestic supply quantity	449,482	404,595	493,554	575,465	608,058	696,278

Source: FAO



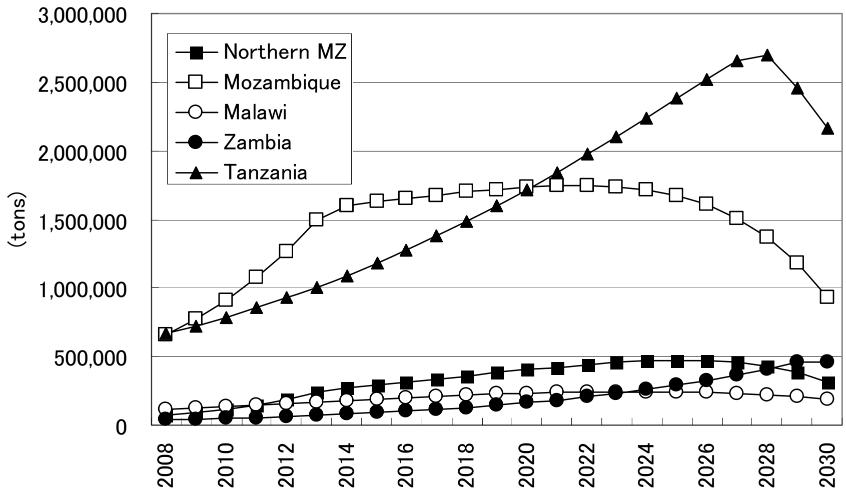
Source: Study Team

Figure 3.5-16 Net trade flow of wheat in Southern Africa (average of 2005 and 2006)

Considering the trend of wheat consumption and trade, the Study Team developed a scenario of future trade flow of wheat as described below.

- Wheat consumption increases at the historical increase rate of each country until the annual consumption per capita reaches 63 kilograms, which is the current consumption per capita in South Africa, thereafter the consumption increases in proportion with the population growth of each country.
- The self-sufficiency rate of wheat in each country is going to increase until it reaches the level of current self-sufficiency rate of Zambia (which is the second highest in Southern Africa after South Africa) in the target year of 2030.
- Northern Mozambique, which has 34% of the total population of the country, consumes only 11% of total consumption of wheat in the country at present. Its share of wheat consumption is going to be increasing up to an equivalent percentage to the population share of the region toward the target year.
- Malawi imports flour as well as wheat at present (the ratio of import volume of wheat to flour is around 7:2). But, the flour import is going to be substituted by wheat import due to the increasing capacity of domestic mills, and flour imports will ceases in 2020. (One ton of flour import is substituted by 1.25 tons of wheat import.)
- At present around 70% of imported wheat to Zambia comes from South Africa, and the rest is seaborne cargoes. With the increase of capacity of Mozambican and Namibian ports, the ratio of seaborne cargoes is going to double in the target year.

The result of the micro forecast based on the above mentioned scenario is shown in Figure 3.5-17. The import volume increases rapidly with the increase of consumption, and then the increase decelerates by stabilization of consumption growth and increasing self-sufficiency rate. The import volume begins to decrease in the long run. The forecasted import volumes in the target years are given in Table 3.5-29. Table 3.5-30 shows required volume for modification of macro forecast. Since various factors are considered in the macro forecast, it is very difficult to assess impacts of individual factors on historical data. Accordingly, the Study Team calculated the volume of modification assuming that the historical growth rate of wheat import was equal to the average growth rate of all commodities.



Source: Study Team

Figure 3.5-17 Forecasted import volume (seaborne only) of wheat

Table 3.5-29 Forecasted volume of wheat import

(1000 tons)

	2008	2020	2030
Northern MZ	70	400	310
Mozambique	660	1,730	930
Malawi	120	230	180
Zambia	37	160	460
Tanzania	670	1,720	2,160

Source: Study Team

Table 3.5-30 Required volume for modification of macro forecast on wheat import

(1000 tons)

		2020	2030
Bulk	Northern MZ	250	0
	Malawi	-76	-370
	Zambia	35	230
Container	Malawi	-91	-160

Source: Study Team

9) Imported vehicles

Maputo handles around 20,000 metric tons of vehicles annually, and is the only Mozambican port which Pure Car Carrier (PCC) serves. All imported vehicles unloaded in Nacala Port are containerized at present, however this is not an economical way of transport when the handling volume increases. Import of vehicles to Northern Mozambique is expected to keep increasing in line with economic growth, and vehicle transport mode via Nacala will be diverted from container to PCC. Description below is the Study Team's assessment on diversion of transport mode for vehicles.

Table 3.5-31 shows the import volume of vehicles in the hinterland (average of 2005 and 2006) provided by SADC trade database. Since only monetary data is available for Mozambique and Malawi, the data were converted into metric tons by using the unit price in Zambia.

Table 3.5-31 Import volume of vehicles in the hinterland (average of 2005 and 2006)

(tons)

Mozambique	South Africa	71,577
	Other African Countries	4,185
	Others	43,798
Malawi	South Africa	45,081
	Other African Countries	2,247
	Others	19,210
Zambia	South Africa	82,665
	Other African Countries	2,966
	Others	33,700

Source: Study Team

Table 3.5-32 Numbers of vehicles registered in each Mozambican province in 2008

	Cars	Heavy Vehicles	TOTAL	Share
Niassa	141	73	214	5.71%
C. Delgado	140	72	212	
Nampula	790	281	1,071	
Zambézia	115	16	131	7.49%
Tete	185	63	248	
Manica	318	176	494	
Sofala	786	307	1,093	
Inhambane	656	44	700	86.80%
Gaza	70	9	79	
Maputo Prov.	10,009	3,370	13,379	
Maputo Cid.	6,775	1,838	8,613	
Total	19,985	6,249	26,234	

Source: MTC

As information on breakdown by commodities for containerized cargoes in Southern Africa are not available, the Study Team estimated seaborne import volume of vehicles based on following assumptions:

- Imported volume of each country increases from 2005 to 2008 with the average growth rate of import to each country in 2008 for macro forecast.
- All imported vehicles to Northern Mozambique are transported as seaborne cargoes. Import share of Northern Mozambique is the same as its share of car registration as shown in Table 3.5-32.
- Vehicles imported from South Africa to Malawi or Zambia are not seaborne cargoes, whereas vehicles from other origins are transported by sea.

The Study Team forecasted imported volume of vehicles based on the scenario described below:

- Vehicle import increases with the growth rates of total import volume of each country in the macro forecast over the planning horizon.
- The import share of Northern Mozambique is going to be increasing from current 5.71% up to 34%, which is equivalent to the current population share of the region, toward the target year of 2030.
- Seaborne transport share for Malawian import from South Africa is going to be increasing due to the increase of port capacity in Nacala, Beira and Dar es Salaam. All imported vehicles to Malawi are going to be transported by sea in the target year.
- Zambian import from South Africa continues to be transported by land even in the target year.

Based on the scenarios above, the estimated import volumes in 2008 and the forecasted import volumes in the target years are obtained as shown in Table 3.5-33.

Table 3.5-34 shows required volume for modification of macro forecast. Since trends of increase of seaborne vehicle trade must be reflected basically in the historical time series of imported cargoes, it is not necessary to modify total cargo volume. However, alteration from container to break bulk is required for Northern Mozambique because the handling volume of vehicles in Nacala will exceed current handling volume in Maputo in 2020, and vehicles are expected to be transported by PCCs. For Zambian and Malawian seaborne import, at present vehicles are supposed to be transported mainly via Durban or Dar es Salaam where PCCs call. Accordingly, modification is not necessary for them.

Table 3.5-33 Forecasted volume of vehicle import (seaborne only)

(1000 tons)

	2008	2020	2030
Northern MZ	11	61	180
Malawi	31	150	380
Zambia	45	140	250

Source: Study Team

Table 3.5-34 Required volume for modification of macro forecast on vehicle import

(1000 tons)

		2020	2030
Northern MZ	Container	-61	-180
	Bulk	61	180

Source: Study Team

10) Imported fertilizer

Fertilizer is one of the major bulk cargoes handled in the Port. At present almost all of it is transit cargo to Malawi, and little fertilizer is delivered to Northern Mozambique through Nacala Port. In the forecast of future handling volume of fertilizer in the Port, the following two factors should be considered:

i) Increase of consumption of fertilizer in Northern Mozambique

As previously mentioned, agricultural development in Northern Mozambique is one of the highest priorities in the country. It is expected that agricultural production in Northern Mozambique is going to increase rapidly. With the increase of agricultural production, it is obvious that fertilizer consumption and its import are going to increase. As shown in Table 3.5-35, fertilizer consumption in Mozambique is less than that in neighboring countries at present. Regarding Northern Mozambique, although there are no statistics, it can be assessed that the consumption would be less by far considering the current import volume of fertilizer in Nacala Port. Accordingly the import volume of fertilizer in Northern Mozambique is expected to increase at higher rate than the increase rate of agricultural production in the course of the productivity improvement of agriculture in the region.

ii) Commencement of production of fertilizer in the large plant in southern Tanzania (Mtwara) and Phosphate production in Nampula Province and Malawi

Tanzania plans to install a large fertilizer plant in Mtwara in the south of the country. The production of fertilizer, which requires only natural gas as a raw material, is a very suitable industry for the isolated region of Mtwara with rich hydro-carbon resources. At present Eastern Africa, which doesn’t have fertilizer plants, imports fertilizer mainly from the Middle East bearing high transportation cost. This results in high fertilizer cost and a relatively low manuring volume. By the completion of the new fertilizer plant in Mtwara, it is expected that East African countries including Mozambique, Malawi and Zambia, will divert their import origin of fertilizer from the Middle East to Tanzania. Malawi will import fertilizer via Mtwara Corridor, and transit through Nacala Port is going to cease in the long run. Some amount of fertilizer would be transported to Nampula Province from Mtwara via Nacala Port. But the Port would serve only for littoral districts. Inland region of Nampula Province as well as other Northern Provinces would import fertilizer directly from Mtwara via the Friendship Bridge. On the other hand, the planned development of phosphate rock resource in Phalombe District in Malawi is expected to lower the local price of fertilizers by at least 33%. Large scale production of phosphate is also planned in Nampula Province by Vale Mozambique.

Thus the above two factors will impinge on the throughput of fertilizer in the Port quite contrarily, though they possess uncertainties. In such a situation, the pragmatic and acceptable way of assessment on the impacts is to assume that the two factors counteract each other and cancel out.

Therefore, the Study Team assumed that the future handling volume of fertilizer would be the same as the result of the macro forecast, and that the modification of the macro forecast would not be necessary.

Table 3.5-35 Fertilizer consumption in Mozambique and neighbor countries

	Fertilizer consumption (100 grams per hectare of arable land)
Mozambique	49.5
Malawi	182.9
Zambia	138.5
Tanzania	68.1
South Africa	475.6

Source: WB

(4) Forecasted volume of generated cargoes by types and by origin/destination

The results of forecast of cargo generation in the hinterland obtained from above mentioned macro and micro approach are summarized in Table 3.5-36. Since “others” in Mozambican bulk import became negative value due to accumulation of estimation errors in the course of modification by the micro forecast, the total Mozambican bulk import was adjusted so that “others” would increase with the average import growth rate.

Table 3.5-36 Forecasted volume of cargo generation in the hinterland

(MT)

			2008	2020	2030
Northern Mozambique	Export	Containers	152,000	726,600	1,890,700
		Bulk	28,000	10,230,000	20,723,000
		Mineral products	0	10,000,000	20,000,000
		Wood chip	0	96,000	384,000
		Others	28,000	134,000	339,000
		Total	180,000	10,956,600	22,613,700
	Import	Containers	124,000	307,600	821,700
		Bulk	311,000	1,197,000	976,000
		Fuel	90,000	190,000	360,000
		Clinker	130,000	500,000	30,000
		Wheat	70,000	400,000	310,000
		Vehicle	0	61,000	180,000
		Others	21,000	46,000	96,000
		Total	435,000	1,504,600	1,797,700
	Total	Containers	276,000	1,034,200	2,712,400
		Bulk	339,000	11,427,000	21,699,000
		Total	615,000	12,461,200	24,411,400
Other Provinces in Mozambique	Export	Coal		20,000,000	40,000,000
	Import	Wheat		1,730,000	928,000
Malawi	Export	Containers	192,000	364,000	606,000
		Bulk	68,200	129,000	215,000
		Total	260,200	493,000	821,000
	Import	Containers	328,000	760,000	1,410,000
		Bulk	694,000	1,544,000	2,590,000
		Fuel	290,000	490,000	760,000
		Clinker	50,000	0	0
		Wheat	120,000	230,000	180,000
		Vehicle	31,000	150,000	380,000
		Others	203,000	674,000	1,270,000
	Total	Containers	520,000	1,124,000	2,016,000
		Bulk	762,200	1,673,000	2,805,000
		Total	1,282,200	2,797,000	4,821,000
Zambia	Export	Containers	246,000	680,000	1,140,000
		Bulk	579,000	1,600,000	2,690,000
		Total	825,000	2,280,000	3,830,000
	Import	Containers	529,000	1,670,000	2,980,000
		Bulk	772,000	2,395,000	4,330,000
		Fuel	570,000	940,000	1,370,000
		Wheat	37,000	160,000	460,000
		Vehicle	45,000	140,000	250,000
		Others	120,000	1,155,000	2,250,000
	Total	Containers	775,000	2,350,000	4,120,000
		Bulk	1,351,000	3,995,000	7,020,000
		Total	2,126,000	6,345,000	11,140,000
Tanzania	Import	Wheat		1,720,000	2,160,000

Source: Study Team

3.5.2 Container traffic

In this section, future container handling share of the Port is estimated by developing scenarios for operational improvement and applying a mathematical model to estimate the future demarcation among the ports, and then, the container handling volume in the target years is forecasted.

(1) International container cargoes to/from domestic hinterland

All international cargoes generated in the Northern Provinces, except some containerized timbers exported from Cabo Delgado, have been handled in Nacala Port. Notwithstanding the improvement of Pemba Corridor, the Study Team assesses that the demarcation of Nacala and Pemba in the container market of the Northern Provinces will basically remain unchanged within the planning horizon due to the limited capacity of Pemba Port.

Since the container handling volume of Pemba Port is not included in the cargo generation volume in the Northern Provinces obtained by the macro forecast, the Port's handling volume of international containers to/from the domestic hinterland can be considered to be the same as the cargo generation volume in Northern Mozambique as listed in Table 3.5-36 when future demarcation between Nacala and Pemba remains unchanged.

(2) Transit containers

1) Methodology

Transit container cargo market is highly competitive. Efficiency of ports and corridors as well as the maritime network is a decisive factor in the demarcation of ports. Therefore the Study Team assessed future demarcation in the transit cargo market in Malawi and Zambia by using a mathematical model developed by OCDI, which takes all of the three factors into consideration. The description below is an outline of the model:

The OCDI Model is based on the Model for International Container Cargo Simulation (MICCS) developed by a researchers' group from various institutions including the University of Tokyo and National Institute for Land and Infrastructure Management (NILIM), Ministry of Land, Infrastructure and Transport. The input of MICCS is origin and destination (OD) data of containerized cargo and the output is the demarcation to the transportation routes. MICCS simulates the decision of carriers and shippers, both sides reiterate decision making for optimal cargo and ship allocation, and outputs solution when decision making reaches an equilibrium point. MICCS can simulate impacts of economic and trade/transport policies on global maritime/port network as well as local networks.

The OCDI Model is a simplified and handy model for simulation of impacts of transport policies on local maritime/port networks. The model can be employed with very limited quantity of data and information.

For the shipper side, the model allocates cargo to each route according to an aggregate logit model. Selection probability p_k^{rs} for route k of OD pair (r, s) is shown as the formula below:

$$p_k^{rs} = \frac{\exp(-\theta^{rs} \times C_k^{rs})}{\sum_i \exp(-\theta^{rs} \times C_i^{rs})} \qquad (1)$$

where

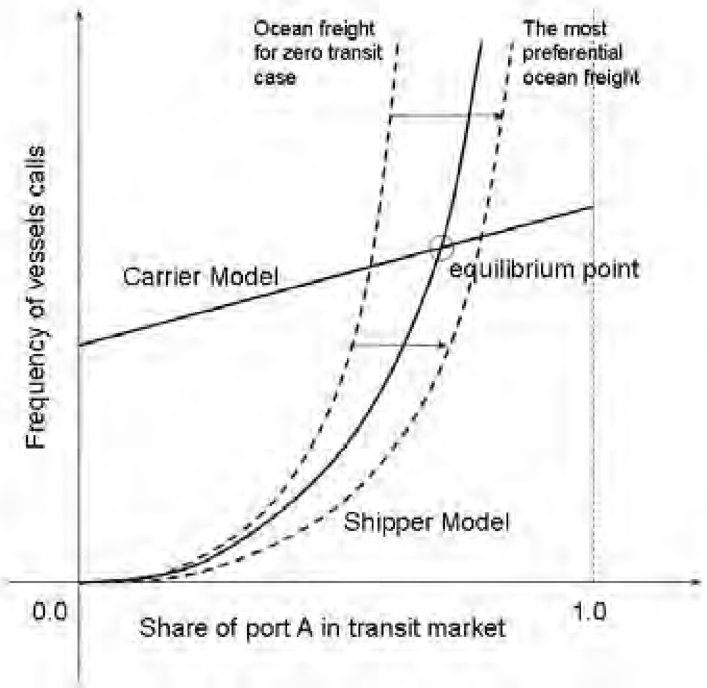
$$C_k^{rs} = c_k^{rs} + V^{rs} \times t_k^{rs} \qquad (2)$$

c_k^{rs} : transportation cost from r to s via route k
t_k^{rs} : required time for transportation from r to s via route k

C_i^{rs} is generalized cost for route i of r-s transportation. Generalized cost includes time cost corresponding to transportation time as shown in the equation (2). The parameter θ^{rs} and time value V^{rs} can be obtained from actual share of route selection, transport cost and time for transportation.

Once the parameters are set, demarcation of route can be forecasted from transportation cost and required time for transportation of each route in the future. Since the cost and the required time are influenced by a service level of maritime network, normally the demarcation is calculated based on an assumption of the future maritime network. However, it should be noted that assuming the maritime network as an exogenous variable can cause serious error in the forecast, because this is one of the most important and decisive factors for port demarcation and should be obtained as an endogenous variable. The importance of the maritime network is clear when observing the high competitiveness of Durban Port in the transit market for Malawian or Zambian cargoes, which requires very long and costly land transport.

The OCDI Model includes Carrier Model which generates liner service frequency as an endogenous variable when cargo handling volume in a port is given. An equilibrium point can be found out from simultaneous equations of Carrier Model and Shipper Model (equation (1)) as illustrated in Figure 3.5-18. With the Shipper Model, share of a port increases exponentially when the frequency of vessel calls increases at the port, and the share converges on a certain point which corresponds to zero ship waiting time. Meanwhile, with the Carrier Model, the frequency of vessel calls shall increase in proportion to the cargo share.



Source: OCDI

Figure 3.5-18   Conceptual illustration of OCDI Model

As stated in the Section 3.4.1, substantial volume of cargoes is currently connected with main line vessels at Durban at high cost for feeder freight. The shipping lines are looking at the chance to place their vessels directly to Nacala comparing their cost for direct callings and the revenue which can be obtained from those direct callings. Once the cargo volume at Nacala increases to a certain level in which shipping lines can offset their extra cost, they will be eager to call Nacala.

The development of Nacala Port will reinforce that tendency because once the operational efficiency is improved at the Port, it will attract more exporters who desire to encash the price of goods quickly, and importers also who want to receive the goods in shorter time. The improvement of operational efficiency will also benefit the shipping lines who desire to minimize the vessels' stay at the Port.

The possible direct callings at Nacala will be envisaged by the shipping lines mainly for the trade lanes of East Asia, Southeast Asia, South Asia and Middle East, taking Nacala's geographical position into consideration. As far as the cargo volume at Nacala is not enough to fill up the full capacity of the vessels, Nacala may remain combined with the other ports in those trade lanes.

Based on the above, a simulation is conducted on the correlation between cargo volume and frequency of vessel calls, which is in line with the logic employed by shipping lines when determining extra callings.

When shipping lines consider placing a vessel at a port as an extra calling, they usually compare the cost and revenue relevant to the extra calling. If the amount of revenue per calling exceeds the same of costs, the shipping lines will decide to place the vessel to that port. The cost to be considered will be "port charges" payable to the port of extra calling, and "deviation cost" for detouring a vessel away from the original navigation route. The revenue is namely the ocean freight for export cargoes which is expected to be gained at the port of extra calling.

2) Setting of parameters for Carrier Model

Assuming that an extra calling is envisaged at Nacala, following simulation will be made by the shipping line:

a) Costs

Port charges

Average size of the vessels is assumed as follows, as per the average vessel size currently calling at Durban:

Capacity	: 2,824TEUs
DWT	: 41,474
GT	: 35,054

When the existing port tariff is applied to the above, total amount of port dues per call at Nacala is calculated as : US$ 14,585 --- ①

Deviation cost

Deviation cost may be varied subject to the intention of the shipping line, by which trade lane to cover Nacala. Most probable trade lanes to be considered will be East Asia connecting Far East/Southeast Asia with Southern Africa via Singapore. Another possible trade lane will be Middle East/South Asia connecting India/Middle East with East Africa in a triangle-shaped route.

(East Asia)

The distances for navigation based on the great circle routing are as follows:

Durban → Singapore	4,893 nautical miles ----------------------	②
Durban → Nacala	1,119	
Nacala → Singapore	4,101	
Total	5,220 nautical miles ----------------------	③

Deviation is given as ③－② ＝ 327 nautical miles

When the vessel sails at the speed of 19 knots/hour, the time for deviation is given as:

327 nautical miles ÷ 19knots/hr ÷ 24hrs	＝	0.717 days
Fuel cost: 70t × 0.717 × US$ 470	＝	US$ 23,589
Charterage: US$ 20,000 × 0.717	＝	US$ 14,340
Total		US$ 37,929 ------ ④

(Middle East / South Asia)

Dar es Salaam → Nhava Sheva	2,500	nautical miles -------	⑤
Dar es Salaam → Nacala	511		
Nacala → Nhava Sheva	2,765		
Total	3,276	nautical miles -------	⑥

Deviation is given as ⑥－⑤ ＝ 776 nautical miles

When the vessel sails at 18 knots/hour, the time for deviation is given as:

776 nautical miles÷ 19knots/hr ÷ 24hrs ＝ 1.702 days
Fuel cost: 70t × 1.702 × USD 470 ＝ US$ 55,996
Charterage: USD 20,000 × 1.702 ＝ US$ 34,040
Total US$ 90,036 ------ ⑦

Total cost for the additional calling is given as:

East Asia: ①＋④ ＝ US$ 52,514
Middle East / South Asia: ①＋⑦ ＝ US$ 104,621

To simplify the calculations henceforth, the weighted average of 2 different figures above is applied, taking current trade cargo volume by area into account. USD 85,215 is given as the weighted average of extra cost for additional calling as below:

Area	East Asia	Southeast Asia	South Asia	Middle East
Trade volume portion	27%	10%	14%	49%
Extra costs	US$52,514	US$52,514	US$104,621	US$104,621
Weighted average exra costs	US$85,215 ---- ⑧			

b) Revenue

Ocean freight rate

Currently the prevailing ocean freight rates for Asian ports by area are as follows:

East Asia (Shanghai) : US$ 1,300/20'
Southeast Asia (Jakarta) : US$ 1,200/20'
South Asia (Nhava Sheva) : US$ 1,050/20'
Middle East (Jebel Ali) : US$ 1,000/20'

The weighted average of freight rate is given as follows:

Destination	Shanghai	Jakarta	Nhava Sheva	Jebel Ali
Trade volume portion	27%	10%	14%	49%
Export freight rate	US$1,300	US$1,200	US$1,050	US$1,000
Weighted average of freight rate	US$1,108			

It should be noted that, when shipping lines intend to acquire containerized export cargoes, they need to bring the empty containers in advance. The shipping lines need to bare the costs for empty containers in terms of loading/discharge at Nacala and the capital cost for the days during those empties are kept by the shippers/consignees. The amount of those costs is given as US$377/TEU.

The shipping line's overall administration cost also needs to be considered. The amount usually considered is approximately US$300/TEU.

After deducting all those costs, NET freight rate per TEU is given as:

US$1,108 - US$377 - US$300 ＝ US$431 ------------------ ⑨

c) Marginal TEU required for an extra calling

Marginal export cargo volume in TEU is given by dividing the total amount of extra costs with the NET freight rate per TEU.

⑧ / ⑨＝US$ 85,215÷US$ 431/TEU＝199.7 TEUs ------ ⑩

When the marginal TEU is considered for the total of export and import, the above figure needs to be doubled, as the shipping line desires to keep balance between exports and imports at a port.

⑩×2＝395.4TEUs.

Namely, when 395.4TEUs of additional laden containers in total of export and import are expected by a shipping line, they will decide to make one extra call to Nacala. The correlation between the cargo volume in TEU and the number of vessel callings is formulated with a simple equation below, which we name as the Carrier Model:

$$Y = X / 395.4$$

Where, Y: Number of vessel callings,
X: Total TEUs of laden export and import

To check the reproducibility of the formula above, we now try to obtain the number of vessel callings by applying the formula to the actual throughput figure for the year 2008 shown below. When 29,615TEUs of Import/Export Sub total is divided by 395.4TEUs/vessel, 75 is given, while actual vessel calling for the year 2008 was 78. As the result of 75 is based on the bigger vessel size assumed as 2,824TEUs and actual figure of 78 was based on the average vessel size of 1,100TEU to 1,700TEUs, the aforementioned formula is considered almost adaptable.

2008 actuals (CFM statistics)		Throughput			Vessels callings
		Laden	Empty	Total	
International	Import	15,076	6,928	22,004	78
	Export	14,540	6,561	21,101	
	Sub total	29,616	13,489	43,105	
	Tranship	1,851	1,028	2,879	

3) Setting of parameters for Shipper Model

As indicated in 1), the Shipper Model is indicated by the formula of cost and time for the transportation on the routes between Malawi/Zambia and the various gate ports. 5 ports of Nacala, Beira, Durban, Dar es Salaam and Walvis Bay are considered as the gate ports of those countries.

The current cost and time for the transportation is assumed on each route to 5 ports and for the traffic of export and import respectively. Table 3.5-37 shows the details of cost and time by route and traffic.

Following is the notable points on the component items of cost and time.

- Cost
  - The amount of “Inland transportation” for Nacala and Dar es Salaam represents the weighted average of rail and road charges.
  - “Inland transportation” for empty containers is lower at Durban, Dar es Salaam and Walvis Bay because stuffing facilities are well developed at those ports; empty containers need not be carried to inland area.
  - “Ocean freight” represents the rates for 20’ to/from Shanghai, as those rates are frequently offered in the market by most of the shipping lines.
- Time
  - “Waiting for vessels” represents the average interval of international vessels’ callings; given as 365days÷yearly callings÷2. Cabotage vessels’ callings are excluded.
  - The figures of “Customs clearance” are referred to WB’s “Logistics Performance Index”, being effective for import only.
  - Transit time of ocean carriage is not considered in this model, as it is not a decisive factor for exporters/importers in Malawi/Zambia, while the amount of ocean freight rates is more crucial to them, taking the value and characteristic of their cargoes into consideration.

Table 3.5-37 Assumption of cost and time for export from Malawi

			Nacala	Beira	Durban	Dar es Salaam	Walvis Bay
Cost (USD /TEU)	Inland transportation	Full	1,259	2,670	4,996	4,475	8,320
		Empty	630	1,335	300	300	300
	Stevedorage	Loading	220	250	148	320	509
	Ocean freight	Shanghai	1,300	1,300	640	520	800
	Cost total		3,409	5,555	6,084	5,615	9,929
Time (days)	Inland	Transportation	6.46	1.16	3.10	2.15	4.14
		Waiting for vessels	2.48	2.48	0.00	0.81	1.75
		Customs clearance	0.00	0.00	0.00	0.00	0.00
	Port	Anchorage	0.00	0.50	0.80	3.00	1.00
		Berth	2.83	1.71	1.30	1.83	1.00
	Time total		11.77	5.84	5.20	7.79	7.89

Source: Study Team

Table 3.5-38 Assumption of cost and time for import to Malawi

			Nacala	Beira	Durban	Dar es Salaam	Walvis Bay
Cost (USD /TEU)	Inland Transportation	Full	1,891	2,670	4,996	4,475	8,320
		Empty	861	1,335	300	300	300
	Stevedorage	Discharge	270	250	148	320	509
	Ocean freight	Shanghai	2,000	1,300	640	520	800
	Cost total		5,022	5,555	6,084	5,615	9,929
Time (days)	Inland	Transportation	6.46	1.16	3.10	3.15	4.14
		Waiting for vessels	2.48	2.48	0.00	0.81	1.75
		Customs clearance	2.00	2.00	0.50	1.64	0.50
	Port	Anchorage	0.00	0.00	0.00	0.00	0.00
		Berth	2.83	1.71	1.30	1.83	1.00
	Time total		13.77	7.34	4.90	7.43	7.39

Source: Study Team

Table 3.5-39 Assumption of cost and time for export from Zambia

			Nacala	Beira	Durban	Dar es Salaam	Walvis Bay
Cost (USD /TEU)	Inland Transportation	Full	4,075	2,990	5,120	3,272	5,320
		Empty	2,934	1,794	300	300	300
	Stevedorage	Loading	220	250	148	320	509
	Ocean freight	Shanghai	1,300	1,300	640	520	800
	Cost total		8,529	6,334	6,208	4,412	6,929
Time (days)	Inland	Transportation	2.82	1.24	2.89	2.00	3.21
		Waiting for vessels	2.48	2.48	0.00	0.81	1.75
		Customs clearance	0.00	0.00	0.00	0.00	0.00
	Port	Anchorage	0.00	0.50	0.80	3.00	1.00
		Berth	2.83	1.71	1.30	1.83	1.00
	Time total		8.12	5.92	4.99	7.64	6.96

Source: Study Team

Table 3.5-40 Assumption of cost and time for import to Zambia

			Nacala	Beira	Durban	Dar es Salaam	Walvis Bay
Cost (USD /TEU)	Inland Transportation	Full	4,075	2,990	6,400	3,909	6,650
		Empry	2,934	1,794	300	300	300
	Stevedorage	Discharge	270	295	298	400	509
	Ocean freight	Shanghai	2,000	2,000	1,057	2,000	1,390
	Cost total		9,279	7,079	8,055	6,609	8,849
Time (days)	Inland	Transportation	2.82	1.24	2.89	2.10	3.21
		Waiting for vessels	2.48	2.48	0.00	0.81	1.75
		Customs clearance	2.00	2.00	0.50	0.75	0.50
	Port	Anchorage	0.00	0.00	0.00	0.00	0.00
		Berth	2.83	1.71	1.30	1.83	1.00
	Time total		10.12	7.42	4.69	5.49	6.46

Source: Study Team

The parameters may vary by country and traffic i.e. export/import, because time value of the cargoes is different. A pair of optimal parameters shall give the most approximate and proportional figures for the shares of 5 ports, which will be considered as “reproducible” of the actual share figures for the year 2008.

“Time value” given as “(parameter for time)÷(parameter for cost)” reflects the reality of parameters settings. Time values indicated below are found to be within the acceptable range. Therefore, the parameters obtained here are considered to be applicable in the assessment of future demarcation of the ports.

Table 3.5-41 Calculation to find the parameter pairs

Malawi Export

		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Actual (2008)	Cargo volume (TEU)	3,244	8,500	4,701	208	0	16,652
	Share	19.5%	51.0%	28.2%	1.3%	0.0%	100.0%
Simulation	Share	16.7%	47.1%	29.0%	7.2%	0.0%	100.0%
Assumptions	Cost (USD)	3,409	5,555	6,084	5,615	9,929	
	Time (day)	11.77	5.84	5.20	7.79	7.89	

Parameters	for Cost (θ^{rs})	0.002
	for Time ($\theta^{rs} V^{rs}$)	0.899
Time value (V^{rs})	USD 450 /day	

Malawi Import

		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Actual (2008)	Cargo volume (TEU)	2,969	15,046	4,215	3,000	0	25,231
	Share	11.8%	59.6%	16.7%	11.9%	0.0%	100.0%
Simulation	Share	10.7%	58.3%	18.4%	12.6%	0.0%	100.0%
Assumptions	Cost (USD)	5,022	6,567	7,900	7,175	10,519	
	Time (day)	13.77	7.34	4.90	7.43	7.39	

Parameters	for Cost (θ^{rs})	0.0024
	for Time ($\theta^{rs} V^{rs}$)	0.84
Time value (V^{rs})	USD 350 / day	

Zambia Export

		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Actual (2008)	Cargo volume (TEU)	0	753	3,220	12,000	705	16,678
	Share	0.0%	4.5%	19.3%	72.0%	4.2%	100.0%
Simulation	Share	0.0%	7.3%	19.3%	72.3%	1.0%	100.0%
Assumptions	Costs (USD)	8,529	6,334	6,208	4,412	6,929	
	Time (day)	8.12	5.92	4.99	7.64	6.96	

Parameters	for Cost (θ^{rs})	0.0019
	for Time ($\theta^{rs} V^{rs}$)	0.79
Time Value (V^{rs})	USD 416 / day	

Zambia Import

		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Actual (2008)	Cargo volume (TEU)	0	6,411	10,702	20,989	4,083	42,185
	Share	0.0%	15.2%	25.4%	49.8%	9.7%	100.0%
Simulation	Share	1.2%	16.3%	24.5%	51.0%	6.9%	100.0%
Assumptions	Cost (USD)	9,279	7,079	8,055	6,609	8,849	
	Time (day)	10.12	7.42	4.69	5.39	6.46	

Parameters	for Cost (θ^{rs})	0.0007
	for Time ($\theta^{rs} V^{rs}$)	0.4
Time Value (V^{rs})	USD 571 /day	

Source: Study Team

4) Preliminary simulation

Before assessing the future demarcation in the transit market, the Study Team carried out a preliminary simulation to confirm the behavior of the model using the parameters obtained above.

In the preliminary simulation the following two operational improvement scenarios are assumed under the current cargo generation volume (These scenarios will be discussed in detail in "3.6.2 Target of productivity improvement":

- "Improved Productivity (Base Case)": Reduction of average berthing time from current 2.83 days to 0.74 days by increasing the number of reach stackers from one to four.
- "Highly Improved Productivity": Further reduction of average berthing time to 0.48 days by introduction of 3 quay gantry cranes.

Time for inland transportation for the Port is also considered to be reduced assuming that the road corridors connecting Malawi and Zambia were already developed.

Table 3.5-42 shows the required time and cost for transportation corresponding to each scenario. It should be noted that vessel waiting times for Improved Productivity and Highly Improved Productivity are determined endogenously in the model. The time for inland transportation by road is assumed to be improved in the cases of Improved Productivity and Highly Improved Productivity, based on the fact that the Nacala Corridor is paved in full length in those cases. The rail transportation for Malawi is assumed to be performed with a relatively improved time of 8 hours in all cases.

Table 3.5-42 Time and cost required for transportation in each productivity improvement case

Malawi Export

			Current Productivity	Improved Productivity (Base Case)	Highly Improved Productivity
Cost (USD /TEU)	Inland transportation	Full	1,259	1,259	1,259
		Empty	630	630	630
	Stevedorage	Loading	220	220	220
	Ocean freight	Shanghai	1,300	1,300	1,300
	Cost total		3,409	3,409	3,409
Time (days)	Inland	Transportation	6.46	6.32	6.32
		Waiting for vessels	To be given endogenously		
		Customs clearance	0.00	0.00	0.00
	Port	Anchorage	0.00	0.00	0.00
		Berth	2.83	0.74	0.46
	Time total		11.77	9.53	9.25

Malawi Import

			Current Productivity	Improved Productivity (Base Case)	Highly Improved Productivity
Cost (USD /TEU)	Inland Transportation	Full	1,891	1,891	1,891
		Empty	861	861	861
	Stevedorage	Discharge	270	270	270
	Ocean freight	Shanghai	2,000	2,000	2,000
	Cost total		5,022	5,022	5,022
Time (days)	Inland	Transportation	6.46	6.32	6.32
		Waiting for vessels	To be given endogenously		
		Customs clearance	2.00	2.00	2.00
	Port	Anchorage	0.00	0.00	0.00
		Berth	2.83	0.74	0.48
	Time total		13.77	11.53	11.27

Zambia Export

			Current Productivity	Improved Productivity (Base Case)	Highly Improved Productivity
Cost (USD /TEU)	Inland Transportation	Full	4,075	4,075	4,075
		Empty	2,934	2,934	2,934
	Stevedorage	Loading	220	220	220
	Ocean freight	Shanghai	1,300	1,300	1,300
	Cost total		8,529	8,529	8,529
Time (days)	Inland	Transportation	2.82	1.80	1.80
		Waiting for vessels	To be given endogenously		
		Customs clearance	0.00	0.00	0.00
	Port	Anchorage	0.00	0.00	0.00
		Berth	2.83	0.74	0.48
	Time total		8.12	5.01	4.75

Zambia Import

			Current Productivity	Improved Productivity (Base Case)	Highly Improved Productivity
Cost (USD /TEU)	Inland Transportation	Full	4,075	4,075	4,075
		Empry	2,934	2,934	2,934
	Stevedorage	Discharge	270	270	270
	Ocean freight	Shanghai	2,000	2,000	2,000
	Cost total		9,279	9,279	9,279
Time (days)	Inland	Transportation	2.82	1.80	1.80
		Waiting for vessels	To be given endogenously		
		Customs clearance	2.00	2.00	2.00
	Port	Anchorage	0.00	0.00	0.00
		Berth	2.83	0.74	0.48
	Time total		10.12	7.01	6.75

Source: Study Team

As stated in 3.5.2-(1), following equation is formulated as the Carrier Model:

Y = X / 395.4
Where, Y: Number of vessel callings,
X: Total TEUs of laden export and import

To find an equilibrium point between the Shipper Model and the Carrier Model, following cycle of calculations is done until the result of calculations becomes convergent:

The Shipper Model gives X → the Carrier Model gives Y and frequency Y/365/2
→ the Shipper Model gives X' → the Carrier Model gives Y' and frequency Y'/365/2
→ the Shipper Model gives X'' → ·····

As the result of the calculation cycle above, the unique figure of TEU and vessel calls is given for each case.

Table 3.5-43 shows the result of preliminary simulation.

Table 3.5-43 Result of the preliminary simulations with the different scenarios for efficiency improvement of Nacala Port

		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Malawi Export	2008 actual	19.5%	51.0%	28.2%	1.3%	0.0%	100.0%
	Current Productivity	16.7%	47.1%	29.0%	7.2%	0.0%	100.0%
	Improved Productivity (Base Case)	84.0%	10.5%	3.9%	1.6%	0.0%	100.0%
	Highly improved Productivity	87.4%	8.3%	3.1%	1.3%	0.0%	100.0%
Malawi Import	2008 actual	11.8%	59.6%	16.7%	11.9%	0.0%	100.0%
	Current Productivity	10.7%	58.3%	18.4%	12.6%	0.0%	100.0%
	Improved Productivity (Base Case)	70.6%	20.8%	4.1%	4.5%	0.0%	100.0%
	Highly improved Productivity	75.6%	17.2%	3.4%	3.7%	0.0%	100.0%
Zambia Export	2008 actual	0.0%	4.5%	19.3%	72.0%	4.2%	100.0%
	Current Productivity	0.0%	7.3%	19.3%	72.3%	1.0%	100.0%
	Improved Productivity (Base Case)	0.7%	7.8%	13.2%	77.2%	1.1%	100.0%
	Highly improved Productivity	0.8%	7.8%	13.2%	77.1%	1.1%	100.0%
Zambia Import	2008 actual	0.0%	15.2%	25.4%	49.8%	9.7%	100.0%
	Current Productivity	1.2%	16.3%	24.5%	51.0%	6.9%	100.0%
	Improved Productivity (Base Case)	6.7%	16.2%	19.4%	50.7%	6.9%	100.0%
	Highly improved Productivity	7.5%	16.1%	19.3%	50.3%	6.8%	100.0%

Source: Study Team

5) Results of the forecast

For the simplification of simulation, the Study Team assumed that the frequency of ship's call at ports besides Nacala could be given exogenously. This assumption can be justified by the fact that in larger ports of which the ship's call frequency is high, the frequency is less sensitive to the calculated market share than the case in smaller ports like Nacala due to the characteristic of exponential function in the Shipper Model. The numbers of international vessel calls at Beira, Durban, Dar es Salaam and Walvis Bay are assumed in 2020 and 2030 as per Table 3.5-44 below. Growth of callings is assumed simply to be in proportion to the growth of seaborne cargoes in Mozambique because the calling frequency for Beira is the most sensitive among these ports.

Table 3.5-44 Assumption of vessel calls at the ports other than Nacala

Year	Beira	Durban	Dar es Salaam	Walvis Bay
2008	74	323	224	104
2020	236	1,034	718	334
2030	520	2,277	1,583	735

Source: Study Team

As the result of the calculations above, the cargo volume is shown in Table 3.5-45 for shares and in Table 3.5-46 for TEUs as below.

The sharp increase of Nacala's share for Malawi in the cases of Improved Productivity and Highly Improved Productivity indicates a strong time-sensitivity of Nacala as the cost amount thereof is the lowest among 5 ports.

Compared with Malawi, the share increase of Zambia is quite few for Nacala, because the cost and time of Nacala are both far less competitive than those of other ports.

Although the laden TEUs of Nacala show a steady increase for the year 2020 and 2030, the shares thereof show some decreases for those years. It is due to the probable assumption of the Study Team on the vessel calls at other competitor ports indicated in Table 3.5-44 above.

As far as the cargoes of Malawi and Zambia are concerned, Beira shows some decreases in its shares for those transit cargoes in the cases of Improved Productivity and Highly Improved Productivity. However, its shares in those cases increase in the long term through 2020 and 2030 with the volume of laden TEUs as well. Furthermore, it is expected that the agricultural development in Central Mozambique region and economic recovery of Zimbabwe will take place in near future, which will contribute to Beira's continued growth of container handling volume as a whole.

The numbers of vessel calls at Nacala concurrently given by the calculations above will be shown in Table 3.5-54 later.

Table 3.5-45 Distribution of shares for 5 ports

Traffic	Year	Case	Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Malawi Export	2008	Actual	19.5%	51.0%	28.2%	1.3%	0.0%	100.0%
	2020	Current Productivity	24.3%	64.8%	7.4%	3.6%	0.0%	100.0%
	2020	Improved Productivity (Base Case)	74.6%	21.7%	2.5%	1.2%	0.0%	100.0%
	2020	Highly Improved Productivity	79.0%	17.9%	2.0%	1.0%	0.0%	100.0%
	2030	Current Productivity	24.6%	66.9%	5.7%	2.8%	0.0%	100.0%
	2030	Improved Productivity (Base Case)	72.4%	24.5%	2.1%	1.0%	0.0%	100.0%
	2030	Highly Improved Productivity	77.0%	20.4%	1.7%	0.9%	0.0%	100.0%
Malawi Import	2008	Actual	11.8%	59.6%	16.7%	11.9%	0.0%	100.0%
	2020	Current Productivity	14.5%	74.5%	4.9%	6.2%	0.0%	100.0%
	2020	Improved Productivity (Base Case)	57.3%	37.2%	2.4%	3.1%	0.0%	100.0%
	2020	Highly Improved Productivity	62.9%	32.4%	2.1%	2.7%	0.0%	100.0%
	2030	Current Productivity	14.6%	76.6%	3.8%	5.0%	0.0%	100.0%
	2030	Improved Productivity (Base Case)	54.6%	40.7%	2.0%	2.7%	0.0%	100.0%
	2030	Highly Improved Productivity	60.1%	35.8%	1.8%	2.3%	0.0%	100.0%
Zambia Export	2008	Actual	0.0%	4.5%	19.3%	72.0%	4.2%	100.0%
	2020	Current Productivity	0.0%	17.5%	10.5%	70.3%	1.7%	100.0%
	2020	Improved Productivity (Base Case)	0.7%	17.4%	10.4%	69.8%	1.7%	100.0%
	2020	Highly Improved Productivity	0.9%	17.4%	10.4%	69.7%	1.7%	100.0%
	2030	Current Productivity	0.1%	21.0%	9.7%	67.4%	1.8%	100.0%
	2030	Improved Productivity (Base Case)	0.7%	20.9%	9.7%	66.9%	1.8%	100.0%
	2030	Highly Improved Productivity	0.9%	20.8%	9.6%	66.8%	1.8%	100.0%
Zambia Import	2008	Actual	0.0%	15.2%	25.4%	49.8%	9.7%	100.0%
	2020	Current Productivity	1.8%	24.3%	17.2%	48.1%	8.5%	100.0%
	2020	Improved Productivity (Base Case)	6.6%	23.1%	16.4%	45.8%	8.1%	100.0%
	2020	Highly Improved Productivity	7.3%	23.0%	16.3%	45.5%	8.0%	100.0%
	2030	Current Productivity	1.9%	26.3%	16.4%	46.6%	8.7%	100.0%
	2030	Improved Productivity (Base Case)	6.7%	25.1%	15.6%	44.3%	8.3%	100.0%
	2030	Highly Improved Productivity	7.4%	24.9%	15.5%	44.0%	8.3%	100.0%

Source: Study Team

Table 3.5-46 Distribution of laden TEUs for 5 ports

(unit: TEU)

Traffic	Year	Case	Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Malawi Export	2008	Actual	3,244	8,500	4,701	208	0	16,652
	2020	Current Productivity	7,664	20,455	2,327	1,123	0	31,570
	2020	Improved Productivity (Base Case)	23,548	6,864	781	377	0	31,570
	2020	Highly Improved Productivity	24,949	5,665	645	311	0	31,570
	2030	Current Productivity	12,938	35,142	2,983	1,495	1	52,559
	2030	Improved Productivity (Base Case)	38,063	12,857	1,091	547	0	52,559
	2030	Highly Improved Productivity	40,446	10,743	912	457	0	52,559
Malawi Import	2008	Actual	2,969	15,046	4,215	3,000	0	25,231
	2020	Current Productivity	8,462	43,553	2,841	3,603	2	58,462
	2020	Improved Productivity (Base Case)	33,478	21,762	1,420	1,800	1	58,462
	2020	Highly Improved Productivity	36,747	18,915	1,234	1,565	1	58,462
	2030	Current Productivity	17,675	92,473	4,588	6,029	4	120,769
	2030	Improved Productivity (Base Case)	65,932	49,188	2,440	3,207	2	120,769
	2030	Highly Improved Productivity	72,560	43,243	2,145	2,819	2	120,769
Zambia Export	2008	Actual	0	753	3,220	12,000	705	16,678
	2020	Current Productivity	23	8,075	4,836	32,394	775	46,102
	2020	Improved Productivity (Base Case)	319	8,023	4,805	32,185	770	46,102
	2020	Highly Improved Productivity	397	8,009	4,797	32,131	768	46,102
	2030	Current Productivity	46	16,240	7,518	52,072	1,413	77,288
	2030	Improved Productivity (Base Case)	564	16,131	7,467	51,723	1,403	77,288
	2030	Highly Improved Productivity	695	16,103	7,455	51,634	1,401	77,288
Zambia Import	2008	Actual	0	6,411	10,702	20,989	4,083	42,185
	2020	Current Productivity	2,414	32,387	22,960	64,119	11,294	133,174
	2020	Improved Productivity (Base Case)	8,736	30,821	21,849	61,019	10,748	133,174
	2020	Highly Improved Productivity	9,689	30,585	21,682	60,552	10,666	133,174
	2030	Current Productivity	4,630	62,610	38,960	110,660	20,780	237,640
	2030	Improved Productivity (Base Case)	15,822	59,603	37,088	105,344	19,782	237,640
	2030	Highly Improved Productivity	17,289	54,577	38,691	108,050	19,033	237,640

Source: Study Team

6) Sensitivity analysis

Sensitivity analysis was conducted to assess the impact on the simulation result when some changes in the competitive relations with other ports arise. Following 5 cases are considered as a variation of Improved Productivity case for the year 2030:

Case 1: The rail portion in the inland container transportation of Nacala Corridor decreases from the current 75.3% to 50.0% due to the rapidly increased demand of coal transportation.

Case 2: The rail transit time of Nacala Corridor is reduced to 4 days from the original assumption of 8 days with the current rail portion of 75.3%.

Case 3: In addition to Case 2, Sena railway is developed to connect Lilongwe/Blantyre with Beira with the same service quality and rail portion assumed for Case 2.

Case 4: In addition to Case 3, Nacala Corridor railway is extended to Lusaka with the same service quality and rail portion assumed for Case 2.

Case 5: Export/import ocean freight rates at Nacala and Dar es Salaam are reduced to the same level as Durban, owing to the increase of competitiveness at those ports.

Costs and times for inland transportation applicable to this sensitivity analysis are assumed as per Table 3.5-47 below:

Table 3.5-47 Assumption of cost and time for sensitivity analysis

			Nacala Corridor (Malawi/Nacala)		Sena Railway (Malawi/Beira)		Nacala Corridor (Zambia/Nacala)	
			Rail	Road	Rail	Road	Rail	Road
Transit time (days)			4.0	1.2	4.0	1.2	7.6	1.8
Cost (USD /TEU)	Export	Full	752	2,805	556	2,670	1,240	4,075
		Empty	285	1,683	211	1,335	470	2,445
	Import	Full	1,591	2,805	1,177	2,670	2,624	4,075
		Empty	591	1,683	437	1,602	975	2,445

Source: Study Team

The result of the calculations for each case is summarized in Table 3.5-48 below. Port-wise laden TEUs and shares are calculated by applying the assumptions above to the original simulations for Improved Productivity Case for the year 2030.

Table 3.5-48 Result of sensitivity analysis

Original Simulation

		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Malawi Export	TEU	38,063	12,857	1,091	547	0	52,559
	Share	72.4%	24.5%	2.1%	1.0%	0.0%	100.0%
Malawi Import	TEU	65,932	49,188	2,440	3,207	2	120,769
	Share	54.6%	40.7%	2.0%	2.7%	0.0%	100.0%
Malawi Total	TEU	103,995	62,045	3,532	3,754	2	173,328
	Share	60.0%	35.8%	2.0%	2.2%	0.0%	100.0%
Zambia Export	TEU	564	16,131	7,467	51,723	1,403	77,288
	Share	0.7%	20.9%	9.7%	66.9%	1.8%	100.0%
Zambia Import	TEU	15,822	59,603	37,088	105,344	19,782	237,640
	Share	6.7%	25.1%	15.6%	44.3%	8.3%	100.0%
Zambia Total	TEU	16,386	75,733	44,556	157,067	21,185	314,928
	Share	5.2%	24.0%	14.1%	49.9%	6.7%	100.0%
Total	TEU	120,381	137,779	48,088	160,821	21,188	488,255
	Share	24.7%	28.2%	9.8%	32.9%	4.3%	100.0%

Case 1 (Nacala rail portion 50%)

		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Malawi Export	TEU	16,257	32,089	2,806	1,406	0	52,559
	Share	30.9%	61.1%	5.3%	2.7%	0.0%	100.0%
Malawi Import	TEU	26,660	84,415	4,188	5,503	4	120,769
	Share	22.1%	69.9%	3.5%	4.6%	0.0%	100.0%
Malawi Total	TEU	42,917	116,504	6,994	6,910	4	173,328
	Share	24.8%	67.2%	4.0%	4.0%	0.0%	100.0%
Zambia Export	TEU	541	16,136	7,470	51,738	1,404	77,288
	Share	0.7%	20.9%	9.7%	66.9%	1.8%	100.0%
Zambia Import	TEU	15,506	59,688	37,141	105,495	19,810	237,640
	Share	6.5%	25.1%	15.6%	44.4%	8.3%	100.0%
Zambia Total	TEU	16,047	75,823	44,611	157,233	21,214	314,928
	Share	5.1%	24.1%	14.2%	49.9%	6.7%	100.0%
Total	TEU	58,963	192,327	51,605	164,142	21,218	488,255
	Share	12.1%	39.4%	10.6%	33.6%	4.3%	100.0%

Case 2 (Nacala rail with half transit time)

		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Malawi Export	TEU	51,298	1,118	95	48	0	52,559
	Share	97.6%	2.1%	0.2%	0.1%	0.0%	100.0%
Malawi Import	TEU	113,477	6,541	325	426	0	120,769
	Share	94.0%	5.4%	0.3%	0.4%	0.0%	100.0%
Malawi Total	TEU	164,775	7,659	419	474	0	173,328
	Share	95.1%	4.4%	0.2%	0.3%	0.0%	100.0%
Zambia Export	TEU	580	16,127	7,466	51,712	1,403	77,288
	Share	0.8%	20.9%	9.7%	66.9%	1.8%	100.0%
Zambia Import	TEU	16,038	59,545	37,052	105,242	19,763	237,640
	Share	6.7%	25.1%	15.6%	44.3%	8.3%	100.0%
Zambia Total	TEU	16,618	75,672	44,518	156,953	21,166	314,928
	Share	5.3%	24.0%	14.1%	49.8%	6.7%	100.0%
Total	TEU	181,393	83,331	44,938	157,427	21,166	488,255
	Share	37.2%	17.1%	9.2%	32.2%	4.3%	100.0%

Case 3 (Case 2 + Sena rail with 75% portion & same service quality)

		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Malawi Export	TEU	32,665	19,799	63	32	0	52,559
	Share	62.1%	37.7%	0.1%	0.1%	0.0%	100.0%
Malawi Import	TEU	54,436	65,958	162	213	0	120,769
	Share	45.1%	54.6%	0.1%	0.2%	0.0%	100.0%
Malawi Total	TEU	87,101	85,756	225	245	0	173,328
	Share	50.3%	49.5%	0.1%	0.1%	0.0%	100.0%
Zambia Export	TEU	559	16,132	7,468	51,726	1,404	77,288
	Share	0.7%	20.9%	9.7%	66.9%	1.8%	100.0%
Zambia Import	TEU	15,749	59,622	37,101	105,379	19,788	237,640
	Share	6.6%	25.1%	15.6%	44.3%	8.3%	100.0%
Zambia Total	TEU	16,307	75,754	44,569	157,106	21,192	314,928
	Share	5.2%	24.1%	14.2%	49.9%	6.7%	100.0%
Total	TEU	103,408	161,511	44,794	157,350	21,192	488,255
	Share	21.2%	33.1%	9.2%	32.2%	4.3%	100.0%

Case 4 (Case 3 + Zambia rail with 75% portion & same serivice quality)

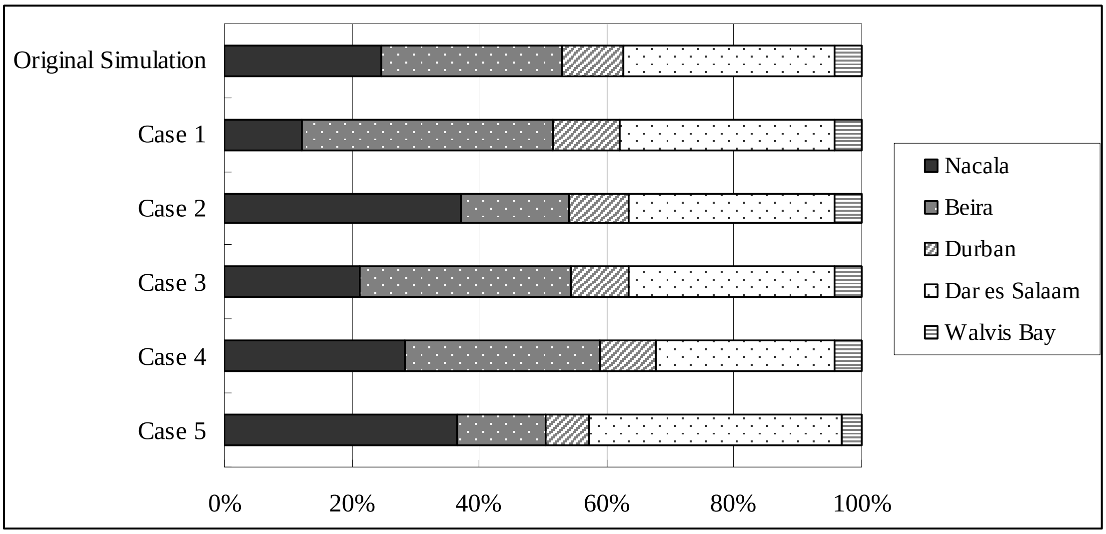
		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Malawi Export	TEU	36,905	15,548	70	35	0	52,559
	Share	70.2%	29.6%	0.1%	0.1%	0.0%	100.0%
Malawi Import	TEU	55,414	64,981	162	212	0	120,769
	Share	45.9%	53.8%	0.1%	0.2%	0.0%	100.0%
Malawi Total	TEU	92,320	80,529	231	247	0	173,328
	Share	53.3%	46.5%	0.1%	0.1%	0.0%	100.0%
Zambia Export	TEU	28,163	10,328	4,781	33,117	899	77,288
	Share	36.4%	13.4%	6.2%	42.8%	1.2%	100.0%
Zambia Import	TEU	18,031	59,009	36,719	104,296	19,585	237,640
	Share	7.6%	24.8%	15.5%	43.9%	8.2%	100.0%
Zambia Total	TEU	46,193	69,338	41,500	137,413	20,483	314,928
	Share	14.7%	22.0%	13.2%	43.6%	6.5%	100.0%
Total	TEU	138,513	149,867	41,732	137,660	20,484	488,255
	Share	28.4%	30.7%	8.5%	28.2%	4.2%	100.0%

Case 5 (Freight rates at Nacala/Dar es Salaam to be equal to Durban)

		Nacala	Beira	Durban	Dar es Salaam	Walvis Bay	Total
Malawi Export	TEU	47,841	4,185	355	178	0	52,559
	Share	91.0%	8.0%	0.7%	0.3%	0.0%	100.0%
Malawi Import	TEU	107,221	8,082	401	5,065	0	120,769
	Share	88.8%	0.0%	0.0%	0.0%	0.0%	0.0%
Malawi Total	TEU	155,061	12,266	756	5,243	0	173,328
	Share	89.5%	7.1%	0.4%	3.0%	0.0%	100.0%
Zambia Export	TEU	1,993	15,830	7,328	50,759	1,377	77,288
	Share	2.6%	20.5%	9.5%	65.7%	1.8%	100.0%
Zambia Import	TEU	20,996	40,312	25,085	137,867	13,379	237,640
	Share	8.8%	17.0%	10.6%	58.0%	5.6%	100.0%
Zambia Total	TEU	22,989	56,142	32,413	188,626	14,757	314,928
	Share	7.3%	17.8%	10.3%	59.9%	4.7%	100.0%
Total	TEU	178,051	68,409	33,169	193,869	14,757	488,255
	Share	36.5%	14.0%	6.8%	39.7%	3.0%	100.0%

Source: Study Team

The share of each port in the total transit containers for each case is summarized as per Figure 3.5-19 below.



Source: Study Team

Figure 3.5-19 Summary of sensitivity analysis

(3) Transship cargoes

In the year 2008, 2,879 TEUs of transship containers were handled at Nacala. Most of those containers were for outbound and transferred by the same shipping line between its different trade lanes; mainly from East Asia service to South Asia/Middle East service. This kind of transshipment will increase with the growth of overall cargo volume.

In addition of the above, the Study Team envisages the potential transshipment needs as follows:

1) Inbound transshipment by existing shipping line

As stated in 2.4.2-(3), inbound transshipment is hampered by customs regulations which requires shipping lines to post a huge amount of bond. However, once the customs deregulate that rule, inbound transshipment will become a reality. The same volume as aforementioned outbound transshipment is expected.

2) Shift of the transshipment base from IOI ports

In 2008, Mutsamudu handled 8,025 TEUs of transshipment including the export containers at Quelimane and Pemba. Mutsamudu is in the similar geographical position as Nacala. Once the operational efficiency is improved at Nacala, some portion (say 50%) of such transshipment might come to Nacala.

3) Shift of the transshipment base from Durban for the containers ex. Beira

Currently some export containers at Beira for South Asia/Middle East are transshipped at Durban. To save the transit time, those containers might come to Nacala.

After conservative estimation of 30% less, approx. 46,000 TEUs in total of 1) to 3) above is forecasted for the year 2020, and 105,000 TEUs for the year 2030.

It is assumed that those additional transships are obtained by the Port only in the Highly Improved Case where 3 quay gantries are equipped.

(4) Cabotage

Cargo Volume of domestic maritime transport is decreasing mainly due to improvement of the road network and absence of domestic service shipping line for cabotage containers. However it is expected that the volume of cabotage containers will increase, although further improvement of the road network is planned. Historically, there has been little transport demand between the north and south parts of the country due to the undeveloped domestic market, manufacturing, and commercialized agriculture, however, the demand would increase with acceleration of industrial development. It is one of the priority transport policies of GOM to resume cabotage by domestic shipping lines.

The Study Team forecasted the handling volume of domestic cargoes assuming that the ratio of domestic container cargoes to international container cargoes to/from Mozambican hinterland is constant (domestic outbound to import and domestic inbound to export). The result is shown in Table 3.5-49.

Table 3.5-49 Result of forecast for cabotage containers

(1000 MT)

	2008	2020	2030
Outbound	4	10	27
Inbound	19	91	236
Total	23	101	263

Source: Study Team

The conversion rate of 12.6 ton/TEU is applied to give laden TEU figures.

(5) Forecast of empty containers

Throughput of empty containers for the year 2020 and 2030 above is estimated so that the figures of laden and empty conform to the following conditions:

- { Empty - ABS(laden Import - Laden Export) } / Laden Total = 9.32%
- Total of laden and empty becomes equivalent between international export and international import.
- Total of laden and empty becomes equivalent between cabotage loading and cabotage discharge.

Where; ABS denotes the absolute figures.
9.32% is the rate at Port Elizabeth in 2008, which is used as the reference of a

similar scale port as Nacala.

(6) Summary of container cargoes forecast

Table 3.5-50 summarizes results of the demand forecast for container cargoes handled in the Port.

Table 3.5-50 Summary of demand forecast of container cargoes handled in the Port

Year 2020 (unt: 1000 TEU)

				2008			2020								
				Actual			**Current Productivity**			**Improved Productivity (Base Case)**			**Highly Improved Productivity**		
				Laden	Empty	Total	Laden	Empty	Total	Laden	Empty	Total	Laden	Empty	Total
Inter national	Local		Export	12	7	19	58			58			58		
			Import	12	7	18	29			29			29		
	Transit	Malawi	Export	3		3	8			24			25		
		Zambia	Export												
		Malawi	Import	3		3	8			33			37		
		Zambia	Import				2			9			10		
	Total		Export	15	7	22	65	5	70	81	7	89	83	7	90
			Import	15	7	21	40	30	70	71	17	89	75	15	90
			Total	30	13	43	105	35	140	153	25	177	158	22	181
Cabotage	Loading				1	2	1	8	9	1	8	9	1	8	9
	Discharge			2	1	2	7	2	9	7	2	9	7	2	9
	Total			2	2	4	8	11	19	8	11	19	8	11	19
Tranship				2	1	3	7	4	10	10	5	15	34	19	52
Total				**33**	**16**	**50**	**120**	**50**	**169**	**170**	**40**	**211**	**200**	**52**	**252**

Year 2030 (unt: 1000 TEU)

				2008			2030								
				Actual			**Current Productivity**			**Improved Productivity (Base Case)**			**Highly Improved Productivity**		
				Laden	Empty	Total	Laden	Empty	Total	Laden	Empty	Total	Laden	Empty	Total
Inter national	Local		Export	12	7	19	150			150			150		
			Import	12	7	18	77			77			77		
	Transit	Malawi	Export	3		3	13			38			40		
		Zambia	Export							1			1		
		Malawi	Import	3		3	18			66			73		
		Zambia	Import				5			16			17		
	Total		Export	15	7	22	163	12	175	188	16	205	191	17	208
			Import	15	7	21	99	76	175	159	46	205	167	41	208
			Total	30	13	43	262	88	350	347	62	409	358	57	415
Cabotage	Loading				1	2	2	22	24	2	22	24	2	22	24
	Discharge			2	1	2	19	5	24	19	5	24	19	5	24
	Total			2	2	4	21	28	48	21	28	48	21	28	48
Tranship				2	1	3	16	9	25	22	12	34	77	43	119
Total				**33**	**16**	**50**	**299**	**124**	**424**	**390**	**102**	**491**	**455**	**128**	**583**

Source: Study Team

3.5.3 Break/dry/liquid-bulk traffic

In this subsection, dry bulk, break bulk and liquid bulk cargoes to be handled in the Port are forecasted.

All bulk cargoes generated in Northern Mozambique have been handled in Nacala Port, and this would remain unchanged in the future. In addition to cargoes to/from Northern Provinces, the Port is expected to handle coal from Moatize Mine in Tete Province and imported wheat to all regions of the country fully utilizing an advantage of water depth.

Vale Mozambique plans to ship coal from Moatize 1 via Beira Port, but the port cannot accommodate cape-size vessels due to the limited water depth even after the current dredging work is completed. This causes costly offshore transshipment. Capacity of rail linking Moatize and Beira is also a bottle neck of shipment. Vale plans to transport coal from Moatize 2 via Nacala Port by constructing a deep-water jetty, and constructing and rehabilitating railways. The project is in the stage of EIA. The infrastructure development is expected to be completed in 2015 at the earliest.

As for wheat transport, large bulkers have a great economic advantage, and Nacala Port, the only Mozambican port which can accommodate them, has a potential to be a hub port serving all provinces in the country beyond its traditional hinterland. However, it should be noted that the formation of hub function requires firm intension and constant effort of the Government toward this goal. Increase of local consumption is also a precondition of the hub function. Without considerable amount of local consumption, the hub function cannot be formed no matter how advantageous it is in terms of water depth. In this context, increase of purchasing power of the people in the Northern Provinces through achievement of programs of poverty reduction is essential. And a wheat processing complex shall be strategically invited to Nacala SEZ. Although these are unlikely to be realized in the short run, all of them can be materialized within the long term planning horizon. Accordingly the Study Team estimated wheat cargo volume handled in Nacala assuming that the hub function would be formed before the target year of 2030. Wheat will be transported from the Americas or Europe directly to Nacala by large bulkers. For Central and Southern Mozambique wheat will be transshipped to smaller bulkers, or be processed as flour and be shipped by domestic containers. In addition to the domestic hinterland, Nacala hub will serve some parts of Tanzania. Although Tanzania has a plan to develop bulk port in Mwanbani in Tanga Province in Northern Tanzania, feasibility of the project is not confirmed yet, and its construction would be far into the future. Therefore, the Study Team assessed that in the target year, Nacala Port will serve Southern three provinces (Mtwara, Lindi and Ruvuma), which comprise 9% of the country’s total population. Wheat will be transported to the region via the Friendship Bridge connecting Tanzania and Mozambique.

Zambia is the only country which imports crude oil in the hinterland of the Port. However this traffic is unlikely to divert to Nacala. At present all crude oil is imported through Dar es Salaam Port, and is transported to Zambia via crude oil pipeline. Dar es Salaam Port plans to increase capacity of its oil unloading facility, and it is expected that Dar es Salaam will continue to dominate in crude oil supply to Zambia.

Port selection of other bulk cargoes can be considered to be basically similar to that of containerized cargoes. All cargoes generated in the traditional domestic hinterland would continue to be handled in the Port. Some parts of cargoes to/from Malawi and Zambia would also be handled in the Port, and the share of the Port in the transit market would be determined by operational efficiency of the Port. In this report, the share of Nacala in the bulk transit market is assumed to be the same as that in container market (the Base Case) for the sake of convenience. Unlike containerized cargoes, port selection of bulk cargoes is less affected by the maritime network. Therefore the share of Nacala was calculated without considering the future increase of the frequency of vessel calls.

As for domestic bulk cargo, the handling volume can be expected to increase in the same way as domestic containers. At present, virtually all domestic bulk cargoes are fuel (mainly out bound), and it is expected to increase with import volume of fuel. In addition to fuel, it is forecasted that imported wheat will start to be transported by domestic shipping within the long term planning horizon.

Table 3.5-51 summarizes results of the demand forecast for bulk cargoes.

Table 3.5-51 Summary of demand forecast of bulk cargoes handled in the Port

(1000 MT)

		2008	2020	2030
International to/from Mozambique				
Export	Mineral products	0	20,000	40,000
	Wood chip	0	96	384
	Others	18	134	339
	Sub-total	18	20,230	40,723
Import	Fuel	105	190	360
	Clinker	134	500	30
	Wheat	72	400	1,238
	Vehicle	0	61	180
	Others	65	46	96
	Sub-total	376	1,197	1,904
Transit (Malawi)				
Export	Sub-total	22	77	129
Import	Fuel	30	216	335
	Wheat	25	101	79
	Vehicle	0	66	168
	Others	110	297	560
	Sub-total	165	680	1,142
Transit (Zambia)				
Export	Sub-total	0	3	5
Import	Fuel	0	19	27
	Wheat	0	6	18
	Vehicle	0	6	10
	Others	0	46	90
	Sub-total	0	77	145
Transit (Tanzania)				
Import	Wheat	0	155	194
Domestic				
Outbound	Fuel	17	31	58
	Wheat	0	0	928
	Sub-total	17	31	986
Total		**598**	**22,450**	**45,228**
	Mineral products	0	20,000	40,000
	Wood chip	0	96	384
	Fuel	152	456	780
	Clinker	134	500	30
	Wheat	97	662	2,457
	Vehicle	0	133	358
	Others	215	603	1,219

Source: Study Team

3.5.4 Summary of cargo forecast

Table 3.5-52 and Table 3.5-53 summarize the results of aforementioned demand forecast of the Port in the target years of 2020 and 2030. The total cargo handling volume in 2030 is forecasted to be more than 50 times larger than the current handling volume. When mineral products are excluded, the cargo throughput in 2030 is still more than 10 times larger than the current throughput, which corresponds to annual growth of 11%. The annual growth of container traffic until 2030 is slightly smaller than 11% in terms of TEU, but the annual growth of net weight of containerized cargoes is around 13% (since empty container ratio decreases with the increase of handling volume), which is much larger than the growth of cargo generation in the hinterland. This represents strengthening of competitiveness of the Port due to improvement of the Corridor and the evolution of the Port. Figure 3.5-20 and Figure 3.5-21 depict the forecasted growth of cargoes.

Table 3.5-52 Summary of cargo forecast (total cargo volume)

(1,000MT)

		2008	2020	2030
International	Total	955	24,391	48,723
	Container	374	1,972	4,481
	Bulk	581	22,419	44,242
Outbound	Total	227	21,313	43,195
	Container	187	1,003	2,338
	Bulk	40	20,310	40,857
Inbound	Total	703	2,961	5,262
	Container	162	852	1,877
	Bulk	541	2,109	3,385
Tranship	Total	25	117	266
	Container	25	117	266
	Bulk	0	0	0
Domestic	Total	40	132	1,249
	Container	23	101	263
	Bulk	17	31	986
Total		995	24,523	49,972

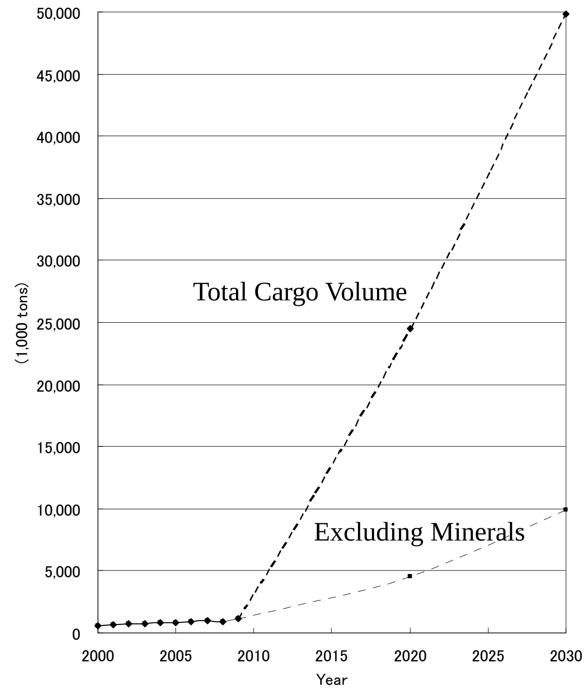
Source: Study Team
Note: Since the container statistics of CFM include tare weight, the data listed here for the base year don't coincident with CFM data.

Table 3.5-53 Summary of cargo forecast (containers)

(1,000TEU)

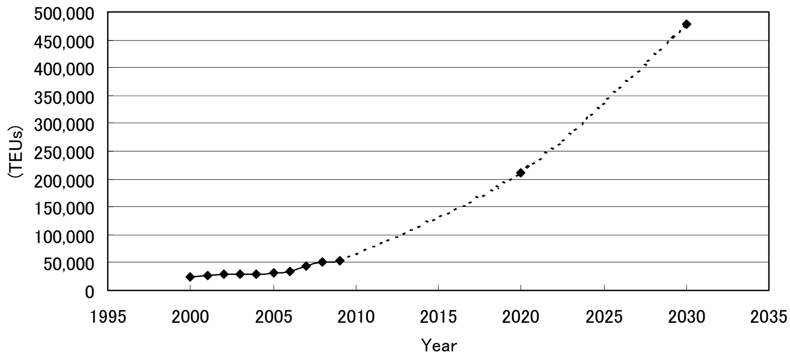
	2008	2020	2030
International	46	192	443
Outbound	22	89	205
Inbound	21	89	205
Tranship	3	15	34
Domestic	4	19	48
Total	50	211	491

Source: Study Team



Source: Study Team

Figure 3.5-20 Forecasted growth of cargo throughput of Nacala Port



Source: Study Team

Figure 3.5-21 Forecasted growth of container handling volume

Table 3.5-54 shows the breakdown of forecasted cargoes by commodity. Due to lack of commodity-basis data for containerized cargoes, the breakdown for forecasted volume as well as actual data in 2008 was estimated based on various data including SADC trade data assuming some scenarios. For example, the commodity-base breakdown of agricultural products exported from Mozambique was estimated from the result of the micro-forecast assuming the ratio of domestic consumption and regionally traded volume, etc. Accordingly, the breakdown listed in the table shall be referred only for understanding the overall tendency of commodity flow through the Port.

Table 3.5-54 Summary of cargo forecast (by commodity)

(1,000MT)

	2008	2030
EXPORT from Mozambique	170	42,614
Tobacco (Nampula and Niassa)		50
Cotton (Nampula)		50
Cashew (Nampula)		40
Maize (Nampula)		80
Sorghum (Nampula)	100	90
Millet (Nampula)		10
Rice (Nampula)		50
Soybean (Nampula)		70
Cassava (Nampula)		290
Sugar (Processed in Nacala)		100
Wood chip (Niassa)	0	380
Timber (Niassa, etc.)	50	750
Coal (Tete)	0	20,000
Other mineral products including iron ore and phosphate in Nampula	0	20,000
Products in IFZ of Nacala SEZ	0	440
Scrap	5	0
Others	15	214
EXPORT from Malawi	57	568
Tobacco	0	200
Sugar	40	260
Tea	0	50
Cotton	0	30
Others	17	28
EXPORT from Zambia	0	13
Copper and Copper Ore	0	7
Others		6
IMPORT to Mozambique	500	2,726
Wheat	72	1,240
Rice	18	30
Edible Oil	40	60
Oil and Gas	105	360
Clinker	134	30
Cement	50	0
Plaster	5	20
Fertilizer	10	50
Machinery	10	120
Vehicle	30	180
Raw materials for IFZ of Nacala SEZ	0	440
Other	26	196
IMPORT to Malawi	203	1,999
Wheat	25	80
Other Agricultural Products	9	183
Oil and Gas	30	340
Clinker	52	0
Fertilizer	43	300
Other Chemical Products	6	123
Textile	6	120
Machinery	9	190
Vehicle	0	170
Others	24	494
IMPORT to Zambia	0	343
Wheat	0	20
Other Agricultural Products	0	40
Oil and Gas	0	30
Fertilizer	0	70
Metal Products	0	50
Machnery	0	40
Vehicle	0	10
Others	0	83
IMPORT to Tanzania	0	194
Wheat	0	194
TOTAL	930	48,457

Source: Study Team

3.5.5 Vessel traffic

(1) Containers

Number of calls of international vessels is given by the calculations in 3.5.2-(3). Number of cabotage vessel calls needs to be added on to have the total vessel calls related to container cargoes.

Table 3.5-55 shows the forecast of total vessel traffics.

Table 3.5-55 Summary of vessel traffics

2008

	Current Productivity	Improved Productivity (Base Case)	Highly Improved Productivity
International	78	148	153
Cabotage	19	21	21
Total	**97**	**168**	**174**

2020

	Current Productivity	Improved Productivity (Base Case)	Highly Improved Productivity
International	266	386	400
Cabotage	79	79	79
Total	**345**	**465**	**479**

2030

	Current Productivity	Improved Productivity (Base Case)	Highly Improved Productivity
International	663	878	905
Cabotage	207	207	207
Total	**870**	**1,085**	**1,112**

Source: Study Team

Table3.5-56 shows the assumption of parcel size (TEU/vessel). The figures of parcel size for Local/Transit in Improved Productivity and Highly Improved Productivity are less than those of Current Productivity because the improvement of operational efficiency attracts more vessels, and enables those vessels to be dispatched in a shorter period of time.

Table 3.5-56 Assumption of parcel size of containers

2008 (unit: TEU)

		Current Productivity			Improved Productivity (Base Case)			Highly Improved Productivity		
		Laden	Empty	Total	Laden	Empty	Total	Laden	Empty	Total
Inter national	Local/Transit	380	173	553	395	206	602	395	212	607
	Tranship	24	13	37	25	14	38	25	14	38
	S.total	404	186	590	420	220	640	420	225	645
Cabotage		101	98	199	101	123	224	101	123	224
Total average		344	169	513	381	208	589	382	213	595

2020 (unit: TEU)

		Current Productivity			Improved Productivity (Base Case)			Highly Improved Productivity		
		Laden	Empty	Total	Laden	Empty	Total	Laden	Empty	Total
Inter national	Local/Transit	395	133	528	395	64	459	395	56	451
	Tranship	25	14	38	25	14	38	84	47	131
	S.total	420	147	567	420	77	498	479	103	582
Cabotage		101	133	234	101	133	234	101	133	234
Total average		347	144	490	366	87	453	417	108	525

2030 (unit: TEU)

		Current Productivity			Improved Productivity (Base Case)			Highly Improved Productivity		
		Laden	Empty	Total	Laden	Empty	Total	Laden	Empty	Total
Inter national	Local/Transit	395	133	528	395	71	466	395	63	459
	Tranship	25	14	38	25	14	38	85	47	132
	S.total	420	146	566	420	84	504	480	110	591
Cabotage		101	133	234	101	133	234	101	133	234
Total average		344	143	487	359	94	453	410	115	524

Source: Study Team

(2) Bulk

Table 3.5-57 shows the forecast of vessel traffics.

Table 3.5-57 Forecast of vessel traffics

	2008		2020		2030	
	Cargo volume ('000MT)	Number of vessels	Cargo volume ('000MT)	Number of vessels	Cargo volume ('000MT)	Number of vessels
Mineral	0	0	20,000	190	40,000	267
Wood chip	0	0	96	5	384	9
Fuel	152	58	456	75	780	86
Clinker	134	n/a	500	24	30	1
Wheat	97	3	662	47	2,457	80
Vehcle	0	0	133	60	358	136
Others	215	48	603	89	1,219	180
Total	598	109	22,450	491	45,228	758

Source: Study Team

Parcel size is assumed as per Table 3.5-58 below.

Table 3.5-58 Assumption of parcel size

(Unit: Metric ton)

	Current parcel size	2020 assumption	2030 assumption
Mineral		105,000	150,000
Wood chip		20,000	45,000
Fuel	3,036	6,071	9,107
Clinker	20,733	20,733	20,733
Wheat	13,950	13,950	30,567
Vehcle		2,200	2,640
Others	3,391	6,781	6,781

Source: Study Team

3.5.6 Traffic volume of automobiles generated in the Port

The Study Team estimated the traffic volume of automobiles generated in the Port in the target years based on the following assumptions:

- All exported mineral products from Mozambique will be transported by rail.
- The modal share of trucks for transit cargoes to/from Malawi will remain unchanged (30%). The share for cargoes to/from Zambia will be the same as that for Malawi, whereas all transit cargoes to Tanzania will be transported by trucks.
- All international cargoes to/from domestic hinterland except mineral products will be transported by trucks.
- Domestic cargoes don’t generate automobile traffic, assuming that all domestic cargoes are feeder cargoes for international transport. International cargoes transshipped to domestic feeder vessels don’t generate road traffic either.
- Trucks carry cargoes only one way.
- A truck carries two TEUs of containers or 15 tons of cargoes.
- The volume of indirect traffic is 180% of traffic volume of trucks calculated from the above assumptions.

Table 3.5-59 shows the estimated traffic volume for the base case. Hourly peak traffic volume was obtained by multiplying average daily traffic by the peak ratio of 10%.

Table 3.5-59 Forecasted traffic volume of automobiles generated in the Port

	Annual Cargo Volume		Hourly Peak Traffic Volume of Automobiles (to and from) (vehicles/hr)	
	2020	2030	2020	2030
Bulk (except minerals)				
Mozambique	1,427,000 tons	2,627,000 tons	146	269
Domestic Feeder	31,000 tons	986,000 tons	-3	-101
Transit (Malawi and Zambia)	767,000 tons	1,421,000 tons	24	44
Transit (Tanzania)	155,000 tons	194,000 tons	16	20
Laden Containers				
Mozambique	87,000 TEUs	227,000 TEUs	67	174
Domestic Feeder	8,000 TEUs	21,000 TEUs	-6	-16
Transit	66,000 TEUs	121,000 TEUs	15	28
Total			258	417

Source: Study Team

3.6. Port capacity and development scale

3.6.1 Capacity of existing facilities

(1) Capacity of existing facilities at the container terminal

In this sub-section, capacity of existing facilities at the container terminal is estimated. Although bulk cargoes such as wheat and clinker are handled currently at the container terminal because the conventional cargo terminal cannot accommodate large vessels, the interference to container handling by bulk handling is not considered in the estimation below since the aim of hte analysis in this section is to evaluate the maximum potential of the existing container terminal in the determination of future development scale of the Port. Accordingly it should be noted that the actual capacity of the terminal is lower than the estimated one when the current mixed operation remains unchanged.

1) Quay side capacity

a) Available working hours

The Port is open 24 hours everyday except January first. The 24 hour operation is done by three shifts and the working schedule is as follows:

Table 3.6-1 Working schedule for container operation

The 1st shift	from 07:00 to 14:30
The 2nd shift	from 15:00 to 22:30
The 3rd shift	from 23:00 to 06:30

Source: CDN (Reorganized by the Study Team)

Operations completely stop for 30 minutes between each shift. However, operation continues non-stop during each shift (operators take tea breaks in turns). Therefore, the number of available working hours for container loading/unloading operation in the Port is 8,190 hours a year. (see Table 3.6-2)

Table 3.6-2 Available working hours for container loading/unloading operation

Effective working hours per day	22.5	hrs
Annual working days	364	days
Available working hours	8,190	hrs/year

Source: CDN (Reorganized by the Study Team)

b) Crane performance

The loading/unloading operation in the Port is done by ship's gears at present. Although vessels have 2 or 3 ship's gears, only one ship gear is used at a time because only one reachstacker is used for ship to shore operation due to shortage of equipment and load limit of the deteriorated pier. Even when two container vessels dock simultaneously, only one ship's gear of two vessels is used for cargo handling for the same reason.

Considering the standard berth occupancy of 65%, which is proposed by UNCTAD for a two-berth terminal, the available number of gears per vessel can be calculated as:

Available number of gears per vessel
= (ratio of two vessels at the quay) x 1/2 + (ratio of one vessel at the quay) x 1/1
= (0.65 x 0.65/(0.65 x 0.65 + 2 x 0.65 x (1-0.65)) x 1/2
+ 2 x 0.65 x (1-0.65) /(0.65 x 0.65 + 2 x 0.65 x (1-0.65)) x 1/1 = 0.76

Assuming the standard design capacity for ship's gear of 15 moves/hour and the standard loading/unloading efficiency of 85%, the effective crane performance per vessel can be obtained as:

Effective crane performance per vessel

= 15(moves/hr) x 85% x 0.76(cranes/vessel) = 9.69(moves/hr)

Since the available number of ship's gears is less than 1.0, interference among gears is not considered in the above calculation.

c) Total turnaround time (TAT) per call

The average number of TEU's loaded/unloaded by one vessel call is called the parcel size. According to the data of 2009 (source: CFM, CDN), the average parcel size of the Port is 487 TEU/call and the TEU factor of the Port is 1.19 (TEU/unit). Though this is rather small, when assuming that this remains unchanged, the ship handling time is calculated as:

Ship handling time = 487(TEU/call) / 1.19 / 9.69(moves/hr) = 42.23(hrs)

The total turnaround time (TAT) of the Port is calculated by summing up the ship handling time and berthing/deberthing time of three (3) hours.

Total turnaround time (TAT) = 42.23(hrs) + 3(hrs) = 45.23(hrs)

d) Capacity of existing quays

The Port has two container berths at present. The berth occupancy factor (BOF) for two container berths is 65% according to the UNCTAD guideline. The available number of ship calls per year is calculated by the following formula:

Available number of ship calls per year
= (Available working hours x BOF x Berth number) / TAT
= (8,190 x 65% x 2) / 45.23 = 235 (calls/year)

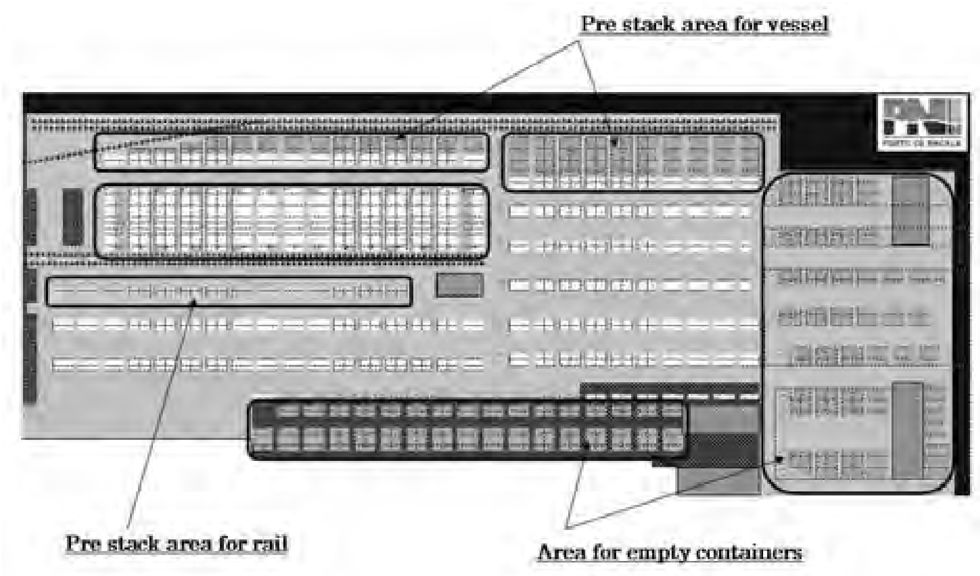
Capacity of existing quays is calculated by multiplying available number of ship calls per year and parcel size. Therefore,

Capacity of existing quays (2 berths) = 235(calls/year) x 487(TEU/call) = 114,445(TEU)

Thus, the existing quays have more than double the capacity of the current handling volume.

2) Capacity of existing container yard

The layout of the container terminal is shown in Figure 3.6-1. The total area of the container terminal is approximately 75,000 m^2 (scaled up by the Study Team). The stacking capacity of each type of container in the container terminal is shown in Table 3.6-3.



Source: CDN (reorganized by the Study Team)

Figure 3.6-1 Layout of container terminal of the Port

Table 3.6-3 Stacking capacity of each type of containers in the container terminal

Description	Height	Grand slots	Total
Full	3	456	1,368
Full	2	56	112
Reefers	2	24	48
Dangerous cargo	2	52	104
Pre stack – Vessel	3	214	642
Pre stack – Rail	3	54	162
Overspill	3	174	522
Overspill	2	38	76
Empties (Terminal) K	4	287	1,148
Empties (Terminal) F	4	200	800

Source: CDN (reorganized by the Study Team)

The pre stack area for vessels indicated in Figure 3.6-1 is located on the deteriorated pier structure, and therefore this area should be eliminated from the stack area in the evaluation of stacking capacity. Table 3.6-4 shows the calculated stacking capacity of the container yard.

Table 3.6-4 Current stacking capacity in the container terminal

Laden container	Transfer crane	880TEU	2,230TEU
	Else	1,350TEU	
Empty container		1,948TEU	1,948TEU
Total			4,178TEU

Source: Study Team

3) Comparison of the quay side capacity and stacking capacity of the yard

The required yard capacity when the container throughput reaches the limit of quay side capacity is calculated below:

The standard dwell time in developing countries and the current dwell time of the Port are shown in Table 3.6-5. The data on current dwell time of the Port was provided by CDN. For reference, the data on Walvis Bay Port is shown as an example of good performance in the region.

Table 3.6-5 Dwell time of the Port and standard

	The Port	Standard	Walvis Bay Port
Import container	10days	10days	5days
Export container	5days	5days	2days
Empty container (Import & Export)	7days	4days	4days
Transshipment container	15days	4days	7.5days
Transit container	27.5days	10days	4.3days

Source: CDN, Study Team

Required stack capacity is calculated by the following formula:

Required stack capacity
= Peak factor x (1 + Reserve capacity) x (Dwell time x Annual container throughput / 364)

Here, the peak factor is considered to cope with seasonal peak demands. Though the peak factor for the Port in 2009 exceeds 1.5 (monthly basis), the standard peak factor of 1.2 is adopted in the calculation because the fluctuation in Nacala doesn’t show any clear seasonal tendency, and this kind of fluctuation is expected to decrease by the increase of cargo throughput. The reserved capacity of 10% is assumed to provide extra storage space for the irregularly arriving vessels.

The estimated breakdown of the container traffic when it reaches the limit of quay side capacity is shown in Table 3.6-6. The total throughput of 114,445 TEU was divided into each traffic, assuming that the ratio of composition for import, export, and so on is the same as that in 2009.

Table 3.6-6 Contents of estimated volume for quay side capacity of existing facilities at the container terminal

	Ratio of composition	Estimated volume (TEU)
Import container	29%	32,928
Export container	21%	24,541
Empty container (Import & Export)	34%	38,678
Transshipment container	5%	5,596
Transit container	11%	12,702
Total	100%	114,445

Source: Study Team

The required stack capacity when the container throughput reaches the limit of the quay side capacity is shown in Table 3.6-7. The capacity was calculated for the following three scenarios of dwell time:

(A) In case of using current dwell time of the Port
(B) In case of using standard dwell time
(C) In case of using the dwell time of Walvis Bay Port

Table 3.6-7 Required stack capacity when the container throughput reaches the limit of the quay side capacity

	Required stack capacity (TEU)		
	(A) Current dwell time	(B) Standard dwell time	(C) Dwell time in Walvis Bay Port
Import container	1,194	1,194	597
Export container	445	445	178
Empty container (Import & Export)	982	561	561
Transshipment container	304	81	152
Transit container	1,267	461	198
Total	4,192	2,742	1,686

Source: Study Team

According to the result of this calculation, the Port requires about 1.5 times larger capacity than the standard when the dwell time is not shortened. When compared to the Walvis Bay Port, 2.5 times more capacity is needed. The following table summarizes the required stack capacity to compare to the current total capacity of the existing container terminal.

Table 3.6-8 Summary of required stack capacity

	Total capacity of existing container terminal (TEU)	Required stack capacity (TEU)	
		(A) Current dwell time	(B) Standard dwell time
Laden container	2,230	3,210	2,181
Empty container	1,948	982	561
Total	4,178	4,192	2,742

Source: Study Team

The result shows that the current yard capacity (laden 2,230TEU) is not sufficient to handle laden container when the container throughput increases up to the quay side capacity without improving dwell time. However, if empty container stack area is converted to the laden container stack area, the yard has enough capacity to accommodate the maximum number of containers within the quay side capacity. In this sense, the capacities of the yard and the quays are balanced on the assumption that the current very long dwell time remains unchanged.

For reference, the required stack capacity for the throughput in 2009 (52,620TEUs) is calculated as shown in the following table. In spite of the very long dwell time, the occupancy of the container yard remains at 47%.

Table 3.6-9 Required stack capacity of the Port in 2009

		Annual container throughput (TEU)	Required stack capacity (TEU)	
			Current dwell time	Standard dwell time
Import container		15,140	549	549
Export container		11,283	205	205
Empty container (Import & Export)		17,784	451	258
Transshipment container		2,573	140	37
Transit container		5,840	582	212
Sub total	Laden	34,836	1,476	1,003
	Empty	17,784	451	258
Total		52,620	1,927	1,261

Source: Study Team

(2) Capacity of existing facilities at the conventional terminal

1) Quay side capacity of existing facilities at the conventional terminal

The specification of the conventional quays in the Port is shown in the following table.

Table 3.6-10 Specifications of the conventional quays in the Port

Quay length	620m (4 berths) 1 berth is designated for liquid commodity
Maximum depth	10m
Electric quay cranes	4 (2x5t, 1x10t, and 1x20t) and 2 broken cranes

Source: CDN

Clinker and wheat are some of the main commodities handled in the Port, and these cargoes should be handled in the conventional terminal. However, many of bulkers carrying these cargoes use the container terminal currently, because the vessels for these commodities have a large draft and it is impossible to berth at the conventional terminal with 10 m deep berths. Table 3.6-11 lists vessels for clinker and wheat which called in 2009. At this point, the quays in the conventional terminal do not have enough capacity.

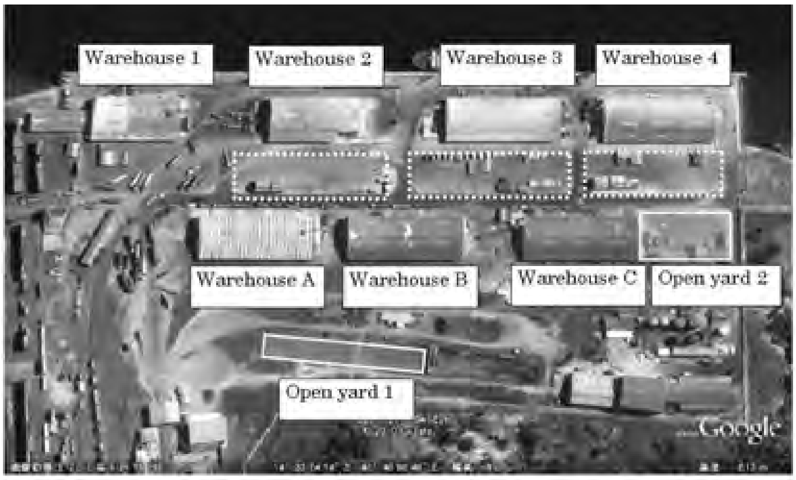
Table 3.6-11 Bulk carriers which called to the Port in 2009 (abstract)

SHIP	Type	Dwt	Gt	LOA	Beam	Depth	Draft	Delivered	Flag	Operator
SIAM SAPPHIRE	CLINKER	27652	16582	165.5	27.0	13.3	9.6	1986/3/1	Bahamas	Mur Shipping BV
POLYHRONIS	WHEAT	37648	23524	199.8	27.9	15.6	11.2	1980/9/1	Malta	Dalex Shipping Co SA
GAO QUIANG	WHEAT	45400	26062	186.2	30.4	16.5	11.6	1998/6/1	Hong Kong	COSCO HK Shipping Co Ltd
HARRIETTE	WHEAT	25952	15531	172.9	22.8	14.4	10.3	1978/4/1	USA	Sealift Inc
MARY ANN HUDSON	WHEAT	36414	21734	186.5	28.5	15.3	10.8	1981/5/1	USA	US United Ocean Services
AYSE AKSON	CLINKER	45694	26063	185.7	30.4	16.5	11.6	1995/9/1	Malta	Akmar Shipping & Trading SA
CONQUEROR	WHEAT	38584	22992	190.0	28.4	15.5	11.0	1985/6/1	Malta	Leros Management
AFRICA LION	CLINKER	26300	16041	168.7	26.0	13.3	9.5	1995/8/1	Bahamas	Mur Shipping BV
THETIS	CLINKER	73653	38891	225.0	32.3	19.0	13.8	1993/9/1	Singapore	Newfront Shipping SA
SELENDANG MILAN	CLINKER	47214	28097	189.9	31.0	16.6	11.9	1997/9/1	Malaysia	Transocean Grabbulk Pool
OMIROS	WHEAT	42183	25169	185.9	30.4	16.2	11.5	1987/1/1	Cyprus	Navina Maritime SA
EMPEROR	WHEAT	38870	22064	179.9	30.5	15.3	10.9	1986/9/1	Liberia	Sea Lion Shipmanagement Pvt
SUNNY GORY	WHEAT	56057	31236	190.0	32.3	17.9	12.6	2006/12/1	Panama	Usui Kaiun KK

Source: CDN, Study Team

2) Capacity of existing warehouses and open yards at the conventional terminal

The current allocation of warehouses and open yards in the conventional terminal is shown as follows.



Source: Study Team

Figure 3.6-2 Layout of warehouses and open yards in the conventional terminal

Table 3.6-12 Existing area of warehouses and open yards in the Port

	Area	Frontage	Depth	Floor	Commodity
Warehouse 1	3,040 m^2	80m	38m	1	Fertilizer
Warehouse 2	2,880 m^2	80m/60m	38m/30m	1	Sugar
Warehouse 3	3,800 m^2	100m	38m	1	Sugar
Warehouse 4	3,800 m^2	100m	38m	1	Fertilizer
Warehouse A	3,800 m^2	100m	38m	1	Wheat
Warehouse B	3,800 m^2	100m	38m	1	Fertilizer
Warehouse C	3,800 m^2	100m	38m	1	Fertilizer
Open yard 1	2,800 m^2	140m	20m	-	Scrap metal
Open yard 2	3,600 m^2	80m	45m	-	Fertilizer

Source: Scaled up by the Study Team

The open yards behind the warehouse 2~4 are used as stacking yard for empty containers and devanning yard. The area of warehouses and open yards for each commodity in the conventional terminal is shown in the following table.

Table 3.6-13 Existing storage area for each commodity in the conventional terminal

Commodity	Place	Area (m2)
Fertilizer	Warehouse 1,4,B,C	14,440 m^2
	Open yard 2	3,600 m^2
	Total	18,040 m^2
Wheat	Warehouse A	3,800 m^2
Sugar	Warehouse 2,3	6,680 m^2
Scrap metal	Open yard 1	2,800 m^2

Source: Study Team

The main conventional commodities in the Port are wheat, rice, fertilizer, clinker, and cement for discharged cargoes and sugar and scrap for loaded cargoes. The dwell time for each conventional cargo is shown in the following table.

Table 3.6-14 Dwell time for each conventional cargo in the Port

Commodity	Type of cargo	Dwell time (days)
Wheat	Bulk	15
Fertilizer	Bulk (partially Bagged)	25
Clinker	Bulk	-
Cement	Bagged	-
Sugar	Bagged	30
Rice	Bagged	-
Scrap	Bulk	30

Source: CDN

The capacity of existing warehouse and open yard is calculated by following formula

$N = A \text{ x } R \text{ x } k \text{ x } w$

Here, N: available annual handling volume (ton/year)
R: cargo turnover (times/year)
k: occupancy rate
w: cargo volume stored per unit area (ton/m2)

The standard cargo turnover (R) for warehouse and open yard is 20-25 times/year. The turnover for the Port in the current situation is calculated to divide 365 days by dwell time.

Standard occupancy rate (k) of 0.5 is used. The standard value of cargo volume stored per unit area (w) is shown in Table 3.6-15. The storage operation in the Port is done manually without using pallet or forklift, so a rather small piled height is chosen for the calculation.

Table 3.6-15 Standard load per area for storage of each commodity

Item	Packing type	Load/unit area (t/m2)	Piled height (m)
Grain	Straw bag, Sack	2.0 - 3.5	3.0 - 4.5
Cement	Bag	1.5 - 3.0	2.0 - 3.0
Fertilizer	Straw bag	2.0 - 4.0	2.0 - 4.0
Sugar, Food	Bag, Box	1.5 - 3.0	1.5 - 4.0

Source: OCDI

Based on the assumption above, the capacity of warehouse and open yard is calculated as shown in the following table.

Table 3.6-16 Capacity of existing warehouses and open yards for each commodity

	Warehouse 1,4,B,C Open yard 2		Warehouse A		Warehouse 2,3	
	Fertilizer		Wheat		Sugar	
A (m^2)	18,040		3,800		6,680	
k	0.5		0.5		0.5	
w (t/m^2)	2.0		2.0		1.5	
	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
R (times/year)	25	15	25	24	25	12
N (ton/year)	451,000	263,384	95,000	92,467	125,250	60,955

Case 1: In case of using the standard value of turnover
Case 2: In case of using the current dwell time of the Port
Source: Study Team

3.6.2 Target of productivity improvement

In the previous sub section, the capacities of the existing terminals were assessed considering operational improvement without further investment in infrastructure and equipment. In this sub section, the target of productivity improvement by investment in infrastructure and equipment in addition to operational improvement is discussed. The target will be utilized as a basis of determination of the development scale.

(1) Container terminal

1) Quay side productivity improvement

The quay side capacity is calculated for the following three conditions:

a) Current Productivity (One reach stacker)

This case represents the use of current facilities (one reach stacker in the terminal with two berths) with standard operational efficiency as previously described.

b) Improved Productivity (Installation of reach stackers): Base Case

This case represents the productivity improvement by increasing the number of reach stackers. In this case, the productivity is calculated assuming that four (4) reach stackers are used on the quays at the same time when two vessels are moored, enabling two ship’s gears of each vessel to work.

c) Highly-Improved Productivity (Installation of quay gantry cranes)

This case represents further productivity improvement by the installation of three (3) quay gantry cranes in the terminal with two berths. For the installation of gantry cranes, thorough rehabilitation of the jetty or construction of a new jetty is required. Efficiency of the quay gantry crane varies depending on ports, for example, 10 moves/hr in Maputo, 15 moves/hr in Durban, and 20 moves/hr in Dar es Salaam. The Study Team has adopted 20 moves/hour for the calculation considering the competitive environment in the region.

The result of the calculation using the assumption above is shown in the following table. The process for calculation is the same as 3.6.1 (1). By the productivity improvement with investment in infrastructures and equipment, the quay side capacity increases more than threefold.

Table 3.6-17 Summary of quay side capacity at the container terminal

	Current Productivity	Improved Productivity	Highly-Improved Productivity
Equipment	1 reach stacker	4 reach stackers	3 quay gantry cranes
Design capacity of ship's gear or quay crane (moves/hr)	15	15	20
(Un)loading efficiency (%)	85	85	100
Number of cranes per vessel (cranes/vessel)	0.76	2	1.76
Handling efficiency combined cranes (%)	100	90	100
(De)berthing time (hrs/vessel)	3		
Other delays (hrs/vessel)	0		
Berth occupancy factor (BOF) (%)	65		
Berth number	2		
Parcel size (TEU/vessel)	487		
TEU factor (TEU/unit)	1.19		
Effective crane performance (moves/hr)	9.69	22.95	35.20
Total turnaround time (TAT) per call (hrs/vessel)	45.23	20.83	14.63
Available number of calls (calls/year)	235	511	728
Capacity of quays (TEU/year)	114,445	248,857	354,536

Source: Study Team

2) Yard productivity improvement

The required yard areas for handling the maximum numbers of containers calculated for each quay side productivity improvement scenario described above are estimated considering improvement of yard operation system (3 to 5 high RTG system). The unit stack area required for reach stacker/forklift system of 3 high is 21m^2 per TEU, and for RTG system, 3 high needs 13m^2/TEU, 4 high needs 10m^2/TEU, and 5 high needs 8m^2/TEU. The dwell time is assumed to be the standard dwell time used in 3.6.1 (1). Other parameters such as peak factor and reserve capacity are set at the same value used in the previous subsection.

The result is shown in Table 3.6-18. Since the area of the container terminal is approximately 75,000m^2, it is necessary to upgrade yard system from reach stacker or toplifter to RTG (4 high or 5 high) unless the terminal area is expanded when the quay side productivity is improved by increase of reach stackers or installation of quay gantry cranes.

In addition, the Study Team estimated the required stack area when the terminal accommodates one Panamax type vessel. In this case, quay side operation is assumed to be done by mobile crane system or quay gantry crane system. The design capacity of the mobile crane is assumed to be equivalent to the capacity of ship's gear. The average Panamax vessel size is 4,386 TEU while the average size of vessels currently calling the Port is 1,305 TEU. For the parcel size, the same rate as at present is adopted. The standard berth occupancy factor given in UNCTAD guidelines is 50% for one berth. The result of the calculation for the required stack area is also shown in Table 3.6-18.

Table 3.6-18 Required stack area for each terminal productivity improvement scenario

			Current vessel (L=372m for 2 berth)			Panamax (L=330 for 1 berth)	
			Current quay side productivity	Improved quay side productivity	Highly-improved quay side productivity	mobile cranes	quay gantry cranes
Quay Capacity		TEU/year	114,445	248,857	354,536	147,330	258,646
		TEU/year/berth	57,223	124,429	177,268	147,330	258,646
Required stack capacity		TEU	2,742	5,946	8,471	3,519	6,180
Required net storage area	Reachstacker/forklift system (3high)	m2	57,582	124,866	177,891	73,899	129,780
		m (Yard depth)	155	336	478	224	393
	RTG system 3high	m2	35,646	77,298	110,123	45,747	80,340
		m (Yard depth)	96	208	296	139	243
	RTG system 4high	m2	27,420	59,460	84,710	35,190	61,800
		m (Yard depth)	74	160	228	107	187
	RTG system 5high	m2	21,936	47,568	67,768	28,152	49,440
		m (Yard depth)	59	128	182	85	150

Source: Study Team

(2) Conventional terminal

As mentioned in 3.6.1 (2), current quays at the conventional terminal do not have enough depth for the vessels of clinker or wheat. Accordingly, berths which have enough depth for conventional cargoes should be provided by new construction or conversion from container berths. The target of productivity improvement for conventional cargo handling will be discussed in the next sub-section.

3.6.3 Proposal of development scale

The Study Team proposes the development scale of the Port in the target year of 2030 based on the demand forecast in the previous section and the target of productivity improvement as discussed above. The development scale is proposed for three scenarios, namely the Current Productivity case, the Improved Productivity Case (Base Case), and the Highly Improved Productivity Case as defined in the previous subsection.

Container Terminal

Dividing the forecasted container throughput by the target productivity defined in the previous sub-section, the required number of container berths is calculated as two Panamax berths in 2030 for the Base Case with mobile cranes and the Highly Improved Productivity Case with quay gantry cranes. It should be noted that rehabilitation of the deteriorated jetty or construction of a new jetty is the precondition to the productivity improvement. Thus, the required numbers are the same in the base and the Highly Improved Case, though the container throughput is 20% larger in Highly Improved Case. On the contrary, in Current Productivity Case, which represents continuation of current insufficient investment in cargo handling equipment, larger number of berths is required, though the throughput is 10% less than that in Base Case. Thus, the Current Productivity Case would not be financially viable.

Mineral Terminal

The total capacity of the state of the art coal terminal with four berths in South Africa’s Richards Bay Port, which can accommodate cape size bulkers, is 91 million tons. The forecasted handling volume of exported coal and other mineral products is 40 million tons in 2030. Assuming that the mineral terminal in Nacala can achieve the same level of productivity as at Richards Bay, the required number of mineral berths in Nacala is estimated to be two in 2030.

Grain Terminal

Capacity of unloader is a decisive factor in the total capacity of a grain terminal. Assuming productivity of 500 tons per hour as the target, the annual capacity of the terminal is calculated as 2.3 million tons when the berth occupancy is 65% and the operation ratio is 80%. This is fairly coincident with the forecasted throughput in 2030. Accordingly, the required number of berths is one.

Minor bulk Terminal

Although the current bulk handling productivity at the quay in the Port is 73.1 tons/hr for wheat, 157.9 tons/hr for clinker, and 45.1 tons/hr for fertilizer respectively, the Study Team estimates that the productivity would increase up to 240 tons/hr for clinker (which is 50% higher than current productivity), and 120 tons/hr for other minor bulks (which is equivalent to current average productivity in Dar es Salaam Port) before the target year. Assuming the same berth occupancy and operation ratio as described above and operating hours of 20 hours/day, the annual handling capacity per berth can be calculated as 910,000 tons/year for clinker and 460,000 tons/year for other minor bulks. Accordingly, required number of miner bulk berths is 3.5 in 2030.

Vehicle Terminal

Assuming productivity of vehicle unloading at the same level as that in Dar es Salaam (39 units per hour), and the above operation hours, operation rate and berth occupancy, the required number of vehicle berth is calculated as 0.5 in 2030, respectively. This implies that specially designated vehicle terminal will not be necessary within the planning horizon. Vehicles shall be handled combined with other break bulk or dry bulk.

Oil and LPG Terminal (for imported oil products)

Assuming the average unloading productivity of 300 tons per hour, and 24 hours operation, the annual handling capacity of one fuel jetty is 1.4 million tons, which exceeds the forecasted handling volume in 2030. Therefore the required number of oil jetties is one.

The required number of berths is summarized in Table 3.6-19. Since the existing container berths are equivalent to one Panamax container berth and the conventional berths are equivalent to two Panamax berths (one for oil and gas, and one for minor bulks), one container berth, two mineral berths, one grain berth and three multi purpose berths shall be additionally constructed by 2030.

Table 3.6-19 Required number of berths in the target years

	Numbers of berths currently available	Required numbers of berths in 2030	
		Current container productivity case	Base case and highly improved container productivity case
Container Terminal	1	3	2
Mineral Terminal	0	2	
Grain Terminal	0	1	
Vehicle Terminal	0	4	
Minor Bulk Terminal	1		
Oil and LPG Terminal	1	1	

The numbers of currently available berths and required berths are counted assuming that all berths are Panamax berths. For mineral terminal, cape size berth is considered.

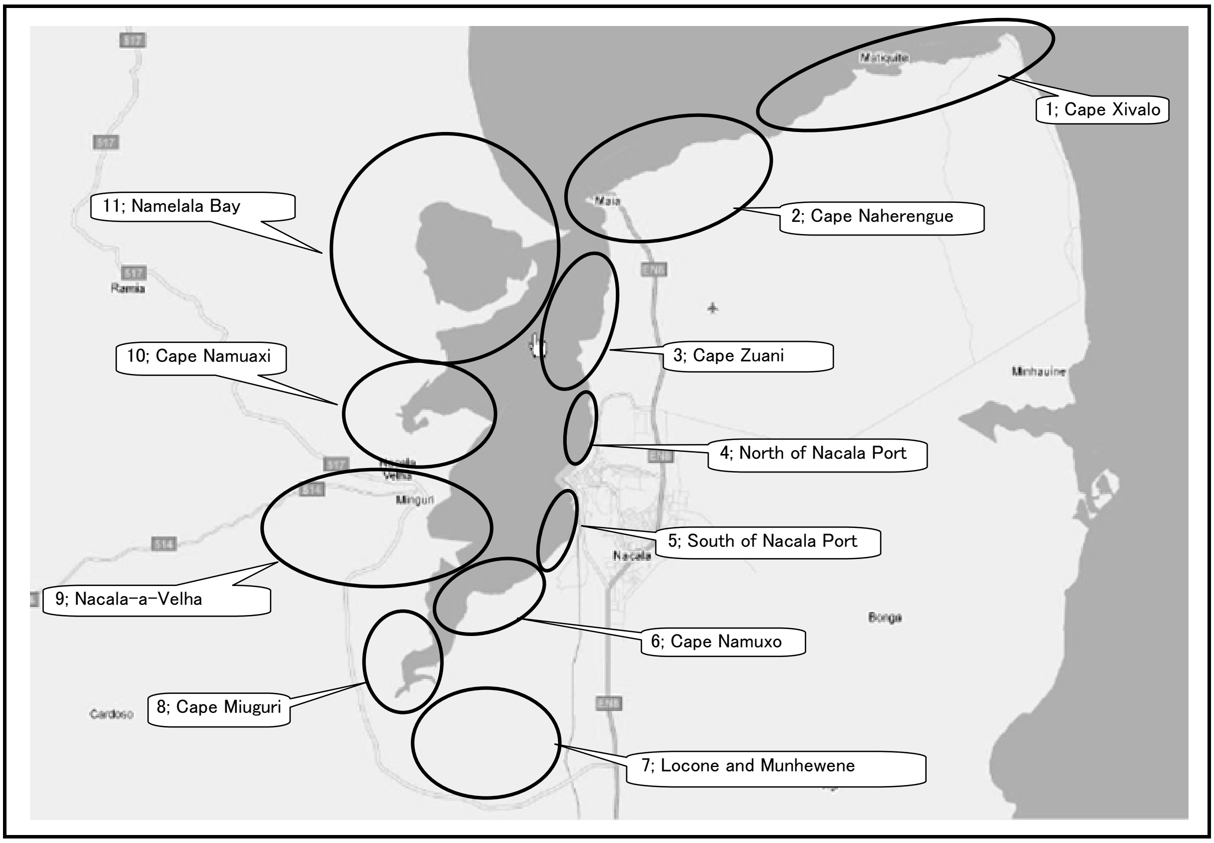
Source: Study Team

3.7. Space for port development in Nacala Bay

3.7.1 Present situation of Nacala Bay area

The Study Team surveyed the coastal area of Nacala Bay and its vicinity in September 2010. Based on this survey, the present situation of Nacala Bay was grasped and is summarized below. Eleven areas are identified along the coast of Nacala Bay as shown in Figure 3.7-1.

(Date of investigation)	20th, 21st and 22nd of September, 2010
(Purpose of investigation)	To investigate space for port development To confirm and record current land use along Nacala Bay To study future land use linking with a port master plan To investigate surrounding environmental situation



Source: Study Team, Google Map

Figure 3.7-1 Identification of coastal area of Nacala Bay and its vicinity

No.1 Cape Xivalo

This area covers Cape Xivalo and the southern coast of Fernão Veloso Bay to the west of the cape. The coastal area has no access road except a path leading to a light house at the cape, and consists of shallow coral rock beach. Although there are a few fishermen’s village at around Cape Xivalo, the others are uninhabited and non-utilized area. Waves from the outer ocean are relatively high.

Source: Study Team

Figure 3.7-2 Area No.1; Cape Xivalo

No.2 Cape Naherengue

This area covers Cape Naherengue and the southern coast of Fernão Veloso Bay to the east of the cape. The cape is connected to the downtown and the existing port by the paved road via new international airport. The cape is facing to the navigation channel leading to Nacala Port. Some modern resort hotels are located around the hotel. The area around the cape is also a fishing center with fishermen’s village, fish market and a beach for boat landing and net repairs. The beach consists of coral sand with a few coral rocks in shallow ground surface. Whales, the largest sea mammal, were observed in this area at the deepest point along the navigation channel in September 2010.

The some part of littoral area to the west of Cape Naherengue is used for agricultural fields with unpaved narrow access road. There is a fish processing factory near the beach. Some buildings are under construction along the access road near the beach.

Source: Study Team

Figure 3.7-3 Area No.2; Cape Naherengue

No.3 Cape Zuani

This area includes Cape Zuani, where a navigation light leading to the Port is located, and the eastern coast of Nacala Bay between Cape Zuani and Cape Naherengue. The coastal area consists of rocky cliff, and there is no access road to the beach except the area near Cape Zuani, where a fishing village and a boat landing beach is located. The coast is mostly undeveloped natural beach. The wave condition is calm. On the cliff, there are some villages and agricultural fields.

Source: Study Team

Figure 3.7-4   Area No.3; Cape Zuani

No.4 North of Nacala Port

This area covers the eastern coast of Nacala Bay between Cape Zuani and the existing facilities of the Port. The topographical feature of this area is almost the same as that of Area No.3, with a cliff dividing the upper and lower areas. However access to the beach is easier because the height of the cliff is lower. A cement factory is located along the beach in the north of this area, and there is an access road from the Port and the national road to the factory for trucks carrying cement and clinker. Around the cement factory, a little more space is available for industrial development. There is a substantial number of small houses on the slope of the cliff behind the beach. Most of them are located more than 100 m away from the beach because it is prohibited to build a house within 100 m from the beach of Nacala Bay.

The wave condition is calm. The coastal area consists of coral sand. At north vicinity of the port, there are coral sand beach as shown in the Figure 3.7-5.

Source: Study Team

Figure 3.7-5   Area No.4; North of Nacala Port

No.5 South of Nacala Port

This area is located to the south of Nacala Port. The coastal area is facing Nacala Bay and the wave condition is calm. The coastal area consists of coral sand. This area is already used for logistics relating to the Port, such as warehouses and oil storage tanks, though the land utilization density remains low. There is enough space for further industrial development and this area has a very high potential as an IFZ specializing in logistics. The access roads are unpaved and roads towards south coast are utilized by fishermen. The beach is used for landing of fishing boats.

Source: Study Team

Figure 3.7-6 Area No.5; South of Nacala Port

No.6 Cape Namuxo

This area is located in the south of Nacala Bay. The coastal area is facing the inner part of Nacala Bay and the wave condition is calm. The coastal area consists of coral sand. A few fishermen are living here and they fish along this sand beach. Some factory is located in this area.

Although the coast of this area is not suitable for industrial use due to shallowness of the water and environmental vulnerability of the inner bay, the proximity to the Port makes the undeveloped flat land suitable for industrial development (export processing etc.).

Source: Study Team

Figure 3.7-7 Area No.6; Cape Namuxo

No.7 Locone and Munhewene

This area is located to the southeast of Nacala Bay along Nacala Railway. This area was designated as an Industrial Free Zone by GAZEDA as shown in the Figure 3.7-8. Residents are currently being relocated. However, as of December 2010, no infrastructure has been developed in this IFZ. Water supply to this free zone could be a major issue since the area is located on a higher hill and is quite vast (50ha x2 =100ha). It is doubtful whether a desalination facility with sufficient capacity to supply industrial water to the IFZ could be established here.

Source: GAZEDA

Figure 3.7-8 Industrial Free Zone nominated by GAZEDA

Source: Study Team

Figure 3.7-9 Area No.7; Locone and Munhewene

No.8 Cape Miuguri

This area is located at the southern end of Nacala Bay. This area has a salt production field using seawater. The coastal area is facing the shallow inner bay area and consists of coral sand beach. The national road connecting Nacala and Nacala-a-Velha passes through this area.

Source: Study Team

Figure 3.7-10 Area No.8; Cape Miuguri

No.9 Nacala-a-Velha center

This area includes downtown in Nacala-a-Velha. The area is connected to Nacala City and Nacala Corridor by a national road. The coast is consists of shallow coral sand beach. The coast in front of the downtown is used for boat landing.


Source: Study Team

Figure 3.7-11 Area No.9; Nacala –a-Velha center

No.10 Cape Namuaxi

This area is located to the north of downtown Nacala-a-Velha. The coastal area consists of shallow coral sand beach with scattered mangrove. The land area is relatively flat, and there are some villages and agricultural fields. Unpaved access road from the national road is available. This area has been nominated as a coal export terminal including a loading facility by Vale Mozambique. Construction of new rail track connecting to Nacala Railway is planned by Vale.


Source: Study Team

Figure 3.7-12 Area No.10; Cape Namuaxi

No.11 Namelala Bay

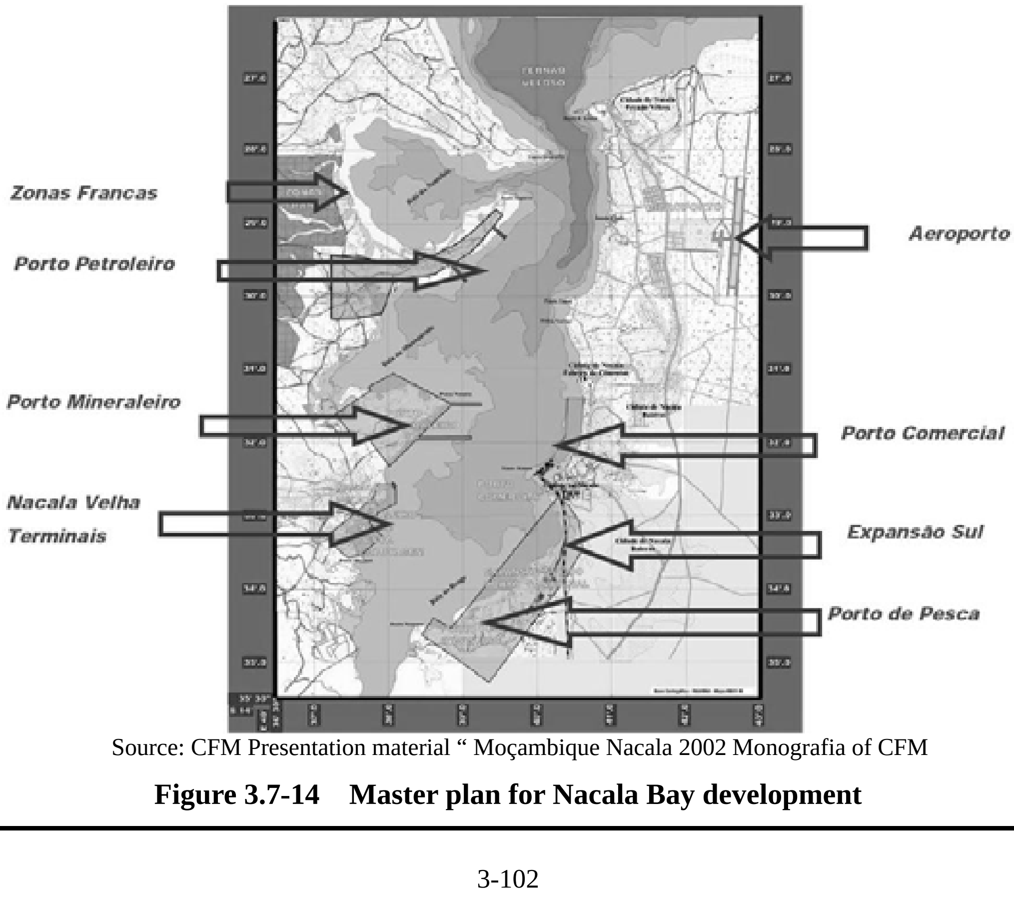
This area is located at the western coast near the entrance of Nacala Bay. The bay is surrounded by Cape Sacamulo to the north and Cape Oquero to the south. The coastal area consists of shallow and beautiful coral sand beach. Fishing villages are scattered along the bay. There is a plan to develop the whole area of Cape Oquero as a oil refinery complex, though it continues to remain in the planning stage.

Source: Study Team

Figure 3.7-13 Area No.11; Namelala Bay

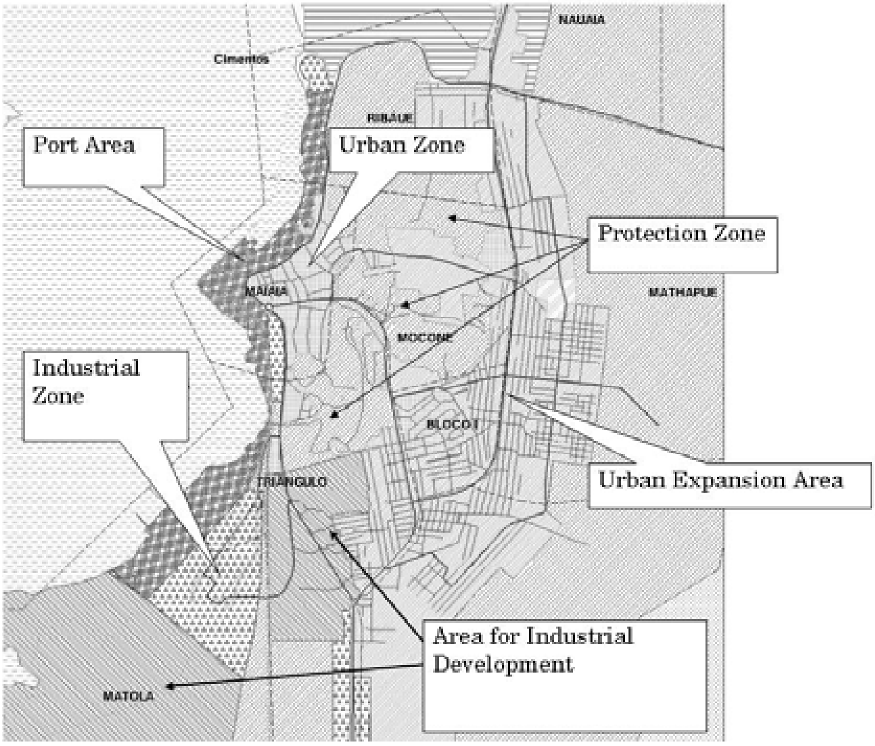
3.7.2 Review of existing land use plans

As mentioned in the previous chapter, a master plan covering the whole area of Port Jurisdiction, namely Nacala Bay and Fernão Veloso Bay, doesn't exist. CFM has a master plan for Nacala Bay Area as shown in Figure 3.7-14 though it is currently being revised. According to the master plan, expansion of the existing port to the north and the south is planned. A very large fishing port is planned to the south of the southern expansion. On the Nacala-a-Velha side, there are plans to construct a petroleum port on Cape Oquero to unload crude oil for a planned oil refinery and a mineral port on Cape Namuaxi, as well as a port terminal in front of downtown Nacala-a-Velha. Nacala City Master Plan defines the port area the same as that given in CFM's Master Plan as shown in Figure 3.7-15. For Nacala a Velha, a city master plan has not been formulated yet. According to information from GAZEDA, a city master plan of Nacala-a-Velha is under discussion, and it is probable that Cape Namuwaxi would be the only littoral area planned as an industrial zone, while another littoral area would be planned as a residential zone or a tourism zone.



Source: CFM Presentation material " Moçambique Nacala 2002 Monografia of CFM

Figure 3.7-14 Master plan for Nacala Bay development



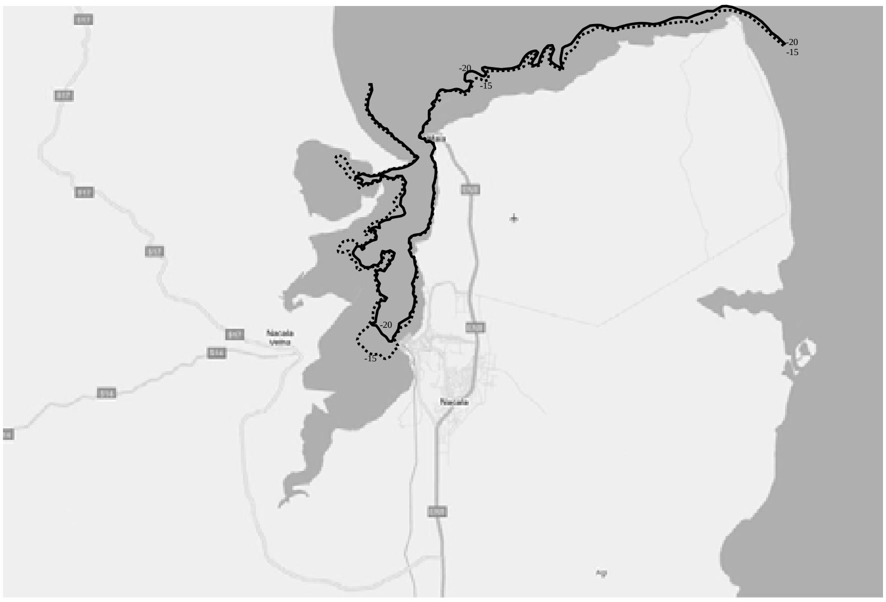
Source: Nacala City Master Plan, Nacala City

Figure 3.7-15 Port area defined in Nacala City Master Plan

3.7.3 Evaluation of development space

Since the eastern side of the bay is deeper than the western side as shown in Figure 3.7-16, basically the Nacala side is more suitable for deep sea port development. However there is a topographical disadvantage at this location. There is little land space available for port development on the eastern side because the cliff rises sharply from the sea. Therefore, for development of bulk terminals, where a cargo handling yard doesn't have to be located in the vicinity of a quay, Nacala-a-Velha side can be advantageous due to the availability of flat land. Thus, it should be noted that very limited land space is available for deep sea port development in Nacala Bay and Fernão Veloso Bay, and a well-planned rational land use of the littoral area is crucial.

Based on the assessment of current land use and the review of existing master plans described in the previous subsections, as well as the above mentioned topographical feature, the Study Team evaluated the potential of Nacala Bay and Fernão Veloso Bay for port development as shown in Table 3.7-1. It is concluded that the only available area for development of a deep-sea commercial port is *The North of Nacala Port*, and that a potential area for mineral port is *Cape Namuaxi*. Considering vital importance of *The North of Nacala Port*, land management of this area and its surroundings shall be strictly conducted, and the area shall be protected from urbanization. It should be also noted that land use of the area to the south of the Port shall be well-harmonized with port activity.



Source: Study Team (based on Google Map and Nautical Chart)

Figure 3.7-16 Chart of isobath in Nacala Bay

Table 3.7-1 Evaluation of port development space

Area	Potential for port development	Remark
1. Cape Xivalo	Low	Environmentally sensitive area. Water depth is insufficient.
2. Cape Naherengue	Low	Environmentally sensitive area. Water depth is insufficient.
3. Cape Zuani	Low	A cliff rises sharply from the sea. Environmentally sensitive area.
4. North of Nacala Port	Very High	Sufficient water depth. Land area is available to some extent. Good access to existing port terminal. The only available area for a deep-sea commercial port.
5. South of Nacala Port	Medium	Not suitable for deep-sea port due to shallowness of the water. Due to its vicinity to the existing port and the city center, this area has potential as a local ferry terminal, fishing port and basin for pleasure boats and other small crafts.
6. Cape Namuxo	Low	Water depth is insufficient. Coastal zone of this area has low potential for port development, however the land area behind it is very important for industrial development closely related with port activity.
7. Locone and Munhewene	Low	ditto
8. Cape Miuguri	Low	Water depth is insufficient.
9. Nacala-a-Velha center	Low	Water depth is insufficient.
10. Cape Namuaxi	High	This area has high potential as a mineral port due to the availability of flat land though a long access bridge to a deep-sea pier is required. Considerable numbers of people are living and farming in this area, and mangroves are scattered along the coast line. Therefore, due socio-environmental consideration is required for the port development.
11. Namelala Bay	Low	Water depth is insufficient. Environmentally fragile. Land area is insufficient. Though the existing master plan locates oil refinery on Cape Oquero (located to the south of the bay), this area is not suitable for a oil port due to environmental reasons.
12. Western shore of Fernao Veloso Bay	Medium	Though due environmental consideration is required, this area would have a potential for development of a crude oil port and an oil refinery.

Source: Study Team

3.8. Dimensions and basic layout of port facilities

3.8.1 Dimensions of port facilities

(1) Container quay

The dimensions of the container ships currently calling on the Port are listed in Table 3.8-1. The largest ship is Wehr Oste having DWT of 33,670, TEU capacity of 2,526, length overall of 208.3m and full load draft of 11.4 m. To accommodate this ship, the minimum length and depth of the berth are 240 m and -13 m, respectively.

Table 3.8-1 Dimensions of container carriers currently calling on Nacala Port

Vessel name	Vessel Type	Geared or not	Container Capacity (TEU)	LOA (m)	Draft (m)	Beam (m)	DWT	GT	Reefer Plug	Delivery date
ESM Traveller	FC	Y	1,128	151.31	9.78	25.07	17,400	12,691	150	01-Nov-84
Karin Rambow	FC	Y	1,118	147.87	8.51	23.25	13,807	9,957	220	01-Sep-05
Orinoco River	FC	Y	1,118	147.84	8.51	23.45	13,760	9,940	220	01-Dec-07
Sea Venture	FC	Y	1,118	147.82	8.50	23.25	13,716	9,954	220	01-Sep-08
Cassandra B	FC	Y	1,698	182.44	10.00	25.20	23,623	18,263	330	01-Sep-08
CMA CGM Maasai	FC	Y	1,452	167.07	9.84	25.00	20,406	14,981	150	01-Oct-95
CMA CGM Kailas	FC	Y	1,858	195.50	11.00	27.80	24,279	21,971	300	01-Feb-06
Elisa Delmas	FC	Y	1,641	168.80	9.21	27.20	20,979	16,916	200	01-Apr-02
Nala Delmas	FC	Y	1,641	168.80	9.22	27.20	20,944	16,916	200	01-Oct-02
Warnow Trader	FC	Y	1,608	167.97	10.82	27.06	22,250	16,165	200	01-Dec-96
MSC Leila	FC	Y	928	158.91	10.10	23.09	16,768	13,315	66	01-Jul-87
Kota Anggun	FC	Y	1,454	182.83	9.53	28.00	23,842	17,652	100	01-Jun-99
Kota Hapas	FC	Y	1,080	159.53	9.22	25.00	18,889	13,491	150	01-Mar-02
Pacific Diamond	FC	Y	1,170	159.53	8.72	25.00	17,296	13,547	150	01-Jan-02
Kota Hakim	FC	Y	1,098	159.50	9.22	25.00	18,830	13,491	150	01-Sep-01
Viona	FC	Y	1,853	178.57	10.86	28.20	22,248	17,360	385	01-Mar-06
Violetta	FC	Y	1,853	178.57	10.86	27.60	22,267	17,360	385	01-Feb-07
Wehr Oste	FC	Y	2,526	208.30	11.40	30.04	33,670	25,703	481	01-Nov-02
Barrier	FC	Y	1,162	162.92	8.10	22.30	14,099	10,743	100	01-Aug-97
Ridge	FC	Y	1,162	163.40	8.12	22.30	14,148	10,749	100	01-Jul-95
White Rhino	SC	Y	474	113.00	8.39	19.03	9,340	5,977	0	01-Apr-86
Black Rhino	SC	Y	364	139.20	3.77	16.70	5,107	4,976	0	01-Jul-95

Source: Lloyd's Register, edited by the Study Team

The size of container ships is expected to increase as the container traffic volume increases. The characteristic dimensions of various sizes of container ships are shown in Table 3.8-2. Except the world container trunk route serving for the trade between the East and the West, shipping lines deploy container ships as large as 50,000 DWT, which is called "Panamax", or smaller ones. Therefore, the maximum size of the container ships calling on Nacala Port within the planning horizon is likely Panamax. Thus, the dimensions of container berths are obtained from Table 3.8-3 as -14 m deep and 330m long.

The width of the apron should be 40 m, which is wide enough for container cargo handling by reach stackers and trailers. It is preferable that the container terminal have inland depth of 350m or more. However, in case of existence of spatial restrictions, it can be reduced to some extent if efficient container operation is carried out.

Table 3.8-2 Dimensions of container ships

DWT	Length Overall (m)	Width (m)	Full load draft(m)	TEU Capacity
10,000	139	22.0	7.9	500 - 890
20,000	177	27.1	9.9	1,300 - 1,600
30,000	203	30.6	11.2	2,000 - 2,400
40,000	241	32.3	12.1	2,800 - 3,200
50,000	274	32.3	12.7	3,500 - 3,900
60,000	294	35.9	13.4	4,300 - 4,700
100,000	350	42.8	14.7	7,300 - 7,700

Source: OCDI, Japanese Design standard for port and harbor facilities, 2009

Table 3.8-3 Standard values of main dimensions of container berths

Self weight tonnage DWT (t)	Length of berth (m)	Water depth of berth (m)	(Reference) Container capacity (TEU)
10,000	170	9	500 - 890
20,000	220	11	1,300 - 1,600
30,000	250	12	2,000 - 2,400
40,000	300	13	2,800 - 3,200
50,000	330	14	3,500 - 3,900
60,000	350	15	4,300 - 4,700
100,000	400	16	7,300 - 7,700

Source: OCDI, Japanese Design standard for port and harbor facilities, 2009

(2) Dry/liquid/break bulk quay

The required dimensions of bulk terminals depend on the kinds of good handled there. The Study Team's recommendation on the dimensions of bulk quays are described below.

Grain Terminal

Grain handling is a strategically important business of Nacala Port thanks to its deep water bay. In order to form a hub function, the Port has to be able to accommodate the largest bulk carrier deployed in grain transport in the region. For this reason, the design vessel shall be a smaller Cape size bulker (90,000 DWT).

Mineral Terminal

For transport of bulk mineral products, larger Cape size vessels are deployed. The design vessel shall be as large as possible, and at least be larger than that of Richards Bay, the largest bulk port in Sub Sahara. Accordingly, the design vessel shall be a 150,000 DWT bulker.

Oil and LPG Terminal

Although current parcel size is very small in Nacala Port, relatively large tankers have called at the Port. With increase of demands, the storage capacity in Nacala would be increased, and the parcel size would become large enough to secure economic efficiency of transport by large tankers. Therefore the design vessel shall be Large Range 1 (LR1:45,000 DWT to 79,999 DWT). LR1s are broadly used for medium or long distance transport of oil products.

Minor Bulk/Vehicle Terminal

Since PCCs generally have smaller draft than bulk carriers, a bulk carrier shall be a design vessel of a multi-purpose berth. Minor bulks such as wood chip, cement, fertilizer and agricultural products are normally transported by Panamax (60,000 DWT to 79,999 DWT), Handymax (35,000 DWT to 59,999 DWT) or smaller bulkers. Panamax bulkers have been calling at Nacala Port with their draft adjusted. Accordingly, the design vessels shall be 70,000 DWT and 55,000 DWT.

Based on the above consideration and standard dimensions of ships and berths shown in Table 3.8-4 to Table 3.8-6, dimensions of bulk quays can be obtained as shown in Table 3.8-7.

The required inland depth of bulk terminals is smaller than that of container terminals with the exception of highly productive bulk terminals such as coal terminals. Therefore, when quays for minor bulk cargoes are planned to be aligned with container quays, the bulk terminals would have enough inland depth.

Table 3.8-4 Dimensions of cargo ships

DWT	Length Overall (m)	Width (m)	Full load draft(m)
10,000	132	20.7	8.1
12,000	139	21.8	8.6
18,000	156	24.4	9.8
30,000	182	28.3	10.5
40,000	198	30.7	11.5
55,000	217	32.3	12.8
70,000	233	32.3	13.8
90,000	251	38.7	15.0
120,000	274	42.0	16.5

Source: OCDI, Japanese Design standard for port and harbor facilities, 2009

Table 3.8-5 Standard values of main dimensions of cargo berths

Self weight tonnage DWT (t)	Length of berth (m)	Water depth of berth (m)
1,000	80	4.5
2,000	100	5.5
3,000	110	6.5
5,000	130	7.5
10,000	160	9.0
12,000	170	10.0
18,000	190	11.0
30,000	240	12.0
40,000	260	13.0
55,000	280	14.0
70,000	300	15.0
90,000	320	17.0
120,000	350	18.0
150,000	370	20.0

Source: OCDI, Japanese Design standard for port and harbor facilities, 2009

Table 3.8-6 Dimensions of tankers

Dead Weight Tonnage DWT (t)	Length overall (m)	Length between perpendiculars (m)	Molded breadth (m)	Full load draft (m)
1,000	63	57	11.0	4.0
2,000	77	72	13.2	4.9
3,000	86	82	14.7	5.5
5,000	100	97	16.7	6.4
10,000	139	131	20.6	7.6
15,000	154	146	23.4	8.6
20,000	166	157	25.6	9.3
30,000	184	175	29.1	10.4
50,000	209	199	34.3	12.0
70,000	228	217	38.1	12.9
90,000	243	232	41.3	14.2
100,000	250	238	42.7	14.8
150,000	277	265	48.6	17.2
300,000	334	321	59.4	22.4

Source: OCDI, Japanese Design standard for port and harbor facilities, 2009

Table 3.8-7 Proposed dimensions of port facilities

	Design Vessel	Length per Berth (m)	Water Depth (m)
Grain Terminal	90,000 DWT bulker	320	-17
Mineral Terminal	50,000 DWT bulker	370	-20
Oil Terminal	70,000 DWT tanker	270	-15
Minor Bulk/Vehicle Terminal	55,000 DWT bulker	280	-14
	70,000 DWT bulker	300	-15

Source: Study Team

3.8.2 Basic layout

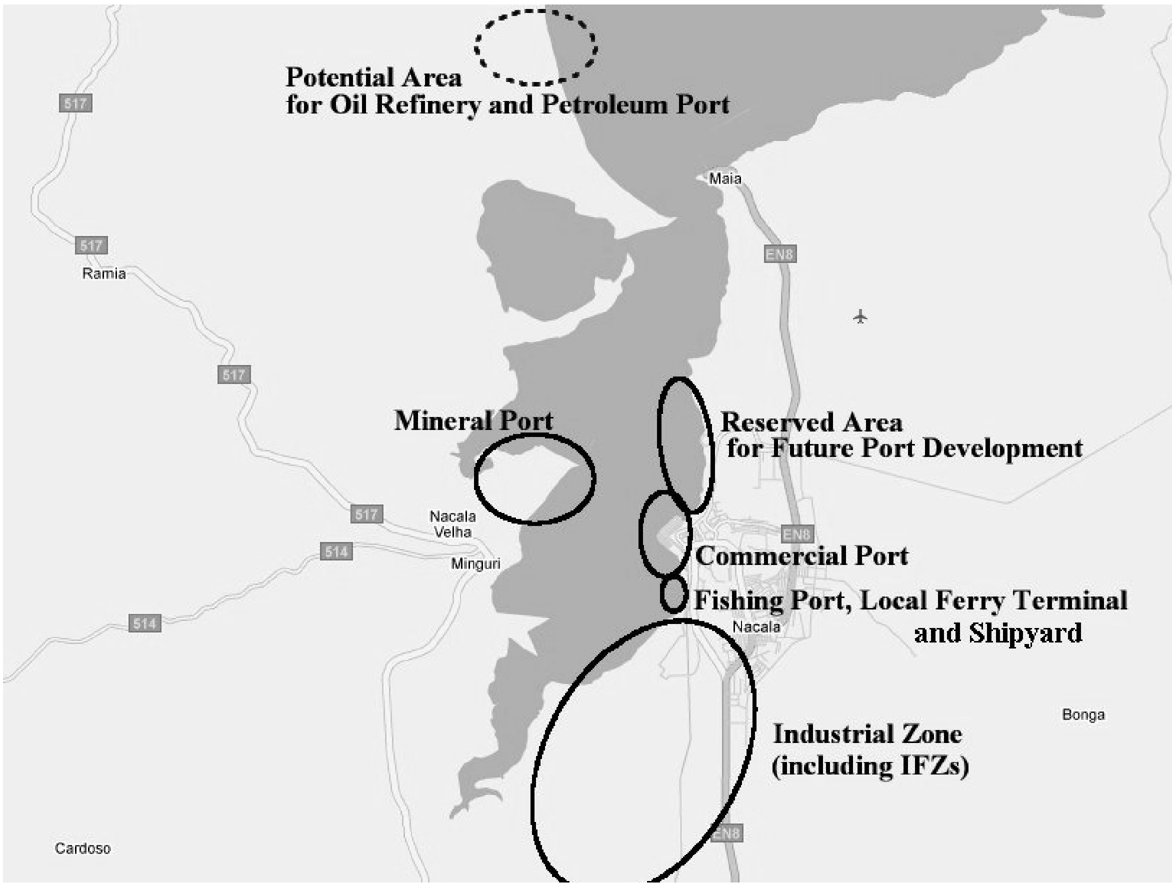
Based on the assessment of development space, the Study Team proposes a zoning plan of the Port as shown in Figure 3.8-1.

Since the existing footprint of the Port has an enough space for future development, the function of the commercial port (which excludes mineral terminal for coal and other ore handling) should be concentrated basically in this area and its vicinity.

The area to the north of the existing port facilities are the only available space for expansion of the deep-sea commercial port in Nacala Bay and Fernão Veloso Bay. Therefore, this area should be reserved for future development, and urbanization of this area should be restricted.

The water depth of the area to the south of the existing port facilities is not enough to accommodate large vessels, but this area is suitable for a fishing port, a local ferry terminal and a basin for small crafts due to the proximity of the city center. This location will be used for a shipyard. Considering future growth of ship's calls at the Port, it is important that a facility for ship repair exists in the Port. Utilizing the incentive scheme of SEZ, private investment in a shipyard shall be strategically promoted.

Cape Namuaxi is suitable for a mineral port handling exported coal and other minerals due to the availability of flat land and access to a deep-water pier, however due socio-environmental consideration is required in the planning and implementation of the mineral port project.



Source: Study Team, Google Map

Figure 3.8-1 Zoning plan of the Port

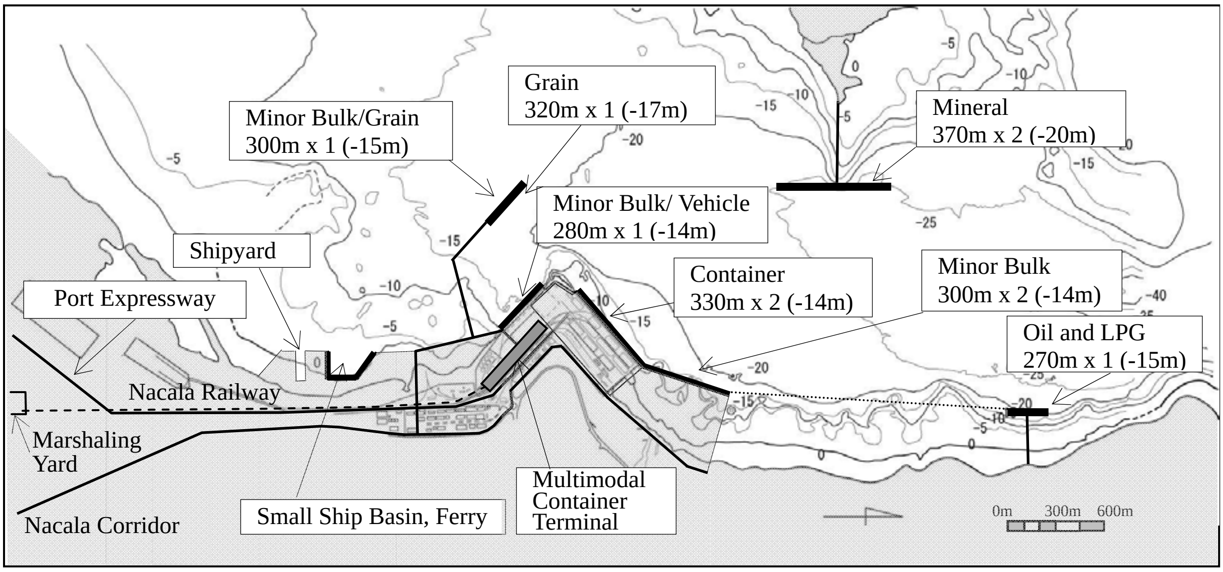
Although the Study Team forecasted that crude oil would not be handled in the Port within long term planning horizon since feasibility of an oil refinery and an oil pipeline has not been confirmed, if demands arise, a crude oil unloading facility and a refinery shall be located out of Nacala Bay. Though the existing master plan locates it on Cape Oquero in Nacala Bay, this should be revised because the semi-enclosed bay of Nacala is environmentally very fragile. It is expected that even Fernao Veloso Bay possesses acceptable calmness for crude oil tankers, and there is no justification to locate a crude oil unloading facility and a refinery inside Nacala Bay. A candidate site would be the western coast of Fernão Veloso Bay.

The layout plan of the Port in the target year of 2030 is shown in Figure 3.8-2. The main points of the plan are as follows:

- The container terminal shall be relocated to the North Wharf because the South Wharf doesn't have enough inland depth which enables modernized container handling. For efficient container operation, the container berths shall be continuously aligned; however the existing South Wharf can accommodate only one berth, and its southward extension is very difficult due to shallowness of the basin. Therefore, instead of repairing the deteriorated container jetties in the South Wharf, new container berths shall be constructed in the North Wharf. The whole area of the North Wharf shall be utilized as a container terminal, and all container handling function shall be relocated there.
- The South Wharf is seriously damaged, and is not suitable for heavy cargo handling. Accordingly, this shall be used for light cargoes handling such as wood chip and vehicle in order to extend residual life of the structure.
- Since all areas of the North Wharf will be utilized as a container terminal as mentioned

above, the fuel terminal shall be relocated to the northern end of the future development area in order to secure maritime safety and to prevent environmental hazards. There is a dispute regarding the location of new fuel terminal. This will be discussed later.

- The sea to the north of the North Wharf shall be reclaimed, and a bulk terminal shall be constructed there.
- Grain berth shall be constructed to the west of the South Wharf, where the access to stock yard and railway is relatively easy and the basin is deepest, because it requires water depth of 17 meters or more in order to let it function as a grain hub in the region (Mozambique and southern Tanzania).
- A multimodal container terminal which realizes competitive sea and rail transport shall be located in the South Wharf directly linked to the container terminal in the North Wharf. This will be discussed in detail in the next section.
- The shallow water to the south of the existing footprint of the Port shall be reclaimed, and the reclaimed land shall be utilized as stock yards, warehouses, a shipyard, a basin for small vessels and a local ferry terminal.



Source: Study Team

Figure 3.8-2 Layout plan of port facilities

Figure 3.8-3 shows the plan of basins and a navigation channel. This figure indicates that the turning basin for mineral terminal blocks the main access channel, and that all vessels calling at the Port except those berthing at the newly developed jetties to the north of the existing footprint have to pass through the turning basin for the mineral terminal. This means that coordination for the use of basin by the harbor master is crucial in order to secure maritime safety. And this coordination and control shall be conducted in a very sophisticated manner to achieve required productivity as an international gateway port.

There is an idea in which the fuel terminal can be relocated to the south of the existing port facilities as shown in Figure 3.8-4. However, the Study Team cannot endorse this idea because the hazard level of tankers is completely different from that of ordinary cargo vessels and a small human error can cause serious incidents.

Another alternative would be to relocate to the area indicated as “Potential area for Oil Refinery and Petroleum Terminal” in Figure 3.8-1. This alternative is perfect in terms of maritime safety, maneuverability, and environmental protection; however it requires a large amount of investment. Accordingly, this alternative would be realistic only when the oil refinery project is materialized in the middle of the planning horizon. It should be noted that the market structure of oil and gas will change thoroughly when a refinery is established in the country, and that the demand forecast would have to be updated.

The comparison of the proposed location by the Study Team and the alternative location is shown in Table 3.8-8. The present location of the fuel terminal, which is at the end of the port terminals and is the nearest place to the mouth of the bay, is ideal from the view point of spatial planning of ports. It is recommended that the location of the fuel terminal should continue to be ideal after the expansion of the Port. Furthermore it should be noted that the existence of the mineral terminal in Nacala-a-Velha changed the situation of vessel traffic in the bay completely. If there were no jetty off the cape Namuaxi, the first alternative plan would have been acceptable though it is not ideal from the view point of maritime safety and environmental protection.

In the final stage of the Study, Nacala Municipality requested the Study Team to reconsider the location of the new oil and gas terminal. The Municipality explained that they could accept any port facility with the exception of an oil and gas terminal. The Municipality proposed that the new oil and gas terminal be constructed on the opposite side of the bay, which is out of their jurisdiction. The Municipality objects to the location of the new oil and gas terminal because there is a plan to construct a sewage plant in the vicinity, though the Study Team feels the two facilities could coexist.

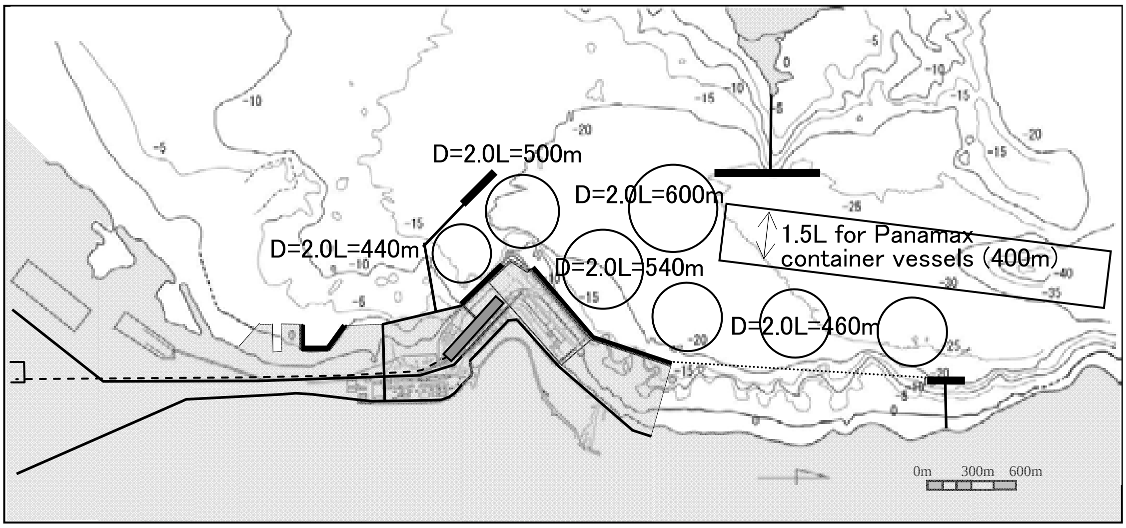
In order to overcome this objection, it is important to reach a consensus on the strategic importance of the coastal zone between the existing footprint of the Port and the Cape Nacuxa to the north, which is the sole area in Nacala Bay or even in the country where a deep sea port terminal can be constructed with minimum investment. Rational and well-coordinated use of this zone is the key strategy of the long term port development. The development of this area as a deep water port terminal is of vital importance in the context of the national economy and local employment. The government should make the utmost effort to instill this among stakeholders.

It should be noted that oil and gas is one of the commodities which require a deep sea terminal. At present large oil tankers call at the Port, but they can carry only very small amounts of oil due to the draft restriction. If the Port can accommodate larger vessels, the transport cost of oil will dramatically decrease and this will benefit the local economy.

In addition, CFM should continuously explain safety measures and environmental protection plans of the new oil and gas terminal to the local community. Continuous improvement of operation of the existing oil terminal is also important to establish a close rapport with the local community.

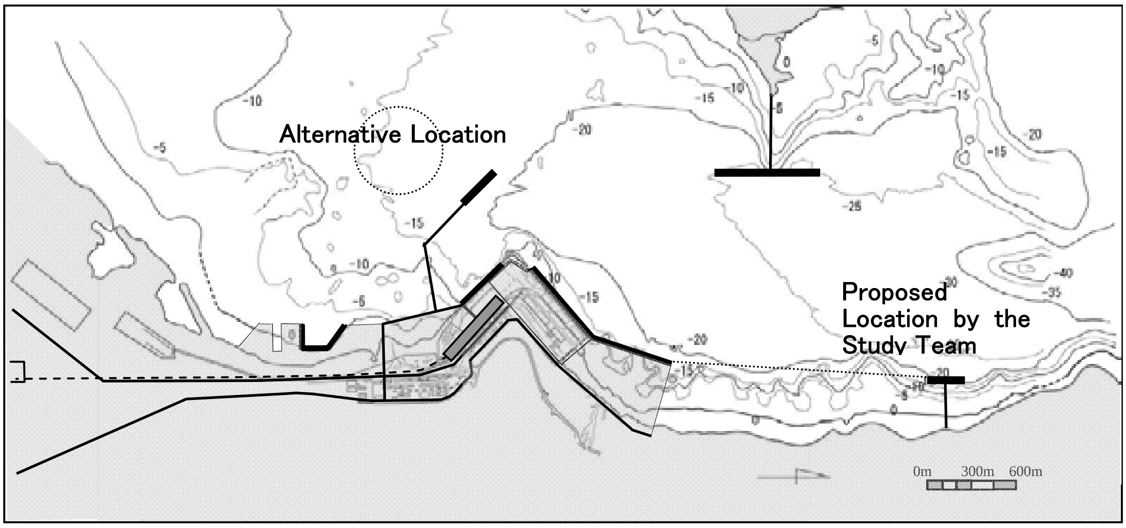
If the planned sewage plant will really be hampered by the oil and gas terminal, finding an alternative location for the sewage plant might be the best solution. One of the alternative locations of the plant might be the coastal zone to the south of the existing port facilities, where port expansion was planned in the previous port master plan but the updated plan proposed by the Study Team doesn’t plan any major port facilities due to the shallowness of the water. There is no conflict with the port development plan in the utilization of this area. To have the sewage plant surrounded by the planned industrial zone would represent an effective use of land. The proximity of this area to the downtown and residential zone may enable efficient planning of the sewer pipe network.

It is unlikely that the relocation is required before 2020 if the new container terminal in the North Wharf is efficiently operated. There is enough time to discuss this issue among all stakeholders and find the best solution.



Source: Study Team

Figure 3.8-3 Plan of basins and a navigation channel



Source: Study Team

Figure 3.8-4 Alternative location of a fuel terminal

Table 3.8-8 Comparison of the location of a new fuel terminal proposed by the Study Team and the alternative location

	Proposed location by the Study Team (To the north of the existing facility)	The first alternative (To the south of the existing facility)	The second alternative (The western shore of Fernao Veloso Bay)
Maritime safety and prevention of environmental hazards	Good	Poor	Excellent
Maneuverability	Good	Difficult	Excellent
Negative impact on the productivity of the mineral terminal	None	Considerable	None
Necessity of relocation of tanks	Yes	No	Yes
Necessity of construction of road and rail	Yes	No	Yes
Length of pipeline	Short (after relocation of tanks)	Medium	Short (after relocation of tanks)
Cost	High	Medium	Very high

Source: Study Team

3.9. Improvement of access to the Port

3.9.1 Access from LLCs and domestic hinterland

(1) Introduction

In this section, the concepts of required improvement for road and railway network are proposed. It should be noted that the improvement of the road and railway network is the precondition in formulating port development strategy and forecasting future demands. Therefore it is very important to keep monitoring the progress of network improvement projects, and ensure that port development is in harmony with the improvement of the road and railway network.

(2) Improvement plan for road network accessing to Nacala Port

The road transportation between LLCs and Nacala Port is currently hardly used due to poor road conditions, except for returning the few of empty containers. The transportation to Baira Port is dominated for the LLCs at present. Thus the improvement of the road network is crucial for strengthening the competitiveness of Nacala Port.

The required functions and conditions of the future road network around northern Mozambique and LLCs are as follows.

- To secure the reliable accessibility throughout the year including in rainy season
- To accommodate the following functions as a main access route to LLCs.
  - Adequate strength of pavement and structure for the heavy vehicles including the container trailers
  - Bypass route around the major city and town to make the through traffic streamline
  - Parking and resting space in the certain interval along the road for the driver driving long distance in the view of road safety
- To secure the redundancy on the road network
  - Access to LCCs: N1 and N11 road in Mozambique through Milange border
  - Access in Northern Mozambique (Niaasa, Nampula, Cabo Delgado Province): N14 road from Lichinga to Monte Puez
  - Access to Southern Mozambique (Zambezia Province): supplement road network for N1
- To resolve the congestion and delay at border post by improving as a OSBP

Based on the above understanding, key access roads to Nacala Port from its hinterland in Mozambique and LLCs are listed below, and their improvement is required in order to achieve the goals of port development discussed in this report.

- Nacala Corridor, from Nacala Port to Lusaka in Zambia via Malawi, will be upgraded to the pavement road by the project of AfDB in corporation with Japan and Korea. The project consists of 3 packages and the construction work from Nampula to Mandimba for 1st phase is supposed to be commenced in 2011. After completion of the entire project, the road of Nacala Corridor will play an important roll for transporting many kinds of products, sugar, woods and coal from LLCs and Northern Mozambique to the Port.

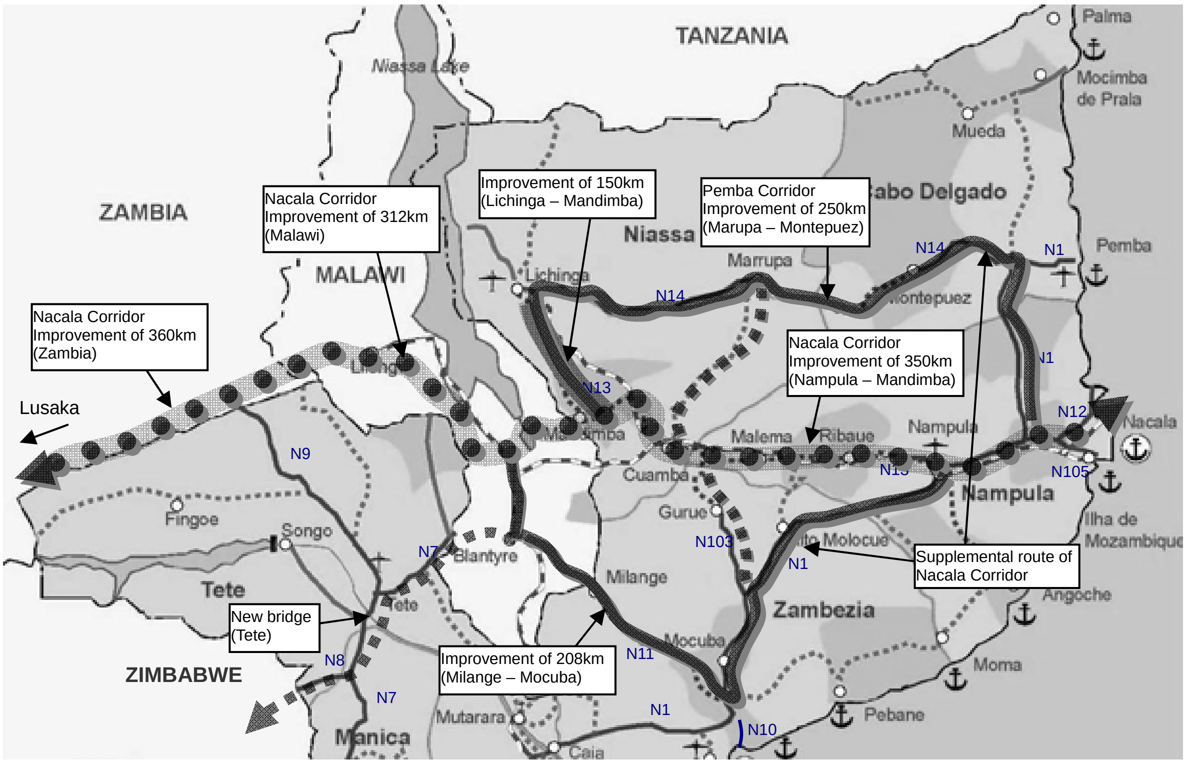
- N13 road, from Lichinga to Mandimba, is also significant component of road network connecting Nacala Port. There is high potential in agriculture, forestry and mining around Lichinga. So this road will be used for transporting the heavy products. The detailed design will be conducted under the Japanese accumulate fund.

- The upgrading of entire section of Pemba Corridor, Lichinga to Pemba to a paved road is scheduled prior to improvement of Nacala Corridor, Initially, this road could be used for transporting the products from Lichinga to the Port. In the future, it is expected to function as the supplemental road of Nacala Corridor.

- The road from Milange – Mocuba – Nacala currently functions as the transportation route from Malawi to Nacala Port even though the section of Milange and Mocuba is the gravel road. EU is undertaking the road upgrading project. As the southern Malawi is developed as a commercial area, it is expected that this route will remain one of access roads to connect Malawi with Nacala Port.

- Apart from above road, Cuamba – Marupa and Cuamba – Mocuba will also contribute to improving the accessibility of Northern Mozambique to Nacala Port. In addition, with the improvement of Nacala Corridor and new bridge on Zambezi River at Tete, it can be expected to generate the export and import traffic to/from Zimbabwe through Nacala Port.

Figure 3.9-1 shows the key access road to/from Nacala Port.



Source: Study Team

Figure 3.9-1 Improvement plan for road network access from/to Nacala Port

(3) Improvement plan for railway network accessing to Nacala port

The railway network will contribute to the transportation of the container with long-distance travel and heavy freight such as mineral products. The expected railway cargoes and their origin/destination are as follows.

<u>Import</u>

- Consumption goods in container/ Malawi, Mozambique
- Fuel/ Malawi, Mozambique

<u>Export</u>

- Coal/ Tete Province (need to open the new railway in Malawi)
- Copper/ Zambia (need to open the new railway in Zambia)
- Forestry products/ Niassa Province（through Cuamba - Lichinga line)

The current railway capacity is too feeble to deal with the demand of transportation. The required improvements of railway network to achieve the long-term development target of Nacala Port are as follows.

- To improve the railway condition in Northern Mozambique
  - Upgrade the rail facility endurable for case of flood in rainy season
  - Strengthen the communication facility
  - Improve the road condition along the rail for restoration of damage in case of emergency
- To increase the capacity for the heavy cargo such as minerals
  - Strength the rail durability
  - Increase the number of section of double track
  - Improve the cargo handling facilities and equipment in freight stations
- To increase the number of locomotives and open/close wagons
- To open the new railways
  - Moatize～Blantyre in Mozambique and Malawi: coal transportation
  - Connection CEAR and Zambia Railway or Tazara Railway at Chipata in Zambia: Copper

North – south railway planed by MOT will give limited effects on cargo transportation related to Nacala Port.

Figure 3.9-2 shows the expected future railway network which will greatly contribute to the achievement of the development target of Nacala Port. The outlines of new railways are described below:

Investment by Vale

In 2010, Vale, Brazilian mining company, purchased a 51% stake in SDCN, owned by the Mozambican company, Insitec (and some private companies). This acquisition made Vale became the top share holder of SDCN which controls CDN and CEAR.

The Moatize mine which Vale has the concession of project is expected to produce 11 million tones in Phase 1 and operations are scheduled to commence in 2011. According to Vale, the coal produced in Moatize in Phase 1 will be transported over the 600 km Sena-Beira rail link to a new seaport terminal in Beira Port.

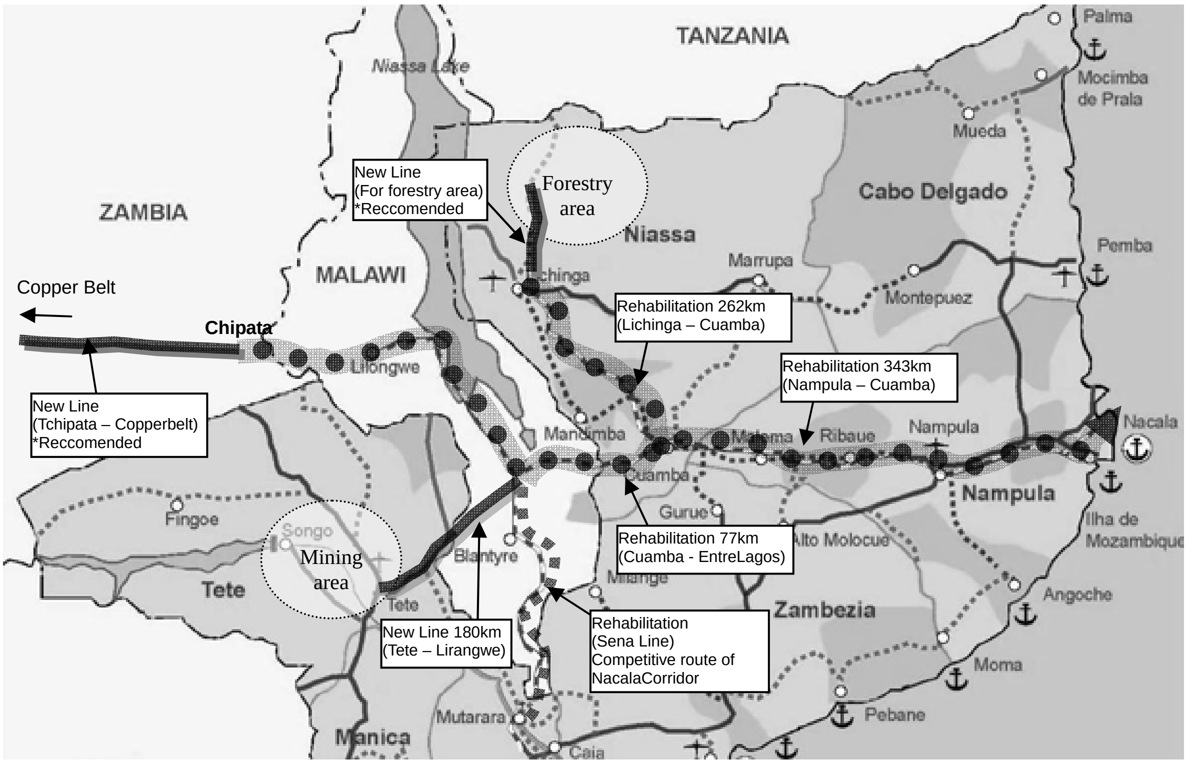
However, given the limitations of Sena-Beira rail transport facilities, Vale are examining the viability of construction of rail connection with approximately 180 kilometers of extension between Moatize and Lirongwe, in Malawi. Besides, it evaluates the rehabilitation of 730 kilometers of the railroad already existent connecting Malawi to Mozambique and construction of new line for planned coal terminal in Nacala-a-Velha.

Studies for finding the mining potential in Niassa Province have been conducted by Vale as well as Chinese and Indian mining companies. If the large potential of mining is discovered, it is required to rehabilitate the railway from Cuamba to Lichinga and construct the new line to mining sites.

Chipata-Mchinji railway

The Chipata-Mchinji railway, which is located at the border between Zambia and Malawi with 24 km, opened in August 2010. With the opening this line, the railway service from Zambia to Nacala Port will soon start. The opening of shortest route from Zambia to Indian Ocean makes it cheaper to bring goods and products from other continents like Asia.

There is no officially announced plan to extend the line but further extension of railway is expected to achieve the integration of Southern African nations and boost trade. If the Copperbelt and Nacala Port are connected by direct railway line, the Port will become the one of ports operating the copper export with the advantage of short way and natural deep water harbor.



Source: Study Team

Figure 3.9-2 Improvement plan for railway network access from/to Nacala Port

3.9.2 Road and railway improvement in Nacala

In this subsection, the Study Team proposes a road and railway access improvement plan in Nacala based on the medium/long-term port development plan discussed in the previous section. In order to improve the overall efficiency of port operation and to strengthen the competitiveness of the Port, the following three strategies for access improvement shall be adopted:

- Streamlining the traffic in/around the Port by the separation of traffic by cargo types
- Drastic improvement of railroad access by the installation of a modernized multimodal terminal
- Strategic integration of the Port and the SEZ by the improvement of road access as well as facilitation of electronic data exchange

(1) Separation of traffic flow by cargo types

It is essential to separate traffic flow by cargo types for increasing the efficiency of port operations. Especially the perimeter of a container terminal must be clearly defined and the area inside the perimeter must be exclusively used for container operation. All movements of vehicles and containers in a container terminal must be controlled and monitored by an operation center using a terminal operating system. Instructions from the operation center to trucks should be relayed automatically or semi-automatically at a dedicated container terminal gate. However, at present container operation in Nacala Port is not like this, and traffic in the Port is topsy-turvy. For example:

- Although the container terminal is fenced, the container traffic inside the terminal is not properly controlled and monitored.
- Due to the shallowness of water alongside conventional quays, bulk carriers often use the container terminal, and trucks carrying bulk cargoes hamper container operation.
- The newly constructed grain silos don’t have their own access road, and use the container terminal as a passage of trucks carrying grain.

- The Port doesn’t have a dedicated container terminal gate which can control the movement of trucks automatically or semi-automatically.
- Customs requires all trucks carrying containers (laden and empty), dry bulk, break bulk, and liquid bulk, and even empty chassis to be scanned. After the scanning, many containers are opened and visually inspected. This causes traffic congestion around the port entrance where the customs inspection center is located despite the relatively small amount of cargo volume handled in the Port.
- Only one weighbridge is used for both inbound and outbound trucks as of December 2010. This also causes traffic congestion.
- Vanning and devanning of containers are done inside the Port. This make the port traffic very complicated.

The Study Team would propose the following measures be taken for streamlining traffic in/around the Port:

- The perimeter of the container terminal shall be clearly defined. Non-container trucks shall be prohibited from entering the container terminal. All movement of container vehicles in the container terminal shall be controlled and monitored.
- A dedicated container terminal gate equipped with a gate operation system shall be constructed, where all trucks receive instructions regarding their movement in the terminal automatically or semi-automatically. The gate shall be located on the ground floor of the One Stop Service Building to be constructed by extending the existing administration building. The One Stop Service Building also functions as a control tower of the container terminal.
- The access road to the container terminal gate shall be separated from access roads for conventional cargoes. The container access road shall be directly connected with the SEZ and Nacala Corridor via “the Port Expressway” described later. The container access road shall by-pass the existing roundabout in front of the existing port entrance to avoid traffic congestion. The number of lanes shall be four (4) at least in the section near the container terminal gate. In other sections, land shall be reserved for future expansion of the road.
- A new access road to the South Wharf, which will be used for dry bulk and break bulk (vehicles) handling, shall be constructed. Since there is no land space available for road construction, the shallow water to the south of the Port shall be reclaimed. The access road shall be also connected with the Port Expressway. Since the southern section of this access road will also function as the access road to fishing port, ferry terminal and ship yards, non-port traffic including carts and pedestrians shall be considered in the designing of the section.
- A new access road to the area to the north of the Port, where a new dry bulk terminal will be developed in the future, shall be constructed. The road shall start from the existing roundabout and pass behind the new container terminal in the North Wharf without crossing the access road to the container terminal. This road shall also serve as an access road to the One Stop Service Building.
- Each new access road to bulk terminals will mean that dedicated bulk terminal gates must also be newly constructed. Unlike container gates, bulk terminal gates don’t require sophisticated gate operation systems. However adequate gate control is required to comply with ISPS.
- Scanning of bulk cargo, empty container, and empty chassis is meaningless and ridiculous. This must be stopped immediately if the Port wishes to be competitive. For containers, sampling inspection based on risk management shall be introduced. Frequency of visual inspection shall also be reduced. Consequently, the entrance of the inspection center shall be moved to the opposite side of the facility where the new access road to the container terminal

faces. The existing system to check radioactive material would be useful for exports to the USA, and this shall be relocated to the container access road where inspections can be completely carried out.

- The number of weighbridges shall be increased, and the time required for measurement shall be shortened.
- Bonded CFSs shall be constructed along the Port Expressway to eliminate unnecessary movement of containers inside the Port. Dry Park shall be relocated to a place along the Expressway. The new Dry Park should have enough capacity in order to reduce the number of empty containers stored in the Port.

(2) Improvement of rail access

The role of railway in the hinterland transport of seaborne cargoes is crucial especially for long distance transport such as transit cargoes to/from LLCs. The overall improvement of railway including rehabilitation and strengthening of infrastructure, increasing the number of locomotives and wagons, and financial restructuring is necessary in order that Nacala Railway bears its important role as discussed in the previous subsection. Functional deterioration of the railway system is one of the major causes of the current business depression of Nacala Port.

Besides overall improvement of the railway system, the Study Team would propose the following measures be taken in order to improve railway access to the Port:

- The rail terminal in the Port shall be utilized only for loading or unloading seaborne cargoes. The Port is neither a depot of locomotives or wagons nor a marshalling yard of the railway. The Port is also not a freight station for local or regional rail cargoes. Therefore, all shunting lines in the port terminal shall be demolished basically, although additional shunting lines will be tentatively necessary to cope with increased rail and sea traffic until a new marshalling yard is constructed outside the Port as discussed later. A depot and a marshalling yard shall be newly constructed outside the Port along the main line. A freight station for non-sea borne cargoes shall also be constructed adjacent to the new marshalling yard. In order to secure operational efficiency, the marshalling yard shall be located in the nearest place from the Port. A passenger station shall be located outside the Port when a sufficient demand arises.
- A new multimodal terminal equipped with modernized operation systems shall be constructed in the South Wharf. Since a container loading/unloading facility requires a long and straight area, it shall be located at the site currently used as marshalling yard and main lines. The facilities for bulk cargo don’t require such long and straight areas. Accordingly the bulk handling facility can be installed in the middle of the wharf.
- Since the direct operation between ship and rail wagon is inefficient and old-fashioned, all rail tracks along quays shall be demolished.
- All rail tracks on the North Wharf shall be demolished because they hamper container operation.
- Since it is physically impossible, the new bulk terminal in the extended North Wharf will not have railway access. Cargoes which require railway transport should basically use the South Wharf.
- The new mineral terminal in Nacala-a-Velha requires railway access. Therefore a branch line to the mineral terminal shall be constructed. For efficient coal handling, a loop line system will be preferable.

(3) Integration of the Port and the SEZ

The strategy of Integration of the Port and the SEZ is of paramount importance in strengthening the competitiveness of the Port and the SEZ. The integration will make the SEZ very unique in the region. Meanwhile abundant cargo flow to/from the SEZ will improve the status of the Port in the international maritime network.

The Port and the SEZ shall be integrated physically, electronically, and institutionally. By the integration, the Port and the SEZ can form a single node in a supply chain. A company in the SEZ will be able to use the Port as if they had a private port in their plot.

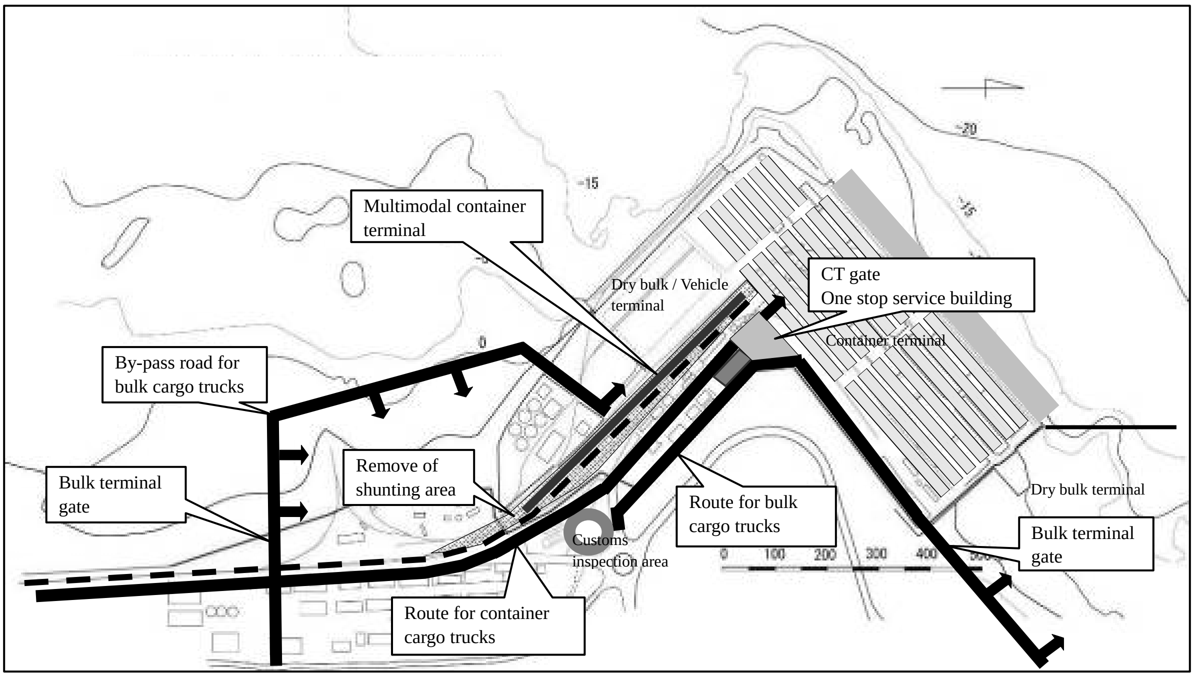
The Port and IFZs in the SEZ shall be regarded to be a single bonded area, and the procedures required for the cargo movement between the Port and the IFZs shall be equivalent to those for movement within a bonded area.

In order to realize the integration, the following infrastructure development is important together with institutional reform:

- The Port Expressway shall be constructed, which directly connects the SEZ including IFZs with the container terminal gate of the Port without passing through the urban area of Nacala. The road shall be connected with Nacala Corridor to the south of the junction to Nacala-a-Velha.
- Flyovers shall be adopted at railroad crossings for the safety and efficiency of transport. There is one crossing on the mainline and probably another crossing on the branch line to the mineral terminal in Nacala-a-Valha.
- Although the Expressway will not be fenced and will be open to the public, the Expressway shall function as a virtual bonded area. Trucks should be able to come and go easily between bonded areas in IFZs and the Port with very simplified and computerized procedure.
- The Expressway shall not be only for vehicles but also for electronic data. Optical fiber cables connecting IFZs and the One Stop Service Building shall be installed along the Expressway. The fiber cables are key infrastructure to realize electronic integration of the Port and the SEZ.
- A freight railway station shall be constructed in a bonded area of IFZ enabling bonded processing in IFZ and bonded transport from LLCs to the world’s market via Nacala Railway, Nacala SEZ and Nacala Port.

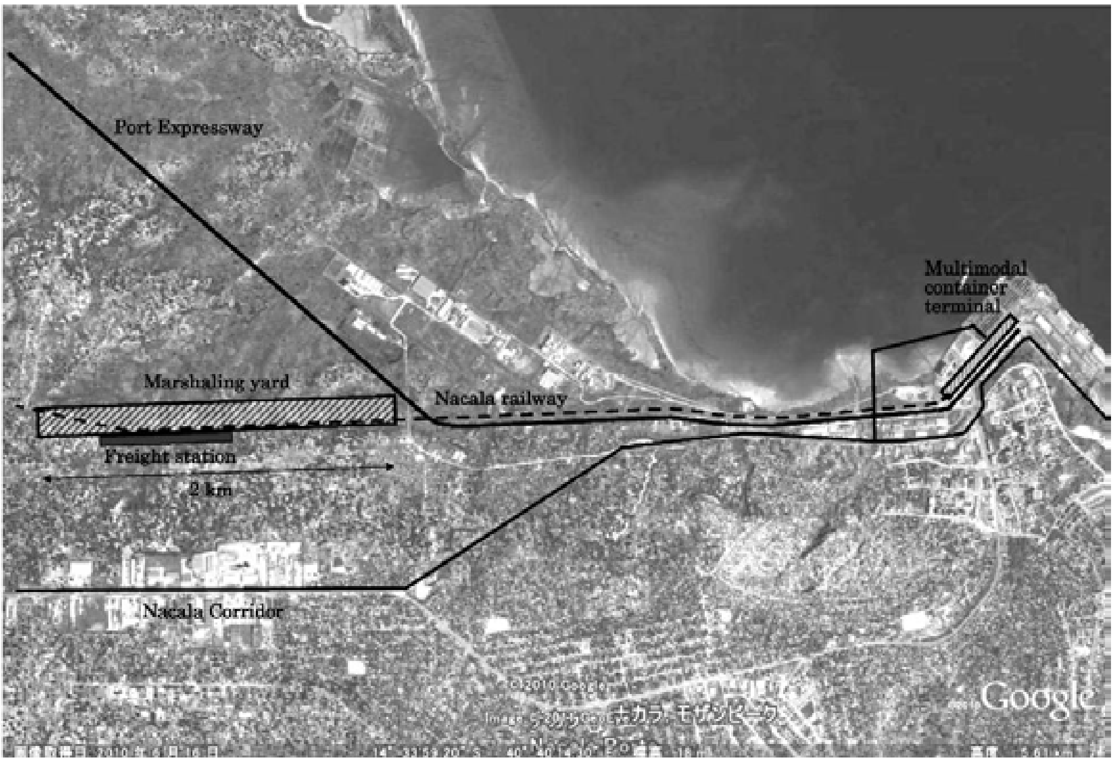
(4) Summary of the proposed access improvement

The following figures summarize the proposed improvement of road and railway access to the Port.



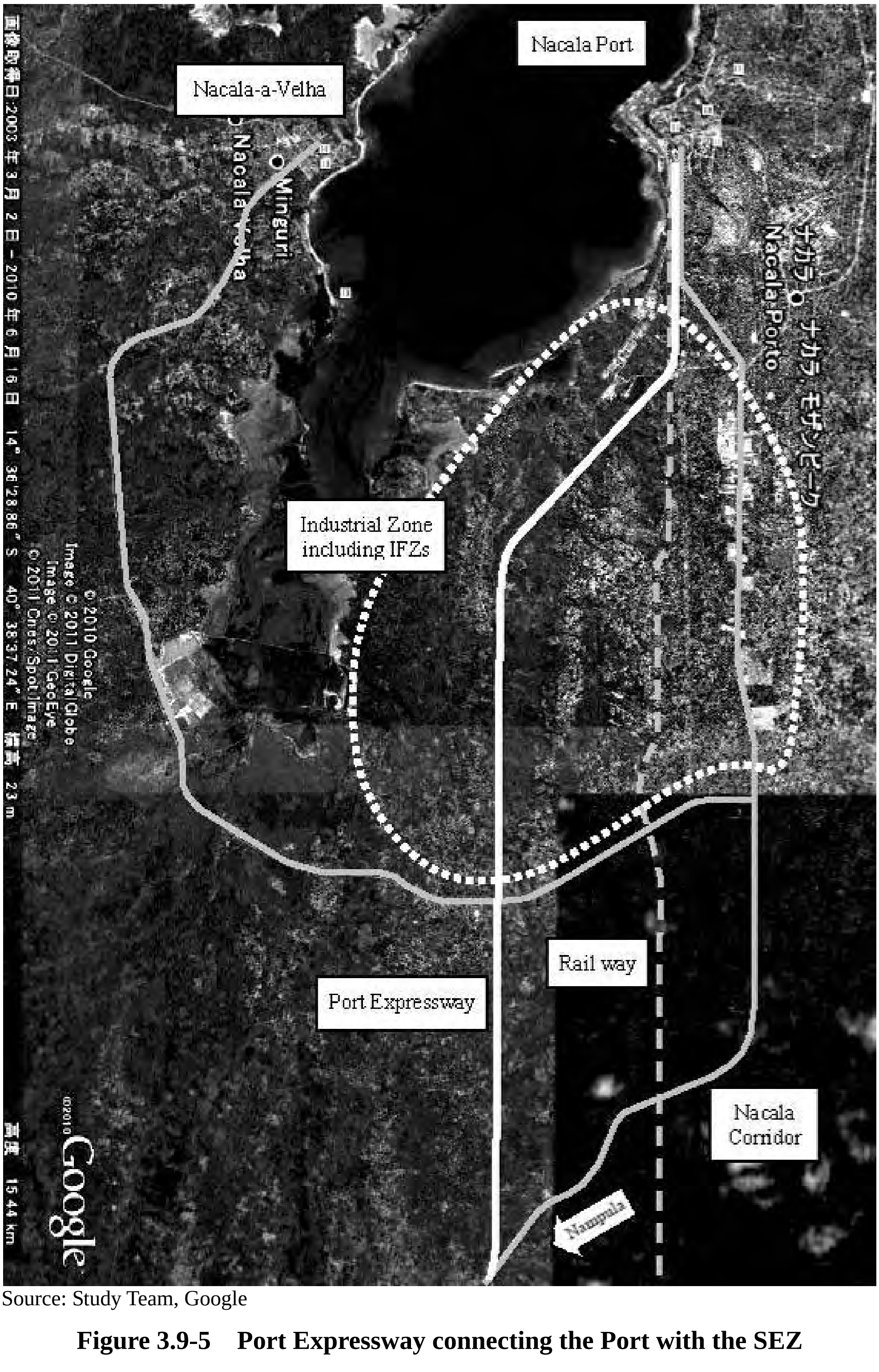
Source: Study Team

Figure 3.9-3 Access improvement in/around the Port



Source: Study Team, Google

Figure 3.9-4 Access improvement in the South of the Port



Source: Study Team, Google

Figure 3.9-5 Port Expressway connecting the Port with the SEZ

3.10. Roadmap for modernization and expansion of the Port

3.10.1 Issues and solutions of the process of the port development

(1) Facilities for container cargoes

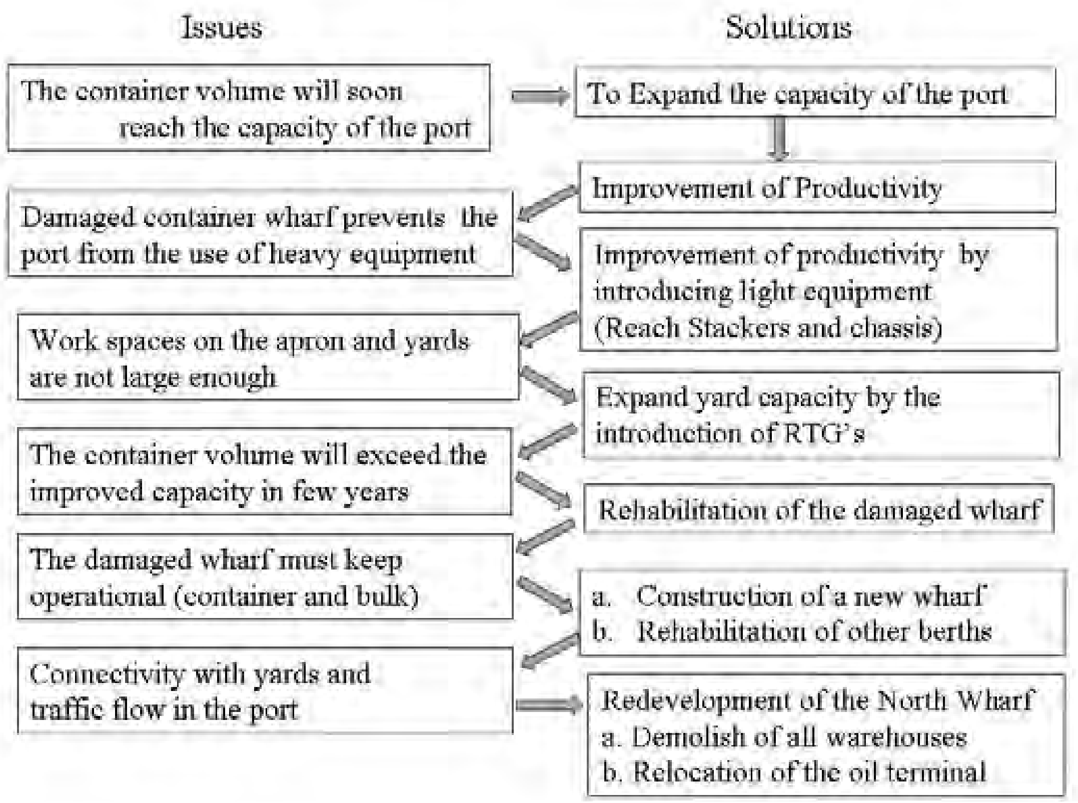
Various issues will be encountered in the course of staged port development. Figure 3.10-1 shows how the issues related to container cargoes can be settled and what issues will be raised in next step.

As discussed in Section 3.2.4, the Port has various problems beside the damaged piers. Taking into account of the construction periods for the development (or rehabilitation) of port infrastructure, the Port has to handle increasing cargoes with the use of available infrastructure, until new and additional facilities are operational. What is most urgently needed for the Port is yard equipment, such as reach stackers and trailers in order to increase the capacity of a container berth by improving container handling productivity.

At present, in general, only one reach stacker is employed for the ship - quay container handling operation, and thus the handling productivity is limited by the capacity of the reach stacker rather than the capacity of ship gears. Therefore, the berth occupancy of the South Wharf is quite high due to the low productivity in ship-quay operation. Taking into consideration the construction period of the additional container wharf, the Port has to handle all the container and bulk cargoes at the South Wharf only, since it is the South Wharf only that can accommodate container and dry bulk carriers having large drafts. By employing two reach stackers, i.e., one at the quay and the other at the yard, and two trailers, which carry containers between quay and yard, per ship crane, the container handling productivity per ship will be doubled or tripled. With the deployment of additional yard equipment, one berth will be able to handle all the container cargoes until the completion of a new (or rehabilitated) container berth, so that one berth of the South Wharf can be exclusively used for bulk cargoes, which are expected to increase over the coming decade.. The capacity of the new container berth can be expanded by the introduction of container quay cranes afterwards in accordance with the increase of container cargo traffic (see Section 3.10.2).

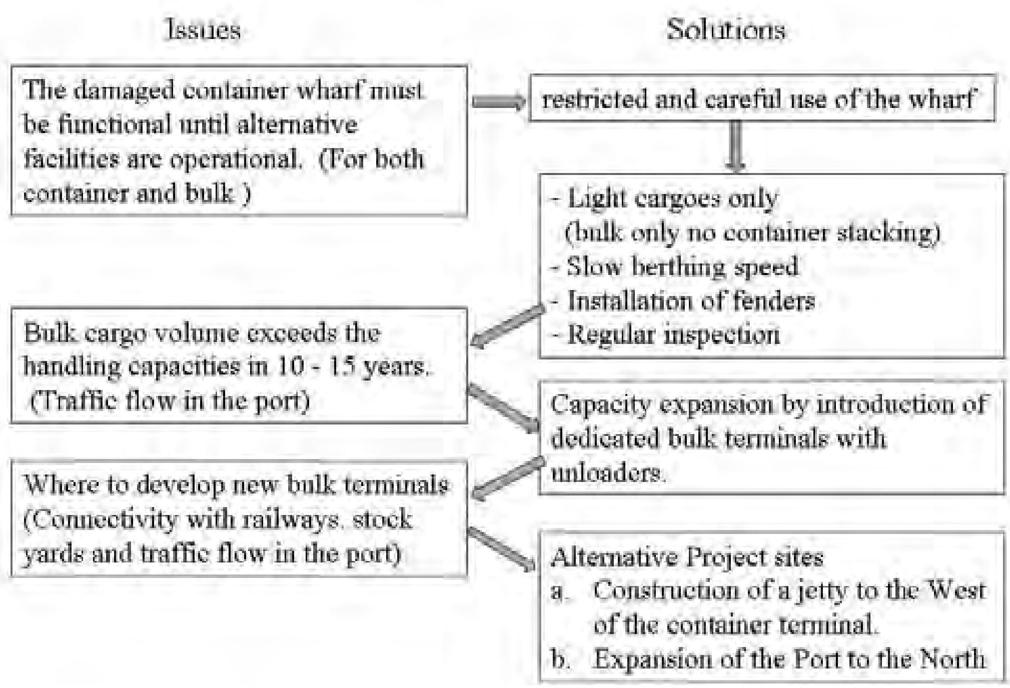
(2) Facilities for bulk cargoes

Issues that will be raised for the bulk cargoes and solutions are summarized in Figure 3.10-2 in the same manner as container cargoes.



Source: Study Team

Figure 3.10-1 Issues of container cargo handling and possible solutions



Source: Study Team

Figure 3.10-2 Issues of bulk cargo handling and possible solutions

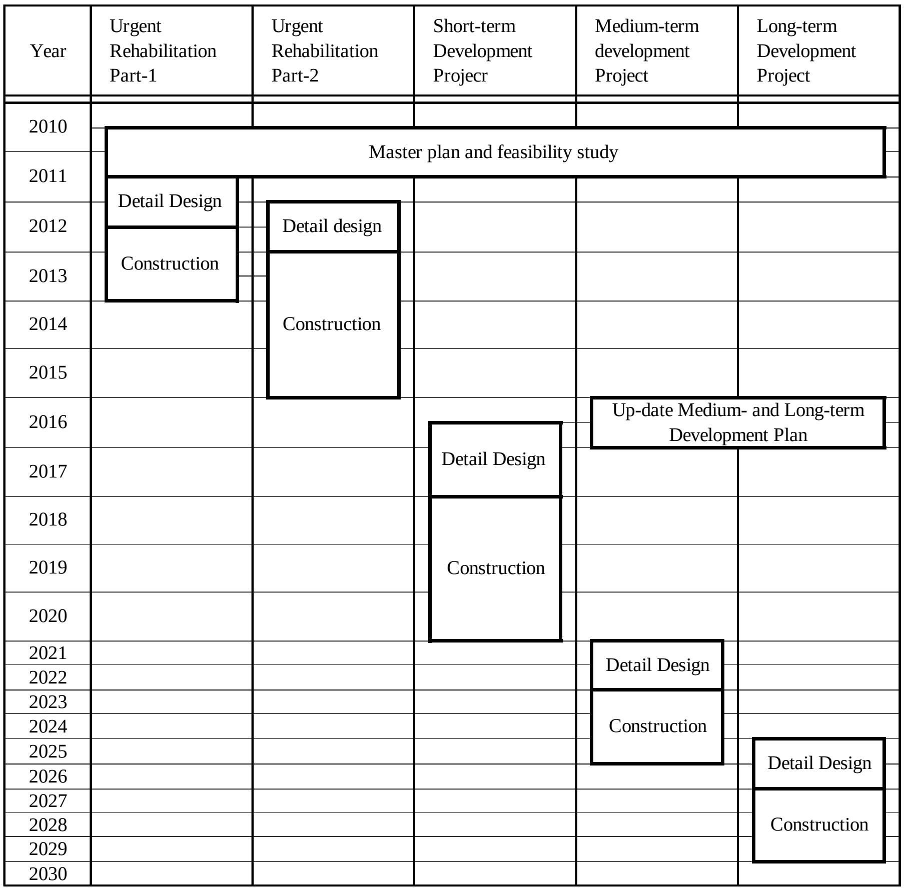
3.10.2 Roadmap for modernization and expansion of the Port

Summing up above discussion, the time schedule of the development of the port is proposed as shown in Figure3.10-3. Notable targets of the development of the Port are listed in chronological order in Table 3.10-1

Table 3.10-1 Targets of the development of the Port

(1)	Urgent Rehabilitation Project Part-1 -Upgrading container handling productivity -Traffic control in the port area	by 2013,
(2)	Urgent Rehabilitation Project Part-2 -Start of operation of a new container terminal, -Start of operation of mineral terminal at Nacala-Velha side	by 2015,
(3)	Short-term Development Project -Installation of container quay cranes, -Redevelopment of port land area (North Wharf), - Installation of grain unloaders	by 2020,
(4)	Medium-term Development Project - Relocation of oil terminal, - Completion of another container berth and the expansion of container yards - Start of the operation of a new dedicated bulk terminal (South side)	by 2025
(5)	Long-term Development Project - Completion of the expansion of container/bulk terminal (North side)	by 2030.

Source: Study Team



Source: Study Team

Figure 3.10-3 Roadmap for modernization and expansion of the Port

3.11. Projects for modernization and expansion of the Port

3.11.1 Long list of the projects

(1) Infrastructural elements to be included in the medium-and long-term development plans

A Nacala area (Commercial port)

1) Container terminal
   (berths, container marshaling yards, empty container stockyard, equipment, maintenance shop, Security and inspection facilities and rail container terminal)
2) Dry bulk terminal (berths and stockyards and silos)
   a. Clinker (import)
   b. Wheat (import)
   c. Fertilizer (Import)
   d. Wood chip (Export)
3) General cargo terminal (berth, transit shed, Open storage yard)
   a. Wood - lumber, plywood (Export)
   b. Vehicles (Import)
   c. Sugar (Export)
   d. Fishery products (Import and Export)
   e. Heavy equipment (Construction equipment, locomotives and rail wagons etc.)
   f. Scrap (Export)
   g. Construction materials (Metal frames, steel rolls etc,)
4) Rail terminal
5) Liquid bulk terminal
   (Petroleum products, Edible oil, chemicals, pipelines and storage tanks)
6) Supply of bunker oil, water
7) Waste management facilities
8) Inland container terminal (including CFS, truck parking)
9) Access road system
10) Access railway system
11) Port gate (including truck scales)
12) Integrated administration building

B Nacala area (Other port facilities)

1) Fishing port
2) Ferry landing

C Nacala-a-Velha area

1) Coal terminal (including access railways)
2) Mineral ore terminal
3) Ferry landings

D Environmental preservation area

1) Designation of Environmental preservation area and monitoring system
2) Designation of tourism reservation area and facilities for pleasure crafts

3.11.2 Prioritized projects for immediate implementation

The performance of the port operation is one of the vital elements that has a great impact on the attraction of cargoes. If the Port fails to provide effective and customer friendly service, investors are discouraged from expanding their business and the products in the north provinces will lose the competitiveness. The impact is more serious for the transit cargoes of Malawi and other inland countries, because transit cargoes can be handled at Beira Port, which is the competitor of Nacala Port.

Therefore, it seems to be most rational to give the priority from the viewpoint of the magnitude of the impact on efficiency of port operation.

Priority projects in the order of priority.

(1) Restoration and repair the existing infrastructure

a. Installation of fenders on the South Wharf (container wharf)
b. Repair of the pavement of aprons and curb stones of the North Wharf (general cargo wharf)
c. Repair of the pavement of the road inside the Port
d. Widening entrance port road
e. Increase gate lanes (including truck scale installation)

(2) Construction of coal & mineral terminal at Nacala-a-Velha

a. Construction of deep draft berths
b. Construction of storage yard
c. Installation of equipment (including loader, belt conveyers)
d. Construction of access railways
e. Installation of navigation aids
f. Procurement of tug boats for large dry bulk ships

(3) Upgrading container handling productivity by repairing the existing facilities

a. Container handling equipment
b. Upgrading container terminal by installing RTG's
c. Relocation of rail container terminal
d. Construction of additional access road to by-pass bulk cargo

(4) Expansion of handling capacity of container and bulk cargoes

a. Construction of a container wharf and yard
b. Bulk cargo stockyard (with extension of rail track)
c. Repair the pavement of open storage yard on the general cargo wharf
d. Expansion of inland depot (Container storage capacity and truck parking)

(5) Further expansion of the Port

a. Upgrading bulk terminal (dedicated bulk terminal equipped with unloaders)
b. Relocation of liquid bulk terminal
c. Construction of another access road to the North Wharf
d. Procurement of additional tugboat for large ships

CHAPTER 4

4. Short-term Port Development Plan and Urgent Port Rehabilitation

4.1. Assessment and repair of existing wharves

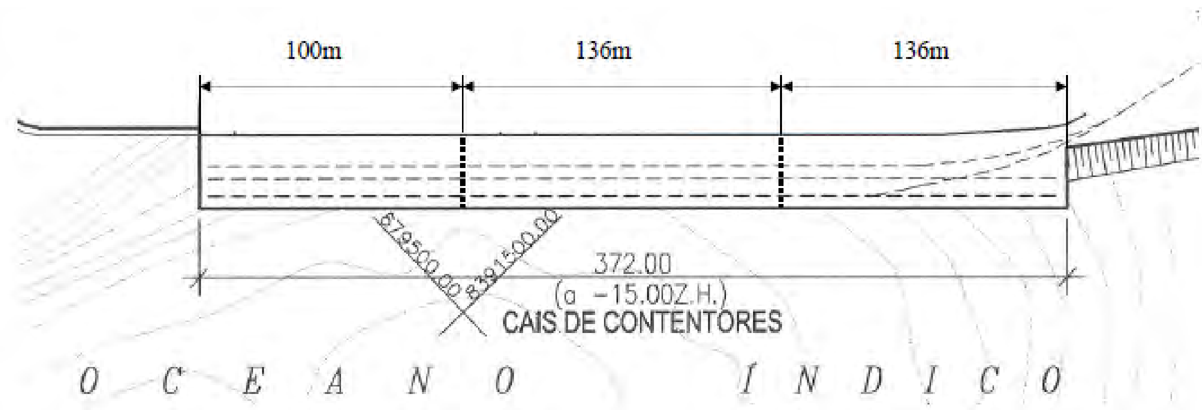
4.1.1 Deterioration assessment of port facilities

(1) General description of wharf structure

1) Container terminal

The terminal presently serves operation of handling containers and such bulk cargo as wheat and clinker which are carried to the Port with deep draft ships.

The wharf was constructed for handling general cargoes in 1974, when it was not assumed that the wharf would serve container operation. The depth is -15m from the chart datum (CD) and the deck elevation was +6.0m above CD. As shown in Figure 4.1-1, the total length of the wharf is 372m, which is divided into 3 blocks of 100m, 136m, 136m respectively. The width of concrete deck is 30m.Two sets of shock-absorbing system are installed at each joint of the deck concrete.

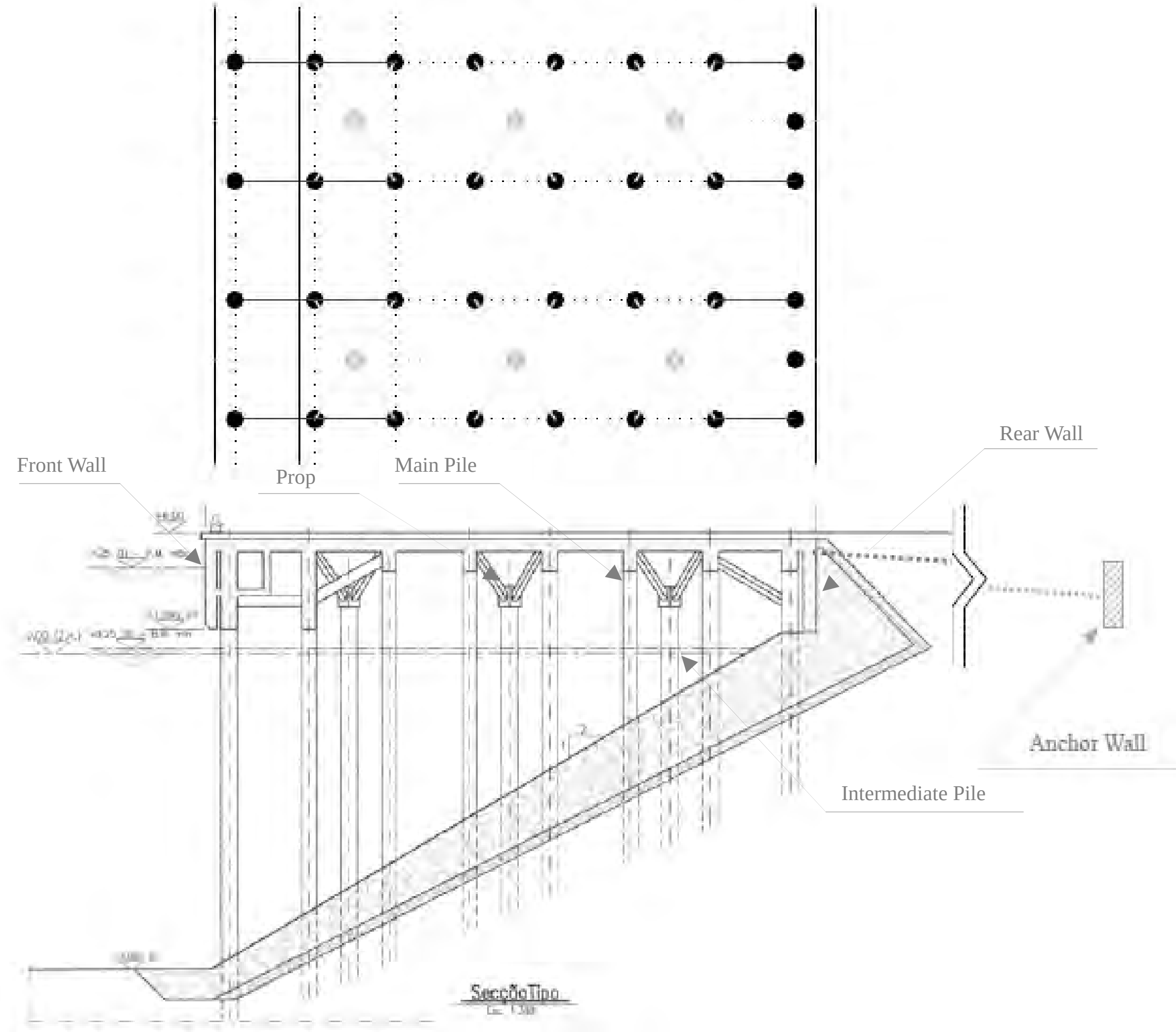


Source: PROMAN

Figure 4.1-1 Layout of container terminal

The structure of the wharf, which is categorized as “open-type wharf on vertical piles”, is illustrated in Figure 4.1-2. The figure also shows the layout of piles in order to illustrate the complicated structure.

The deck is composed of pre-stressed reinforcement concrete of 60cm in thickness and concrete pavement of 25cm in thickness. The structure is very complicated; however, the facility seems to be fully worked out. Vertical piles of approx. 750mm in diameter supporting the deck concrete bears vertical loads on the deck, while impact loads generated by ships might be divided into horizontal and slanting props which link to three front piles. Horizontal forces might be borne with main piles and four slanting beams that connect piles supporting the deck slab with intermediate piles, top elevation of about +3.4m. Tractive force by mooring ships and seismic force are borne with vertical anchor walls connected with concrete decks using 7 cables of 0.5 inches backside of the wharf. The deck slab is constructed with pre-stressed reinforcement concrete; vertical and longitudinal wires are embedded in the concrete at intervals of 1 m.

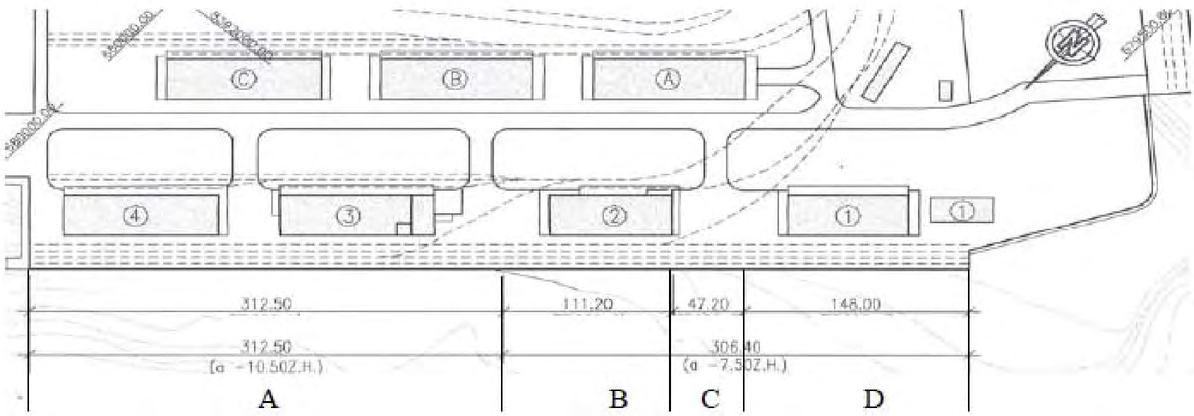


Source: PROMAN & Study team

Figure 4.1-2 Typical cross section of the container wharf

2) General cargo terminal

The layout of the general cargo terminal is shown Figure 4.1-3 and general description of each block of the wharf is tabulated in Table 4.1-1.



Source: Study team & PROMAN

Figure 4.1-3 Layout of general cargo terminal

As shown in the figure above, the terminal is divided into 4 blocks from A to D. Block A, constructed in 1968, has been serving the wharf with a depth of -10m and length of 312.5m for accommodating international cargo vessels. Top elevation of the wharf is 6m above the chart datum as well as all the other wharves in the Port. The Block B was also constructed in 1968 and is -7.5m deep and 111.2 m long. Blocks of C and D were built in 1974 for accommodation of cabotage ships and are -7.5m deep and 195.2m long. The Blocks of C and D and the container terminal presently serving for container operation and bulk cargo operation were completed in the same year of 1974.

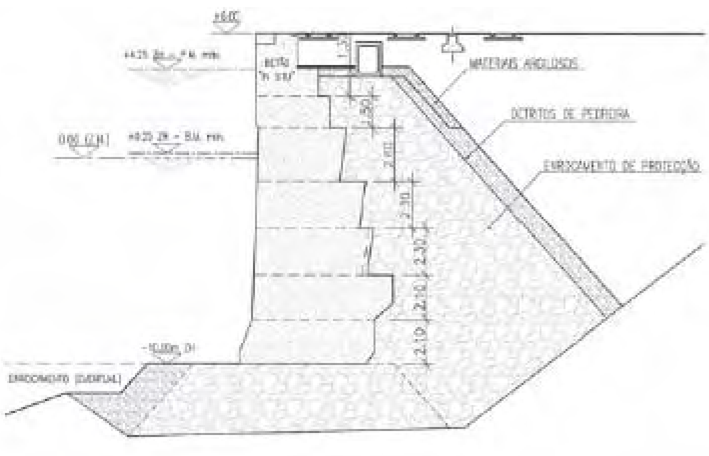
The deeper wharf of the northern side in Block A is commonly used as an oil berth for tankers, and the remaining berth in Block A serves for unloading of bulk cargo like fertilizer. The wharves in Blocks from B to D are used for handling general cargoes, while smaller container carriers are sometimes berthed along the wharf of Block D for container handling.

Table 4.1-1 Descriptions of each block of general cargo terminal

	Overall Length	Block	Depth (below CD)	Top Elevation (above CD)	Structure Type	Contractor (Year in Completion)
International Cargo Wharf	312.5m	A	-10.0m	+6.0m	Gravity type (Rectangular concrete blocks)	Luso-Dana (1964)
Cabotage Wharf	306.4m	B 111.2m	-7.5m	+6.0m	Gravity type (Rectangular concrete blocks)	Luso-Dana (1964)
		C 47.2m			Sheet pile quaywall type (Steel sheet piles)	Construções Técnicas (1974)
		D 148.0m			Open-type wharf on vertical piles (Concrete piles)	Construções Técnicas (1974)

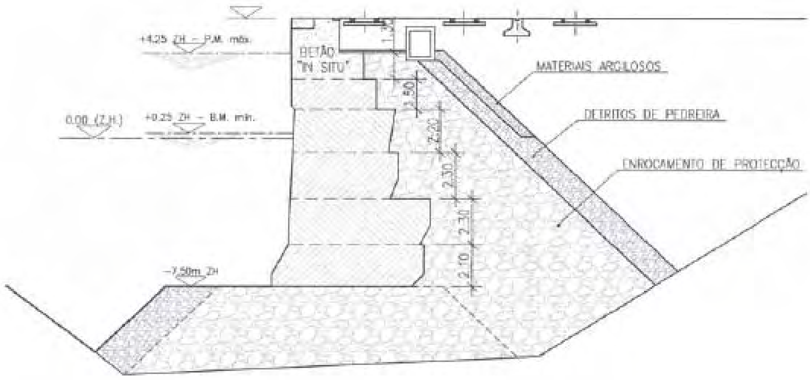
Source: Study Team & PROMAN

As stated in the above table, the vertical wharves in Blocks of A and B are constructed with concrete blocks and the wharf in Block C is of steel sheet piles for connecting Block B of vertical concrete blocks. The wharf in Block D is constructed with the same type as the container terminal structure, that is, open-type wharf on vertical concrete piles. The typical cross sections of the wharves are shown in Figures from 4.1-4 to 4.1-7.



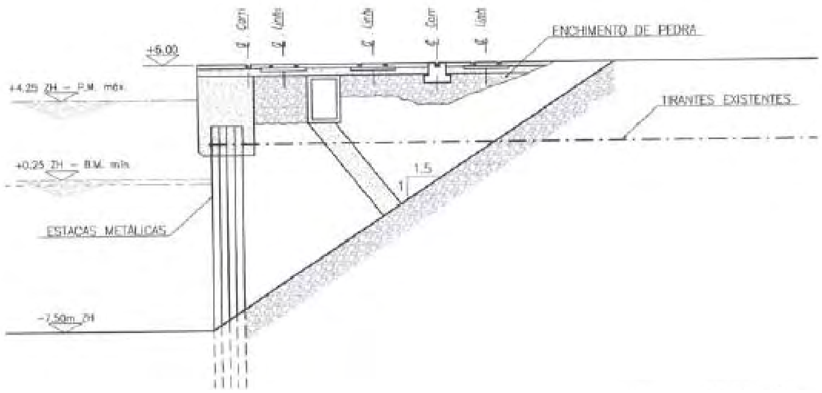
Source: PROMAN

Figure 4.1-4 Typical cross section of international cargo wharf in Block A



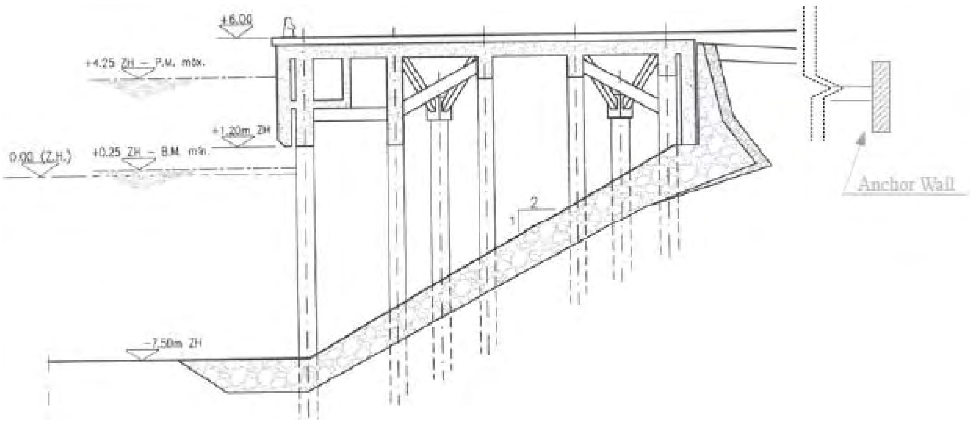
Source: PROMAN

Figure 4.1-5 Typical cross section of cabotage wharf in Block B



Source: PROMAN

Figure 4.1-6 Typical cross section of cabotage wharf in Block C



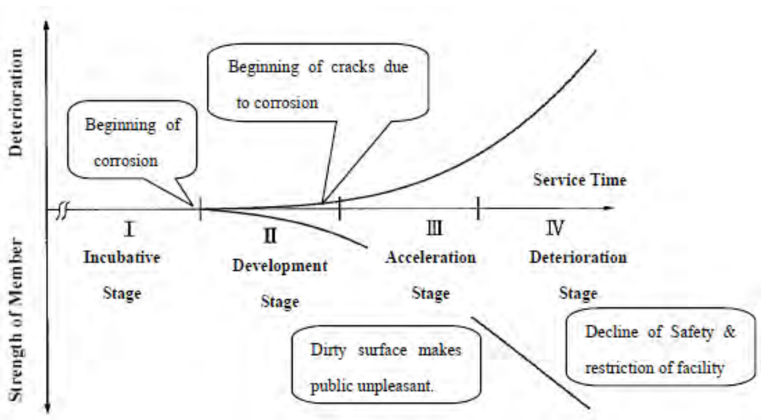
Source: PROMAN

Figure 4.1-7 Typical cross section of cabotage wharf in Block D

(2) Present situations of wharf facilities

Conditions of the existing port facilities were investigated in 2008 by Oz, Lda. commissioned by PROMAN, a Portuguese consulting firm. The investigation was carried out with visual inspection on the concrete surfaces, measurement of concrete cover thickness, and measurement of chloride contents in concrete. Referring to the results of the investigation, the Study Team conducted further investigation with visual inspection, a Schmidt hammer or a rebound hammer and a concrete cover meter.

Even with proper design, reinforced concrete structures in the coastal zone are normally undergo a process of deterioration as illustrated in Figure 4.1-8. At the initial stage re-bars in concrete are statically corroded in the concrete. The expansion of corrosion causes small cracks of concrete and some rust gradually appears on the surface at the next stage. Width of concrete cracks is widening and rust on the concrete surface is widely expanded on the surface at the third stage. At the final deterioration stage stripping of concrete cover is found at many locations to expose re-bars, which are corroded.



Source: Coastal Development Institute of Technology, Japan

Figure 4.1-8 Process of concrete deterioration

In addition to the above static process, reinforced concrete of berthing facilities is sometimes damaged by dynamic forces from ships and seismic forces; damage of old reinforced concrete is occasionally caused by ships larger than expected in design and change of surcharge loads based on change of handling cargo system. Pavement in the container yards and apron is normally damaged due to wear and tear by traffic and to settlement of reclaimed land.

1) Container terminal

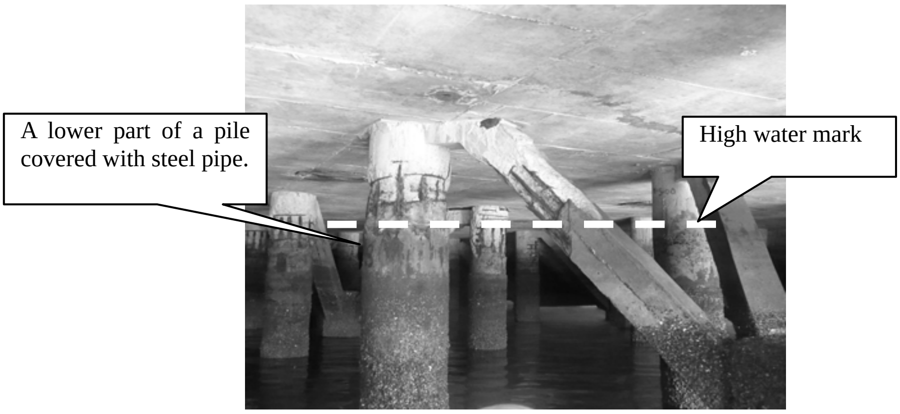
Investigation was carried out in terms of piles and props as the main structure supporting the concrete deck, pavement of the apron and the front vertical wall and accessories. The former is seriously deteriorated and the original strength of the structure has likely been lost. The pavement is not seriously damaged The front vertical wall is partially damaged: re-bars are exposed at several locations. Accessories originally installed are damaged; rubber tires substitute for wooden fenders which have been completely lost.

a) Piles and props supporting concrete deck

i) Current state of concrete structure

For identifying the present state of the piles and props for the main structure of the terminal, investigation was conducted with visual inspection, measurement of concrete cover and compression strength with a rebound hammer.

Photos of most of the piles and their locations are found in Appendix-6. As shown in Figure 4.1-9, top parts of piles in a range from 1 to 1.5m are damaged and corroded re-bars are exposed: the photo shows the typical deterioration of piles and props. It is presumed that the parts without any steel pipe covers are most vulnerable against bending moment.



Source: Study Team

Figure 4.1-9 Overall view of damaged piles and props under the deck concrete

State of piles are checked by visual inspection and categorized into four grades based on their state of deterioration. Inspection was carried out using lighting system in the dark; free access to members of the structure was not always secured due to tides and the structure itself.

Piles were categorized into the four grades of deterioration as indicated in Table 4.1-2. The table shows the grades equivalent to the grades in “Technical Manual for Maintenance and Repair of Port and Harbor Facilities in Japan” (hereinafter referred to as “the Manual”). The Manual targets the extension of the residual life of concrete with usual inspection of concrete structure and maintenance plus repair at an early deterioration stage; otherwise the concrete structure keeps deteriorating to the point where it finally reaches the breakage stage.

Most of the piles of the container terminal seem to be in the final stage of deterioration. Thus inspection was carried out with a mind to propose four deterioration categories of the piles in the Study without subdivision of deterioration grades such as in the Manual.

There remain few piles with cracks less than 1mm even among those categorized as B or C and almost all piles show wider cracks of ten millimeters or more, and corroded re-bars can be seen in between them. Thus all categories of piles seem to be seriously deteriorated with the exception of D.

The piles along the face line of the wharf could not be accessed for inspection as they were covered with maintenance concrete chambers. The total number of piles counted in the inspection excludes the number of these piles.

The piles which are not connected with the concrete slab deck could also not be inspected due to deep covering with sessile organisms as shown in Figure 4.1-10. Ten piles were partially inspected by removing the shells to find the concrete surfaces and they looked undamaged, probably because the top parts of piles were soon covered with shells after their completion and fully-covered steel pipes on concrete piles effectively functioned against the external forces.

Table 4.1-2 Grades of deterioration of concrete

Grade	Conditions	Equivalent Grades in Manual
D	No significant deterioration, damage or fault. Minor local cracking or damage.	0, Ⅰ , Ⅱ ,
C	Major cracking, hollow concrete, minor stripping	Ⅲ (or Ⅳ)
B	Major stripping and sever corrosion of reinforcement,	Ⅳ, Ⅴ
A	Major stripping and corrosion of re-bars w/o strength	Ⅴ (and more)

Source: Study Team

Source: Study Team

Figure 4.1-10 Supporting pile with head and props

Table 4.1-3 shows the inspection results. Following the understanding of the categories mentioned in the above tables, the result indicates that 97.4% of all the piles are seriously deteriorated. They should be repaired and/or replaced for recovering strength of the structure, in accordance the Manual in Japan previously mentioned.

Table 4.1-3 Inspection results of piles under concrete deck

Block	Deterioration Grade of Main Piles				TOTAL
	D	C	B	A	
1	1	7	0	122	130
2	0	9	0	166	175
3	11	10	7	137	165
Total	12	26	7	425	470
Percentage	2.6	5.5	1.5	90.4	100.0

Source: Study Team

The report in 2008 by PROMAN indicated that the percentage of damaged piles was 95% and that the percentage would increase up to 97% in 2 years.

In terms of the main piles, almost the same damages of piles are found at exposed concrete surfaces of about one meter below the concrete deck. Damaged parts show no concrete covers (approx. 5cm in thickness) and completely-corroded re-bars. As a result, 25% or more of an effective cross sectional area of a concrete pile is assumed to be lost; almost 100 % of re-bars to resist tension at the breakage part of the piles are lost and most of the piles are resistless against bending moments generated by berthing forces, etc.

It is also assessed that the reduction in the strength of sound cores of pile concrete, even if remaining, might cause vulnerability of the facility against the design loads set before 1974. The conditions of the said piles seem to be under a structural breakage stage.

Furthermore, at least one or two props at a set of the four members, connecting main piles and support piles, are damaged. Considering the structural functions of the members, the structural system with the props is broken, so dispersion of external loads from the main piles to supporting piles could be possible through the props.

Based on a comprehensive examination of the concrete structure, it is assessed that the piling system under the existing container terminal is maintained only with piles supporting concrete deck and other members might be structurally ineffective.

ii) Thickness of concrete cover

Concrete covers of piles, props, under-deck slab, etc. are measured with an electronic concrete cover meter. Proper locations without hollows underneath were selected for measuring. The result is tabulated in Table 4.1-4. The inspection result by PROMAN is shown in Table 4.1-5.

Table 4.1-4 Thickness of concrete cover of members measured by the Study Team

	Pile (mm)	Props (mm)
Max	55	64
Min	31	26
Average	46	49

Source: Study Team

Table 4.1-5 Thickness of concrete cover of members measured by PROMAN

	Pile (mm)	Props (mm)
Max	51	39
Min	48	36
Average	49	38

Source: PROMAN

According to the report by PROMAN, the thickness of concrete cover is in the range from 40 mm to 50 mm; the report concludes that the results satisfy the Euro Code in a normal environment. The thickness data measured by the Study Team shows a wider scatter than those by PROMAN. The maximum and the minimum figures of the thickness are different; it is considered that designer of the facility targeted the concrete covers of piles and props to be 50 mm and 40 mm respectively.

Recent studies and technical standards in Japan highlight that the cover of 70mm or more is required for protecting concrete facilities in a seawater environment with salty winds. The wharf of the container terminal has been vulnerable against the seawater due to old facilities in accordance with previous specifications. It is considered that insufficient cover thickness has resulted in the deterioration with low durability.

iii) Concrete strength with a rebound hammer

Compression strength of the concrete of piles and props is measured with a rebound hammer at relatively flat surfaces of piles and core surfaces exposed due to stripping of concrete covers. The results are summarized in Table 4.1-6.

Table 4.1-6 Compression test results with a rebound hammer

	Pile Surface (N/mm2)	Core Pile (N/mm2)
Max	29.9	31.4
Min	20.1	16.2
Average	25.3	24.3

Source: Study Team

As seen in the above table, original strength against compression seems to remain to some degree, even if concrete covers are stripped. The results, however, should only serve as a general reference since there are limitations with the measurement system.

iv) Remaining quality of concrete

Regarding chloride ion concentration in the existing concrete, two reports are available; one report was presented by PROMAN in 2008 and another report presented by TECNICA ENGENHEIRO CONSULTORES in 1995.

The former report shows the inspection results of pile concrete of the container terminal using phenolphthalein as shown in Table 4.1-7.

Table 4.1-7 Chloride ion concentration in concrete

Locations		Depth from Concrete Surface (cm)	Percentage of Cl- Contents in Cement (%)
2	Piles under Container Terminal	0 -1	6,60
		4 -5	7,84
		7 -8	2,80
7	Props under Container Terminal	0 -1	4,80
		4 -5	1,12
		7 -8	0,92

Source: PROMAN

The table indicates percentage of the contents of chloride ion in concrete exceeds 0.4%, whilst contents of chloride ion should be less than 0.4% in concrete for keeping concrete in alkalinity. It shows the concrete of the facility holds conditions for re-bars to be corroded and to be structurally deteriorated.

In addition to the survey, BENNIE & PARTNERS in 1992 and TECNICA in 1995 made surveys of piles and props with the same tests. Tested piles by the former contained chloride ion 3.67% in the samples between 45mm and 60m from the surface; the latter indicated the contents from 0.7% to 1.03% in the range of 4 cm to 6 cm from the surface.

The above results seem to be caused by shortage of concrete cover thickness from a viewpoint of the present standard specification in terms of cover thickness.

b) Slab concrete

The deck of the wharf is composed of three concrete slabs: Block 1, Block 2 and Block 3. Stripping of covers from under-deck concrete is found at both the north and south ends of the concrete deck, and along the land side concrete of the Block 1 as shown in Figures 4.1-11 and 4.1-12.

Source: Study Team

Figure 4.1-11 Stripping from deck concrete at north end of under-deck

Source: Study Team

Figure 4.1-12 Stripping from deck concrete from 1st to 2nd columns

Such kinds of damages less than 1m3 are seen at 5 locations in Block 2 and 3. It is highlighted that the surfaces of under-deck concrete have been finished properly except the stripping at the five locations. No information was given on the reasons for the damage in Block 1. Understanding the causes of the damages requires information on cargo handling operation on the wharf since its inauguration.

For reference, compression strength of the under-deck slab concrete with a rebound hammer was measured at the horizontal beams in a stable place. Cover of the slab concrete was also measured with the electronic cover meter. The results of the two measurements are shown in Table 4.1-8 and Table 4.1-9.

Table 4.1-8 Compression strength of under-deck concrete

	Strength (N/mm2)
Max	49.5
Min	42.3
Average	47.0

Source: Study Team

Table 4.1-9 Thickness of cover of under-deck slab concrete at the container terminal

	Thickness (mm)
Max	62
Min	52
Average	56

Source: Study Team

Considering similar strength was measured even at exposed above-deck concrete, 40N/mm2 or more is a reasonable result because the deck is constructed using reinforced concrete with longitudinal and lateral pre-stress.

The cover of the deck soffit ranges from 62mm to 52mm and thickness of the deck is maintained, compared with thickness of the other members like piles.

The Study Team observed that some parts of stripping were repaired properly.

c) Rear vertical wall supporting active earth pressure

The rear wall structurally united with a slab concrete is located at the end of the wharf, as shown in Figure 4.1-2 It functions as support against the active earth pressure from the container yards and it also minimized the berthing forces by ships.

Stripping of concrete covers is found at several locations on the surfaces of the inner wall. The defect indicates marks that bending moments excessively acted on. Two major forces causing the moments can be identified as horizontal forces caused by berthing ships and bending forces caused by cargo handling equipment.

The degradation seems not to be so serious because the limited locations on the inner wall surface are dotted with stripping of concrete covers and rust-surfaced re-bars remain with their cores. Only minor repair is required.

d) Pavement

Pavement of the wharf apron is investigated by visual inspection and a rebound hammer. Although the surfaces of concrete pavement are damaged as seen in the figure; the damage doesn't hamper operation of cargo handling. Several centimeters of surface concrete are removed to be a dips at many locations on the apron pavement. Relatively larger dips are located at railway points and concrete covers for railway sleepers between two rails. These dips are smaller compared with sizes of tiers of trailers and reach stackers. These damages seem to have been left unrepaired for many years.

Areas of the damages are listed below:

- 210m^3: average 1.5cm of dips at a location.
- 0.5m^3: about 5cm of a dip.
- 0.5m^3: average 1cm of dip at 10 locations

These small damages should be repaired as part of regular maintenance work.

e) Front vertical walls and accessories of wharf

Front walls and most of all the accessories were damaged or broken due to impacts from ships. Stripping of concrete is found at 4 locations, however, serious damages are not found. They should be properly repaired.

i) Vertical walls

Stripping of concrete is found at 4 locations, however serious damages are not found. They should be repaired properly.

ii) Accessories

- Fenders

  Wooden fenders and wooden corner protection were completely destroyed by berthing and mooring of ships, and sets of two tires are installed in place of the original. The tire fenders do not function because the tires frequently become flat and directly transmit berthing forces by ships to the quay structure. New and effective fenders should be provided for protection of the old quay facility.
- Bollards

  Most of the original bollards remain while a few damaged ones have been replaced.
- Ladders

  No ladder remains.
- Electricity

  Electricity is available for a quay crane.
- Water

  Supply service can be made at the southern end of the terminal.

2) General cargo terminal

As shown in Figures 4.1-3 to 4.1-7, the terminal is comprised of three blocks with three types of structures. Conditions of each facility were investigated by employing survey techniques stated in the previous subsection.

a) Block 1&2 (Concrete blocks)

Photos taken in 2006 show underwater situations of the front faces of the wharf while the exposed faces of the wharf were observed at low tides. Blocks are properly installed whilst intervals of joints and deviation between blocks seems to be generally wider than the present specifications in Japan.

Source: Study Team

Figure 4.1-13 Face of concrete blocks

Source: CDN

Figure 4.1-14 Joints of underwater blocks

Subsidence remains at two locations on the pavement in Block 1 and it indicates some volume of filling material was lost through the relatively wider intervals of blocks. The phenomenon has been likely prevented with the installation of filter geotextile between backfilling rocks and filling material.

It is assessed that the structure is generally in sound conditions whilst there remain small defects that can be easily repaired.

b) Block 3 (Steel sheet piles)

An interview with the diver who took the underwater photos in 2006 clarified that the steel sheet piles were deeply covered with shells and not so much corrosion was observed. Sheet piles exposed at low tides shows no serious corrosion and layers of shells seems to have protected the surfaces from serious corrosion in the early stage.

Source: Study Team

Figure 4.1-15 Face of steel sheet pile in Block 2

Settlement of the ground in Block 2 is widely found; the settlement was probably caused due to insufficient thickness of rubble stone under rails. This assumption is based on the fact that there is no evidence that filling material was lost through steel sheet piles but a detailed survey will be necessary to know for sure.

c) Block 4 (Piles and beams supporting concrete deck)

Access into the room under the deck is not easy because of the narrow entrance and a wide tidal range. Under such conditions inspection was carried out to the extent possible.

i) Conditions of piles and props

All the piles were surveyed by visual inspection. Definitions of the categories are the same as stated previously as shown in Table 4.1-2. Table 4.1-10 indicates that 96% of all the piles were damaged or destroyed; about 25% of effective cross sectional areas are lost, the same with the piles under the container terminal. Photos of all structural conditions under the deck are shown in Appendix-7.

Table 4.1-10 Deterioration of piles in Block 4

	Sound Level of Main Pile				TOTAL
	D	C	B	A	
Percentage	4.0	0.0	1.0	95.0	100

Source: Study Team

Similar to the deteriorated piles in the general cargo terminal, almost the same percentage of piles in the container terminal have been dynamically damaged in the same period since completion.

ii) Thickness of cover

A scatter of the measured data is wider than those obtained in the container terminal. Present specifications require larger thickness of cover than the acquired data.

Table 4.1-11 Thickness of cover of under-deck slab concrete at the general cargo terminal

	Thickness (mm)
Max	68
Min	35
Average	54

Source: Study Team

iii) Compression strength

For confirming the remaining strength of compression of the piles, rebound hammer tests were conducted and results are shown in Table 4.1-12. Remaining strength of concrete is about 33N/mm2 and relatively high quality of concrete is maintained.

Table 4.1-12 Compression strength of piles

	Pile Surface (N/mm2)	Core Pile (N/mm2)
Max	42.3	38.8
Min	23.5	29.6
Average	33.2	33.2

Source: Study Team

d) Pavement

The pavement of Blocks 1 and 2 in the general cargo terminal is seriously damaged, requiring that lorries be operated at slow speed there. The area of 5000 m3 extending from Warehouses 2 to 4 except oil discharging facility is completely damaged, exposing subsoil that shows no base course.

The apron in Block 3 is damaged due to overall settlement, which is likely caused by insufficient thickness of rubble rocks under the rails and/or insufficient or no re-bars in concrete pavement. There remains no evidence that concrete pavement with re-bars was constructed in all the aprons in the general cargo terminal.

The pavement in Block 4 is partially deteriorated at the southern end of the terminal covering an area of approx. 500 m2. No pieces of re-bars are found in the apron.

With necessary inspection for confirming the causes of settlement, pavement should be laid for extension of the life of the facility.

e) Cap concrete of wharf

Most of the cap concrete in Blocks 1 and 2, structure of which is a gravity type comprised of concrete blocks, was completely damaged by ships' impacts in the cyclone storms in 1994, as shown in Figure 4.1-17. The damage was easily caused due to minor structural defects of the cap concrete. Small precast concrete blocks were installed at the corner of the larger in-situ concrete with poor concrete gluing as shown Figures 4.1-4 and 5.

Other cap concrete in Blocks 3 and 4 are slightly damaged but require only minor repair.

As shown in Figure 4.1-17, front faces of in-situ cap concrete in Blocks 3 and 4 were damaged by ships' impacts in 1994. Concrete covers were stripped to expose re-bars, inducing corrosion. They can be repaired with appropriate measures.

f) Accessories

- Fenders
  Wooden fenders and corner protection of precast concrete block were completely destroyed by ships' impacts and sets of two tires are installed in place of the original fenders. In the Blocks of 1 and 2 made of concrete, additional tire fenders should be installed at intervals of about 5 m considering the little damage to the quay structure by ships. Fender systems should be reconsidered in the Blocks of 3 and 4.
- Bollards
  Five bollards are lost in Blocks 1 &2. CDN intends to install new bollards to replace those lost.
- Ladders
  No ladder remains.
- Electricity
  It is available for quay cranes.

(3) Assessment of existing port facilities

As stated in previous sections, the existing port facilities commenced services in 1968 and 1974; the open-type wharf on vertical concrete piles is seriously deteriorated while concrete block type wharf still reserves its functionality though it requires some minor repairs.

The present sub-section is concerned with the challenge of assessing residual capacity of the existing port facilities based on the physical inspection of the facilities and the investigation of documents/drawings prepared in the past. Limits of the assessment due to shortage of engineering information are discussed also.

1) Availability of as-built drawings and design documents

Assessment of capacity of the existing port facilities definitely requires the engineering information mentioned below:

- Original design criteria for learning external and internal forces acting at the structural members
- Dimensions of structural members for reviewing capacity of the members

The former is usually obtained from design documents and the latter obtained from as-built drawings.

In the course of the Study, no design document for the existing structure of the container terminal was discovered in the office/library of CFM headquarters, CFM branch offices in Nacala and Nampula, and CDN offices in spite of assistance of staff members from CFM and CDN. The original and modified design drawings were found for wharf structures of the container terminal; however, no significant information on as-built drawings of the container terminal was obtained except the piling records for the general cargo terminal. The records showing the embedded length of piles are important for assessing capacity of the structure of the general cargo terminal.

Table 4.1-13 shows the availability of engineering information on each structural type for the container terminal and the general cargo terminal.

Table 4.1-13 Availability of engineering information on wharf structures

<table>
<tr><th colspan="2"></th><th>Design Documents</th><th>Original Drawings</th><th>As-built Drawings</th></tr>
<tr><td colspan="2">Container Terminal</td><td>Nil</td><td>Partially available</td><td>Nil</td></tr>
<tr><td rowspan="3">General Cargo Terminal</td><td>Block Type</td><td>Available</td><td>Partially available</td><td>Nil</td></tr>
<tr><td>Steel Sheet pile Type</td><td>Nil</td><td>Nil</td><td>Nil</td></tr>
<tr><td>Concrete pile Type</td><td>Nil</td><td>Partially available</td><td>Nil except records of embedded length of piles</td></tr>
</table>

Source: Study Team

As seen in the table, sufficient engineering information could not be obtained; almost no information is given for the structure of the container terminal. The above survey results in limits of assessing the residual capacity of the facilities.

2) Open-type wharf on vertical concrete piles (container and general cargo terminals)

a) History of design

i) Surcharge load, etc.

The report of “Nacala Container Terminal, Feasibility Study, 1982-06-08” by NEPTUNE CONSULTING stated “The terminal area was originally intended to be a continuation of the general cargo area. Two warehouses were to be bui1t in the area, but are not now provided practically. The dimensioning and the technical solution of the quay is, therefore, made as for general cargo handling." It is, therefore, presumed that no forklifts of 40t capacity nor other container handling equipment must have been considered. If the wharf is designed for general cargo, uniform loads of 3 t/m^2 and wheel loads of quay cranes with lifting capacity of 5t would have been applied.

The above situation very likely indicates the container terminal has been overloaded since commencement of handling containers.

In addition to the surcharge load, design ship sizes are unclear; however, sizes of presently calling ships seem to be larger than those targeted in the original design. It is assumed that external forces by approaching and berthing ships presently operated might be greater than those by the design ship. There remains high possibility of greater forces to be loaded than expected in the original design.

ii) Structural design

The original drawings in the CFM library show that the piled structure was initially designed as combined structure with vertical and raking piles and the berth length was 408m with three blocks of 136m in length. According to the report "APPRAISAL REPORT of Proposed Methods of Repair and of Terms of Reference for Implementation, March 1992 " presented by Finnish consultants, BINNIE & PARTNERS, the design of structure was likely modified due to insufficient bearing capacity of the driven piles at the beginning of construction. The report indicates the history of design modification as quoted below:

(Quoted)

- The original layout of piles was based on a 4 x 6 meter grid (Professor Cardos produced tender drawings with this layout of piles).
- After installing the first few piles, test loading showed that the piles were not achieving the required bearing capacity.
- The method of pile installation did not allow the piles to be driven further.
- Additional piles were required but the fat slab deck design could not accommodate additional intermediate piles extending to the deck except 56 along the beams at the back, front and ends of the quay.
- It was then decided to add the intermediate pile each with four diagonal struts up to the original points of support of the deck.

(Unquoted)

b) Description of quay structure

Expected external forces should be considered in designing a quay facility. External forces are listed below considering the natural conditions in Nacala Port.

- Berthing forces by ships
- Tractive forces by ships
- Self load and surcharge of static and live loads
- Earthquake

The following is general explanation of the quay structure which resists the above external forces.

The general plan and typical cross section are shown in Figure 4.1-16. The quay structure is composed of concrete deck slab and piles with props supporting the deck. It is presumed that the props connect main piles and intermediate piles for dividing vertical surcharges loads.

Tie cables covered with reinforced concrete unite the quay structure and anchor walls for resisting the tractive forces by ships, and each block is supported with two anchor systems as shown in the figure.

For minimizing the deformation of the structure when horizontal forces by berthing ships act on the quay, the following members and devises are set up in the piling system.

- A front wall rigidly fixed with the first row of piles for avoiding concentration of berthing

forces by ships
- Horizontal and slanting beams which connect the front three piles and slanting beams which connect the seventh and eighth piles
- A rear wall, on which earth pressure act, for minimizing overall displacement of the quay structure
- Anchor walls for resisting tractive forces by ships and rotation of a block of the quay

In addition to the piling system, it is notable that the deck slab is made of prestressed reinforced concrete. The prestress tendons are set at intervals of a meter in longitudinal and transverse directions. Weight of the deck concrete is reduced with application of prestressed concrete.

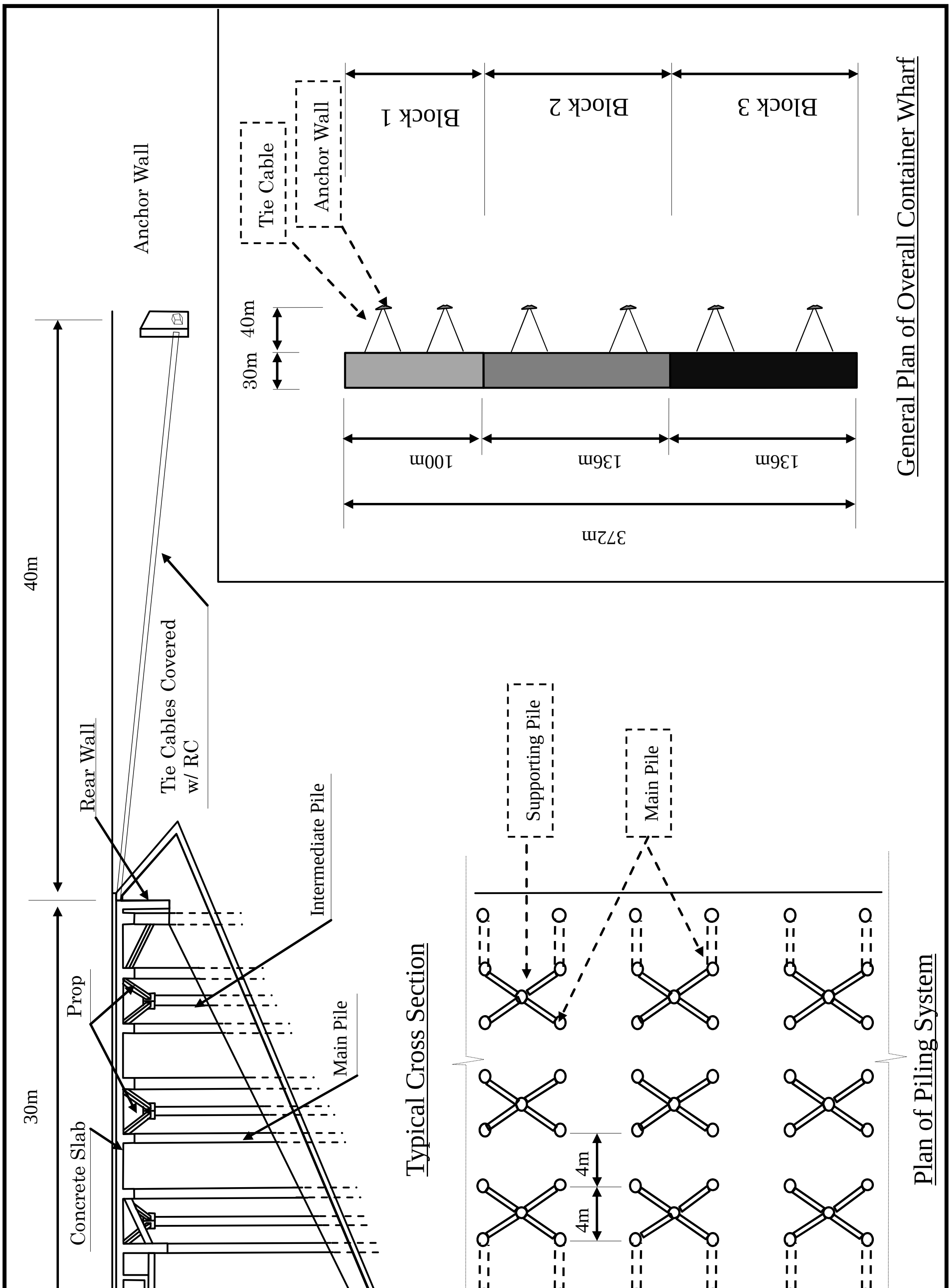
c) Deterioration of structures

As stated in the previous sections, the piles and props in both container terminal and general cargo terminal have been seriously deteriorated during 36 years from 1974. The quite similar degradation was found in almost all pile systems in the terminals with damages of top parts ranging from 1m to 2m from the deck. It is highlighted that 95 % or more of the main piles in both terminals are damaged with the same appearance. In spite of slightly different operation between the two terminals, the difference in the damage of piles is minimal.

The site survey result by the Study Team presents a view that the said damages were not caused by unexpected forces exceeding the design criteria but have been developing through the following causes:

- The external forces have been acting to the quay structure made of reinforced concrete since the port services were commenced.
- Reinforced concrete structure holds micro cracks as its nature and application of strain by bending moment induces development of cracks.
- Micro and small cracks occurred on the members by repeated bending moment generated by external forces and they have been developing.
- With development of width of cracks rebars have rusted and concrete covers have been stripped along with the growth of cracks.
- Almost all rebars have completely rusted and have reached the final stage of deterioration.

Therefore, they urge engineers to presume that some systematic design defects were inherent in the piling system, while the slab concrete on the piling system preserves its integrity though some minor repairs are required. Given the above conditions, it is remarkable that the capacity of core concrete of the piles seems to remain at normal compression strength. In addition, it is considered that reiterated forces generated by ships’ motion have been accelerating damages of piles.



Source: Study Team

Figure 4.1-16 General plan and typical cross section of South Quay

d) Views on deterioration of piles and props

Berthing forces and tractive forces by ships generate maximum bending moment at the top of piles. Displacement is usually allowed within the permissible range in the design of an open-type wharf on vertical concrete piles.

It is considered that high rigidity concrete deck slab is not deformed by ships' forces, and the displacement of the quay structure would not have been caused by the external forces if no displacement of the quay structure occurred with the full function of the anchor walls as the design philosophy stated above.

It is, however, assumed that the quay was somewhat displaced several years after the completion of the quay. This theory is supported by the marks of stripping of concrete covers on the rear wall surfaces.

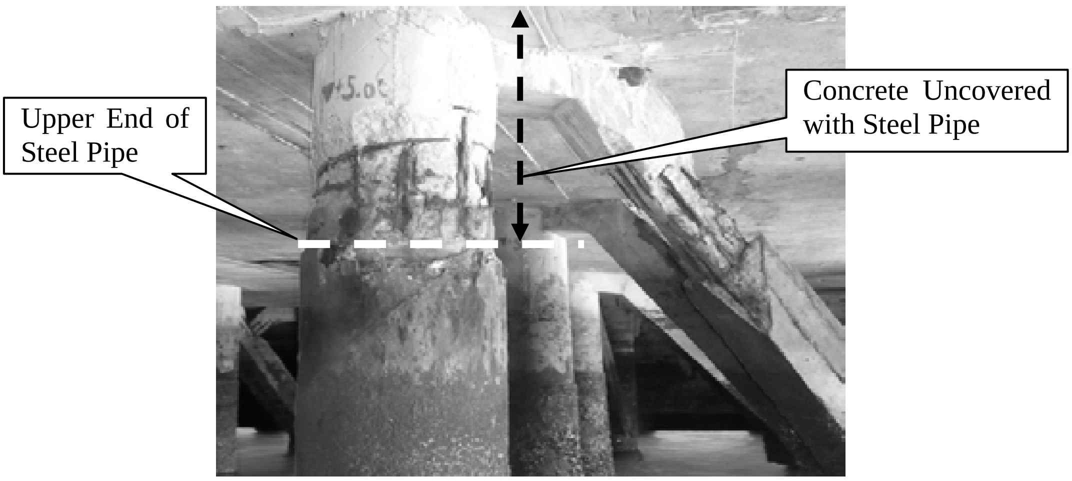
Cracks of concrete occurred at locations of insufficient thickness of covers when tensility was generated by displacement of the upper rear walls. With a lapse of time rust of rebars developed and concrete covers were stripped. The phenomenon is observed at only seven locations on all the rear walls and few indications of development of stripping concrete are found on the rear walls. It is concluded that the displacement of the quay is now structurally controlled and minimized in the system.

As pointed out above, the displacement of the quay likely occurred in early stage after its completion. In displacement of the quay the maximum bending moment was generated at tops of the piles. The piling system normally allows displacement to some extent; however, the systems in Nacala Port restrain the displacement with the props as a result of design modification. Therefore, complicated stress and strain were generated in the members and triggered cracks of concrete.

In terms of the design modification, it is assumed that a detailed analysis was not made because connection of intermediate piles and the deck slab is structurally more effective than provision of the props.

A concrete pile in the port is made of hybrid material of in-situ reinforced concrete cast in a steel pipe. The pile provides high rigidity against bending forces if the whole pile is covered with a steel pipe, however, a head of the pile ranging from 1m to 1.5m is uncovered with a steel pipe. The pile reserves two parts with different rigidity in a pile as below:

- Lower rigidity of reinforced concrete uncovered with a steel pipe, being fixed with a slab concrete
- Higher rigidity of reinforced concrete covered with a steel pipe



Source: Study Team

Figure 4.1-17 Boundary of steel pipe

In action of bending moments at a head of a pile, displacement and bending forces at a pile head and props occur, and complicated stress and strain are generated in the members of the piling system. In the mechanism the inherent nature of the pile seems to govern the dynamic movement; stress and strain generated in the pile are naturally concentrated at the part with lower rigidity, head parts of piles and props, whose tops are fixed with a concrete slab. Since action of the external forces has been frequently repeated by calling ships, it is inferred that this mechanism would be a major cause of overall deterioration.

e) Analysis of piling system

This sub-section is concerned with an attempt to analyze the bending moment and axial loads on the structural members in applying external forces. The attempt is made only for general understanding of stress generated in the members, but not for solving absolute stress on the members, because detailed design information is not available as stated in the previous sub-section. The trial should be, therefore, made on the several assumptions for engineering purposes.

i) Assumption for analysis

- Loads
  - Uniform load: 50 kN/m^2
  - Live load: 1150 kN (Reach stacker)
  - Tractive force by ship: 1000kN
  - Berthing force: 1000kN (for ships ranging from 25,000 to50,000DWT)
  - Coefficient of seismic force: 0.05
- Members
  - RC Pile diameter: 750mm
  - Slab thickness: 600mm
  - RC Prop: 350mm x 350mm
- Analysis conditions
  - Application of Chang's method
  - Virtual ground surface: fixed point method
  - Horizontal subgrade reaction: $kh = 1.5N$
  - N value

    10: a layer of 4m thickness from the virtual ground surface

    5: a layer of 4m or deeper from the virtual ground surface
  - Embeded length of a Pile

    Length of a pile is assumed to be 10m, referring to L = (2.25~3)/ β based on the Chang's criteria

ii) Analysis conditions

Analysis is made for two different cases:

- Case 1

  The external forces by a ship are applied to the end of a block of 136m among the 3 independent blocks of 372 m in total. Directions of forces to the berth are 90 degrees to the face line and 45 degrees. No horizontal spring is considered for anchor walls.

- Case 2

  The external forces by a ship are assumed to be resisted by a small block of 33m, which is one of 4 blocks divided with construction joints in a block of 136m in total. The external forces are assumed to be equally applied to each block.

Calculation for the above two cases was made considering the effectiveness of anchor walls and rear walls; 0 %, no effectiveness, means free displacement of the structure, and 100 % effectiveness means no displacement of the structure. No displacement and little bending moment occur in the latter condition. For the purpose of analysis, results of the extreme condition of the former are presented in the report.

iii) Calculation results

Figures 4.1-18 and 4.1-19 show overall bending moment as the analysis results for the above two cases. Displacement of the structure in the figures is distorted for visually understanding the displacement. As a result of analysis for the two cases, few differences are found from an engineering viewpoint between the cases. The following results are indicated as a result of analysis for case 1.

- General description of bending moment in the system

  Bending moment generated on the landside piles is larger than that on seaside piles because allowable bending length of land side piles is shorter than the length of seaside piles and rigidity against bending moment on the seaside piles is larger than the rigidity on the landside piles.

  Locations in touching and mooring of ships at berths vary in accordance with the length of ships; they might be concentrated at ends of deck blocks because of berthing and mooring operations of ships. The situation is reflected in the Case 1 as above. The result shows that piles at around the edge of a deck have larger bending moment than piles at the central part. The calculation results in the same for the props.

  It is confirmed that the deteriorated piles do not show the tendency of stress concentration generated by ships' motion as mentioned above. It is, therefore, understood that the deterioration has not been caused by excessive stress but caused by development of cracks.

- Maximum stress and strength of members

  The calculation results are tabulated in Tables 4.1-14 and 4.1-15. Permissible bending moment in the tables below is obtained with calculation of axial strength and rebars' areas.

Table 4.1-14 Permissible strength and cracking moment generated on a pile

Analyzed strength		Cracking bending moment	
Mmax	201.0 kNm	minMcr	182.3 kNm
Nmax	486.5 kN	maxMcr	226.5 kNm
Nmin	309.0 kN		
Permissible Bending Moment	315 kNm		

Source: Study Team

Table 4.1-15 Permissible strength and cracking moment generated on a prop

Analyzed strength		Cracking bending moment	
Mmax	30.2 kNm	minMcr	44.4 kNm
N	95.5 kN	maxMcr	63.9 kNm
Permissible Bending Moment	103 kNm		

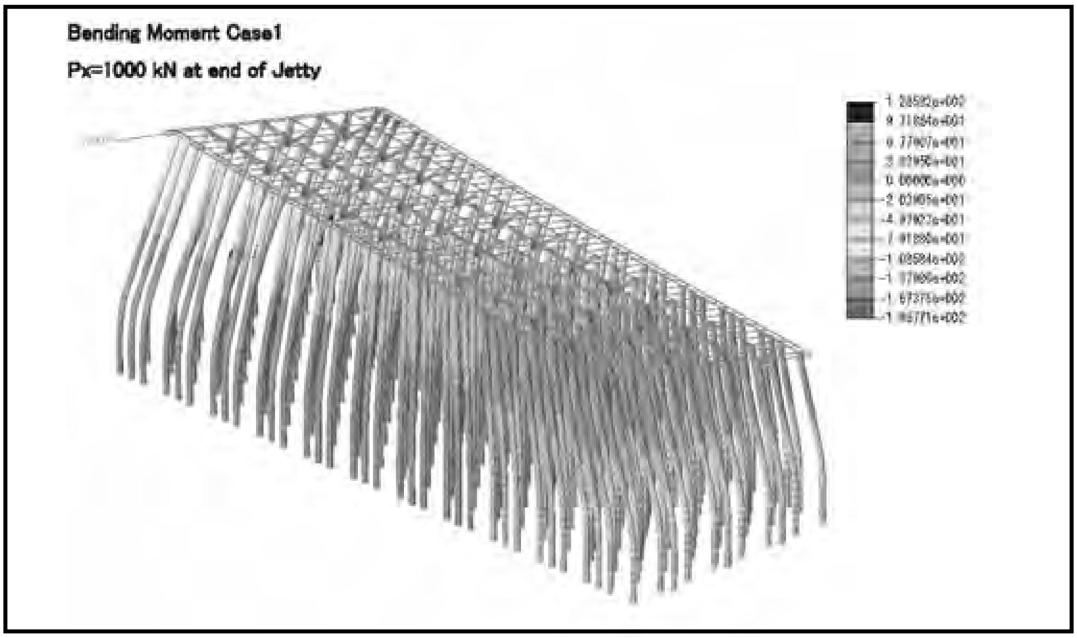
Source: Study Team

In terms of the permissible strength of both members, figures of Mmax in the tables for both members are less than the permissible bending strength and the members would not be likely damaged under the conditions.

As shown in the above tables, the maximum bending moment for a pile, 201 kNm, is located in the range from minimum Mcr, 182.3 kNm, to maximum Mcr, 226.5 kNm. Meanwhile maximum bending moment for a prop, 30.2 kNm, is less than the minimum cracking moment.

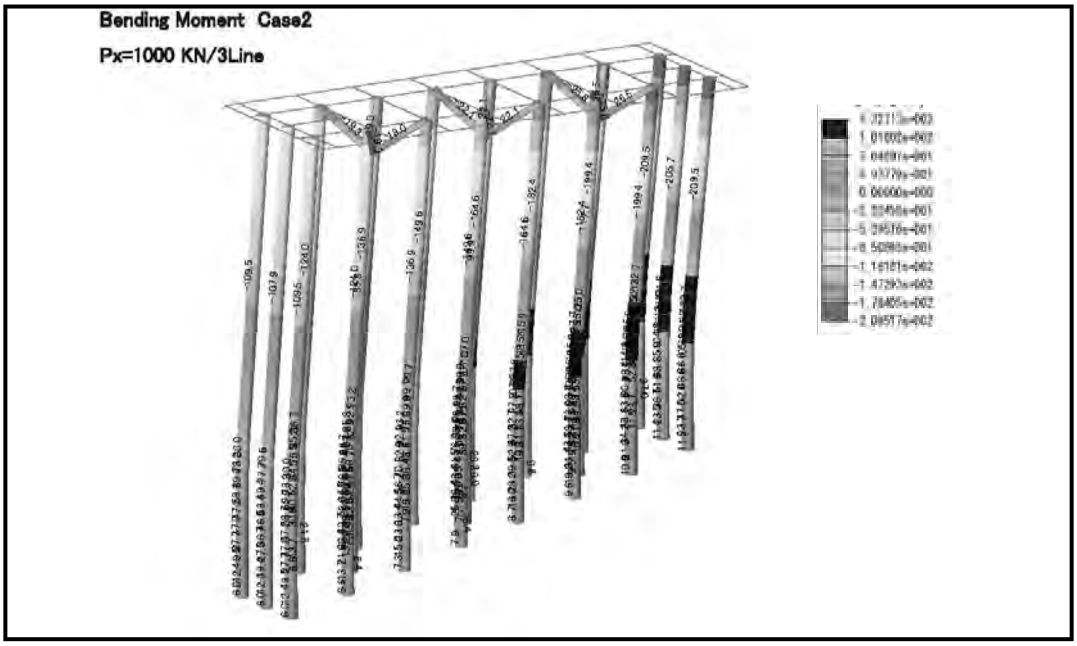
- Complete collapse of props in a future: no effective props

  Under the present situation, intermediate piles will not support vertical and horizontal loads. Regarding axial strength of main piles, increase of maximum axial stress is 8.3%, while maximum bending moment at a pile foot and pile head increases 15.5% and 13.8% respectively.



Source: Study Team

Figure 4.1-18 Overall bending moment in the 136m block (Case 1)



Source: Study Team

Figure 4.1-19 Overall bending moment in the 33m block (Case 2)

f) Assessment of residual capacity

Damage to the head parts of the piles is generally found among all the piles under the concrete deck. Cracking moment on the piles is the approximate value of the bending moment of piles while the maximum moment generated on props is less than the cracking moment. Therefore, it can be assessed that the structural members reserve some bearable strength.

The reinforced concrete has micro and thin cracks as its nature. The piles are situated in the environment of high chloride ion density, and action on the piles by external forces has been repeated for a long period. In addition, concrete covers of piles are thin compared with the present engineering specifications. Piles and props of reinforced concrete are inappropriate for an environment of high chloride ion air and repeated bending moment.

In considering the above conditions, it is believed that cracks of concrete have been induced and expansion of rust of rebars has been developing into the final deterioration stage.

The Study Team assesses, therefore, that the deterioration of the structure has not been caused by the exceeding stress beyond the design criteria but caused by deterioration of durability of reinforced concrete, which occurrence of cracks has been inducing.

The above analysis is on sound engineering assumptions and the conditions of facilities that were inspected focusing on cracking and breakage of the members. The following observations can be made about the structural members:

- Bending moment to cause major cracking has not been recently generated on the rear walls; rear walls seem to be effective.
- No crack or opening is discovered between the container deck slab and the container yard; anchor walls seem to be effective.
- Localized settlement of the deck slab is not found; bearing capacity of piles seems to be secured.
- The deck slab is generally in sound condition.
- There almost remain no rebar on all the top parts of piles; remaining diameter is about 600mm. However, axial strength seems to be bearable.
- Anchor walls and rear walls are effective to resist horizontal force.
- The props are seriously damaged to the point of being structurally ineffective. However, the piling system is still effective without props.
- High concentration of chloride ion in the concrete is developing in all the structural members of the quay except the deck slab.

From the structural analysis, the quay seems to be structurally serviceable, especially as the anchor and rear walls remain structurally effective. The effective structures control displacement of the overall facility and occurrence of bending moment is minimized against external forces. Accordingly, the piling system will withstand the action of external forces by ships even if the piles hold no durability against bending moment

It should be noted, however, that the quality of concrete of the front/rear walls is definitely deteriorated. Intrusion of chloride ion into the concrete has progressed during the 36 years from commencement of the quay services. As indicated in Figure 4.1-8, deterioration has rapidly accelerated to deterioration stage IV, in which the present stage of the structure of Nacala Port seems to be situated.

Accordingly, it should be emphasized that the piling system is now situated in the “*vulnerable*” stability category under the supports by rear and anchor walls of deteriorated concrete.

g) Measures for extending residual life

Since the concrete of the facility is definitely deteriorated, minimization of the external forces against the facility is recommended for extending the life.

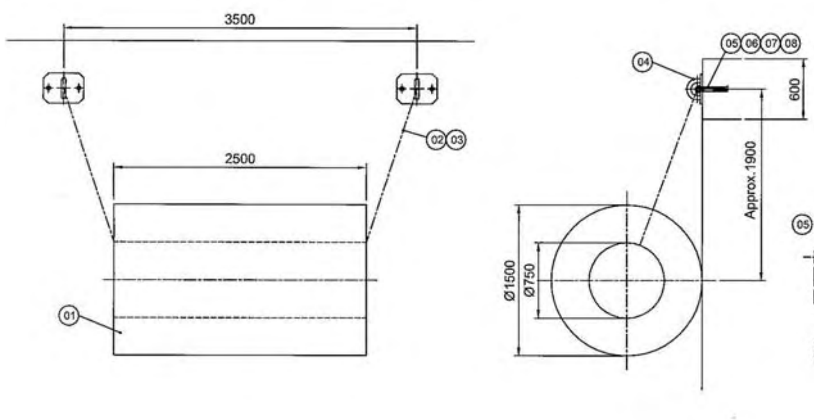
Minimization of the external forces, especially impacts by ships to the facility, should be made for extending the facility life. Container handling should be shifted to the new berth that will come on line soon, and lighter bulk cargoes by lighter vehicles will be handled at the present wharf to reduce surcharge loads.

Piles are bearable against the axial loads from static and live loads. As almost no rebar remains at top parts of piles, durability against bending moment is lost; however, occurrence of bending moment at tops of piles is not expected because the anchor and rear walls reserve structural effectiveness so far. Although the piles are expected to be in the situation of vulnerable stability, minimization of the external forces and surcharge loads are recommended because *"vertical"* and horizontal forces intricately act on the structure of deteriorated reinforced concrete. The Study Team, therefore, recommends the following measures for minimization of the external forces and surcharge loads.

i) Installation of fenders

Fenders should be installed urgently. At present, instead of fenders, tires are hung in front of the wharf; however, tires are seriously deformed when ships are touching the wharf. The deformation is caused by the low capacity of absorbing berthing energy. It results in transmission of a high rate of berthing energy to piles.

Installation of rubber fenders of cylinder type at intervals of 12 m are recommended as illustrated in Figure 4.1-20. The type and size of a rubber fender is selected so as to minimize transmission of ships' energy to the deteriorated wharf structure. The fixing place can be selected at locations where front walls and first row of piles are structurally fixed, and horizontal and slanting beams are connected with the front three piles (Refer to Figure 4.1-16).



Source: Study Team

Figure 4.1-20 Fender of cylinder type

ii) Minimization of surcharge loads

Two measures should be taken to minimize surcharge loads. The first one is to clear all the loaded containers from the deck and the second is to minimize the active loads for handling containers by heavy equipment. The existing facility will not collapse within a few years; however, unexpected collapse might locally occur in the field of complicated action of vertical and horizontal forces in the process of future development of the concrete deterioration. The horizontal forces by berthing ships will be alleviated with installation of fenders while the heaviest vertical loads generated by reach stackers should be minimized. Although the present operation is obliged to be maintained due to unavailability of an alternative berth for several years under the *vulnerable* stability, the container operation should be transferred to the new berth when it becomes available. After the transfer of the operation, lighter cargoes will be handled for the purpose of minimizing surcharge loads. However, monitoring the facility is indispensable for securing the facility's effectiveness at all stages.

iii) Measures for alleviation by management

It is also recommended that the port manager with assistance of civil engineers of CDN take the following measures for easing the external forces and properly maintaining the facility:

- Control of approaching velocity of ships to be less than 10cm/sec.
- Clearance of loaded containers from the deck as stated above
- Prohibition of mooring ships in cyclone

In addition to the above, CDN is expected to regularly maintain the port facilities and repair concrete defects like stripping covers. Methods for repair are stated in a later sub-section.

h) Monitoring of the structure

It is crucial to monitor the structure regularly in order to prevent loss and damage caused by unexpected collapse of the structure. The monitoring shall be conducted as follows:

- Regular monitoring of cracks on piles and front/rear walls once in three months
- Regular monitoring of openings between the concrete deck and container yard
- Regular measurement of compression strength of the structural members with a rebound hammer

3) Gravity type of wharf (concrete block type) and steel sheet piling wharf

Major structural defects were not found in the two types of wharves; however, joints and alignment of the blocks should be inspected by a diver for rehabilitating the wharf.

With rehabilitation of the wharves in the general cargo terminal the existing wharves should be utilized until new wharves become available. This sub-section indicates general description of necessary rehabilitation of the wharves.

The following items are so deteriorated that proper operation of handling cargoes is hampered.

a) Cap concrete of concrete block type wharf

Cap concrete of the structure should be repaired by covering the exposed re-bars and corners of cap concrete should be partially demolished and in-situ concrete should be placed there. In rehabilitating the concrete, fenders should be installed

b) Pavement behind gravity type wharf

In the existing general cargo terminal concrete pavement is completely damaged so that free driving in the yard is restricted and smooth cargo handling operation is impeded. For reserving the wharves' functions the concrete pavement should be laid in the yard.

c) Settlement of ground elevation behind wharves of gravity type

Settlement behind the wharf at several locations occurred in the gravity type wharf and it should be completely repaired for stabilizing the structure.

d) Pavement behind steel sheet piling type wharf

In the block of steel sheet piling type wharf, the whole apron is settled; though, no flow of filling material was observed. A detailed inspection is required for clarifying the cause.

4.1.2 Repairing methods

The sub-section is concerned with methods to repair the structural defects listed below:

- Pile system of the container wharf
- Stripped concrete covers
- Cap concrete of the concrete block wharf
- Pavement

・Settlement of ground elevation and outflow of filling material

(1) Repair of pile system of the container wharf

In considering repair of the south wharf facility, the structural functions of the members of the wharf are indicated in Table 4.1-16. Stability of the facility is mainly secured with piles, rear walls and anchor walls. Although the structural stability of the pile system of the container terminal is secured at present, the deterioration of concrete will likely accelerate as discussed above.

Table 4.1-16 Structural functions of the members

Member	Functions
Rear wall	Resisting/minimizing horizontal displacement due to the impacts by ships
Anchor wall	Resisting/minimizing displacement due to the tractive forces by ships
Front walls	Dispersing impacts by ships, and transmitting the forces to the piles and deck slab
Pile	Supporting the deck slab against every load

Source: Study Team

It should be noted that there will remain some difficulties in the overall renovation of the existing facility as discussed below.

The rear walls, which are made of deteriorated concrete, should be completely renovated by demolishing the existing walls. This will allow the facility to be used for future decades. In the renovation works, the earth pressure acting on the rear walls will be released, making the overall structure unstable.

In renovating the anchor walls located under the ground, excavation of the ground around the walls will also result in the release of earth pressure, which will affect the stability of the wharf structure, the same as with the rear walls.

Thus, release of earth pressure by excavation works required for the renovation will disturb the balance of dynamics in the structure system and trigger off instability of the structure during the renovation works.

Even when the renovation of rear wall and anchor wall is successfully completed, the vulnerability of the structure will remain unchanged because it is impossible to recover bending resistance of damaged piles head.

Therefore, the realistic method of overall repair of the structure would be to demolish the entire structure and to construct a new structure.

(2) Repair of stripped concrete covers

The following is a general description on the repairing methods of stripped concrete covers which should be adopted as part of CDN's regular maintenance works.

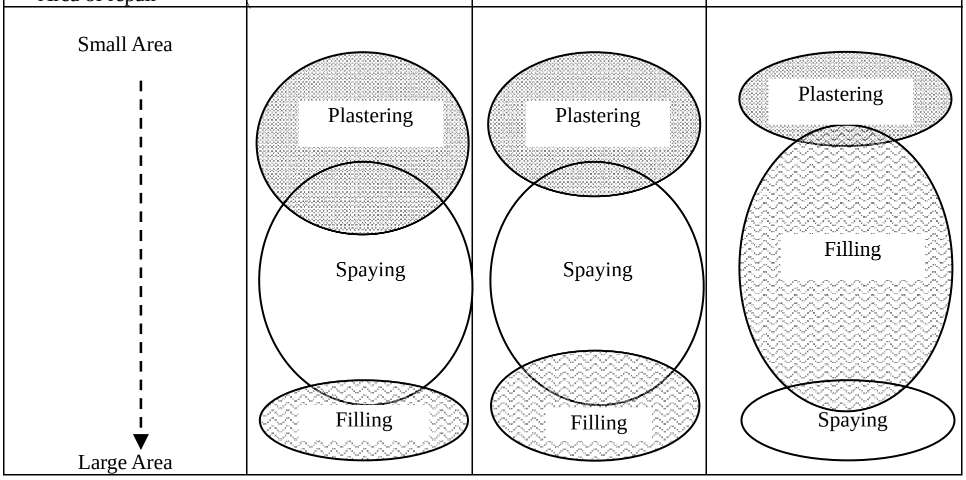
1) Type of repairing methods

Three methods of repairing concrete surfaces are usually applied with plastering, spraying and filling material, according to the situation of concrete and purposes of repair.

Table 4.1-17 conceptually shows application of repairing methods for three categories.

Table 4.1-17 Conceptual scope of application of repairing methods

Locations of repair	Soffit	Side	Upper Surface
Working situation / Area of repair	Upward Working	Sideward Working	Downward Working



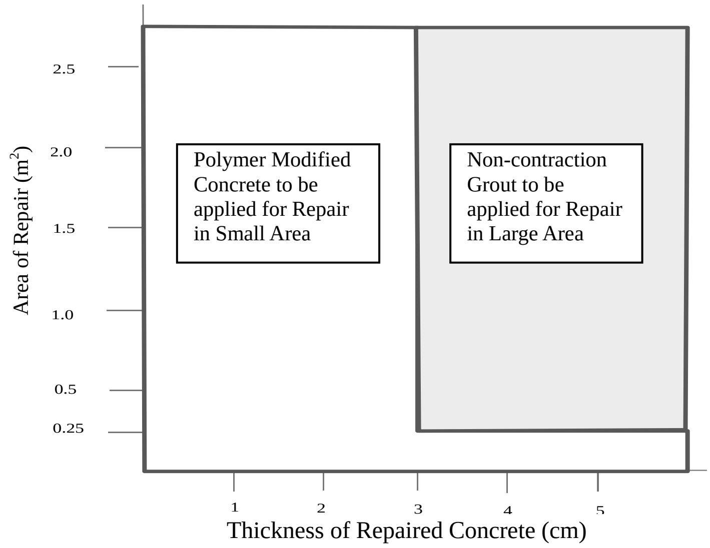
Source: CDIT & Study Team

As shown in the table, repair methods at upper surfaces differ from ones at other locations. While plastering and spraying methods need no concrete form, quality of the work depends on the skills of technicians involved.

Repairing material should have the following characteristics:

- High strength and stiffness,
- No cracks by drying shrinkage and heat of hydration,
- High bonding strength,
- High workability,
- Durability against seawater and
- Smaller dispersion coefficient of chloride ion.

Figure 4.1-21 shows the application range of repairing material according to areas to be repaired that follows a Japanese guideline quoted from the Manual for Maintenance & Repair by Tokyo Port Terminal Corporation.



Source: Tokyo Port Terminal Corporation & Study Team

Figure 4.1-21 Application range of repairing material

The manual recommends that non-contraction grout should be applied for repairing concrete in case that the thickness is more than 3 cm and the area is larger than 0.25 cm^3, while polymer modified concrete should be applied for the thinner repaired concrete or the smaller area.

The damaged concrete in the open-type wharf is categorized into two types:

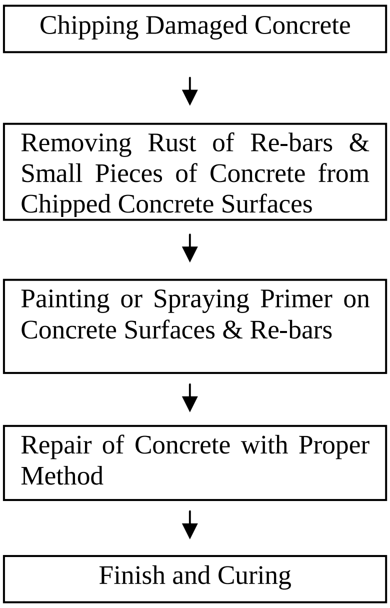
- Seriously damaged concrete in piles and props
- Stripped concrete covers of vertical front walls of the wharves

No concrete repair will be made for the former concrete in the piling system except equipping rubber fenders for absorption of external forces, so long as the existing facilities will be maintained as they are.

The latter shall be repaired by applying the methods mentioned above for prolonging their lives.

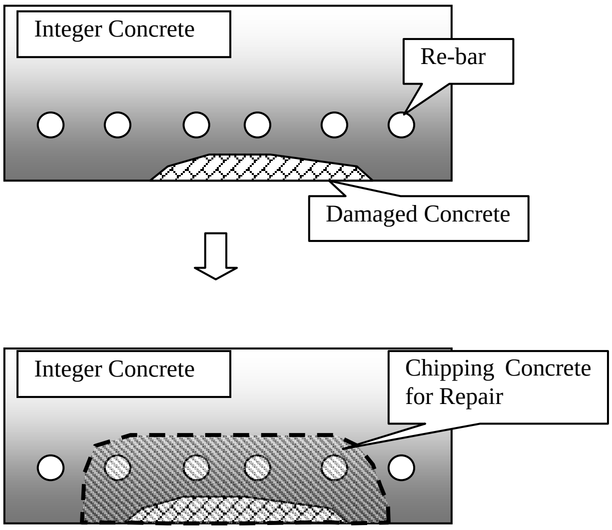
2) Procedure of repair

Locations and areas to be repaired should be specified with site investigation. The procedure of repair is illustrated in Figure 4.1-22. A conceptual illustration of the repair method of a concrete member is shown in Figure 4.1-23.



Source: Study Team

Figure 4.1-22 Flow chart of repair work



Source: CDIT & Study Team

Figure 4.1-23 Conceptual illustration of repairing method

Execution steps are composed of chipping concrete off to expose re-bars, removing rust from re-bars, applying primer and anti-corrosive treatment to re-bars, applying appropriate method for repair, and finishing and curing concrete.

For repairing a damaged part, concrete should be chipped deeply to expose re-bars and appropriate mending material should be filled in the space for combining two kinds of material. In case that re-bars are seriously rusted, additional reinforcement should be provided after anti-corrosive treatment. Appropriate material should be chosen for meeting the guideline as illustrated in Figure 4.1-21.

(3) Cap concrete of concrete block wharf

The cap concrete of the gravity type wharf in the general cargo terminal is entirely damaged as shown in Figure 4.1-24. The damages are caused by the reiterated impacts by mooring ships in the cyclone.

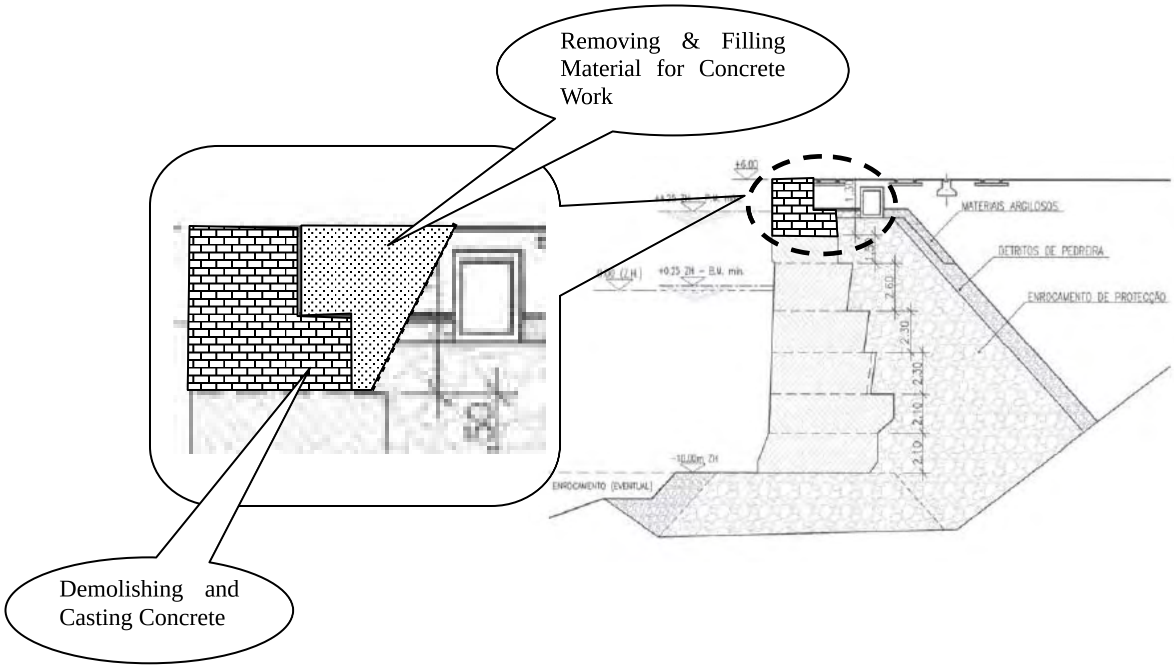
Source: Study Team

Figure 4.1-24 Deteriorated cap concrete of the general cargo terminal

As seen in the above photos, corners of the wharf made of small concrete blocks are seriously damaged. The small precast concrete blocks were installed on the cap concrete by placing concrete for gluing.

For confirming concrete strength, physical compression tests on gluing concrete with a Schmitt hammer were conducted. It is found that small corner blocks were glued with poor mortar onto the cap concrete cast in place. The part was very vulnerable and seems to be a defect in structural design.

The cap concrete should be rehabilitaed to recover the initial function of the wharf. The rehabilitation will be made by demolishing the whole cap concrete and casting in-situ concrete for the part, as shown in Figure 4.1-25.



Source: Study Team

Figure 4.1-25 Conceptual illustration of rehabilitation work for cap concrete

From the viewpoint of coping with future demand, the water depth in front of the wharf will be insufficient for accommodating larger ships calling at Nacala Port. A new deeper berth which can accommodate the larger ships will be constructed in the 10 or 15 years, and the existing berth will terminate its function.

As mentioned in the previous section, the stability of the facility is secured and no repair will be necessary till the provision of a new deep wharf in front of the existing wharf. In case that the existing wharf is utilized as a retaining wall for a new berth, however, long term stability of the wharf structure should be secured by carrying out rehabilitation works, if necessary, based on the survey of the block joints, surfaces of blocks and marks of outflow of filling material.

Existing bollards should be removed and re-installed when the rehabilitation works are completed. New fender system should be installed in rehabilitating the cap concrete.

(4) Pavement

a) Container terminal

Seriouse damages except shallow dips are not found in the terminal and there remain no obstacles. The dips should be repaired as part of regular maitenance work.

Regarding the introduction of RTGs, the existing pavement of interlocking concrete blocks will not be able to bear the loads. Lanes made of concrete pavement that can bear the loads of RTGs should be introduced.

b) General cargo terminal

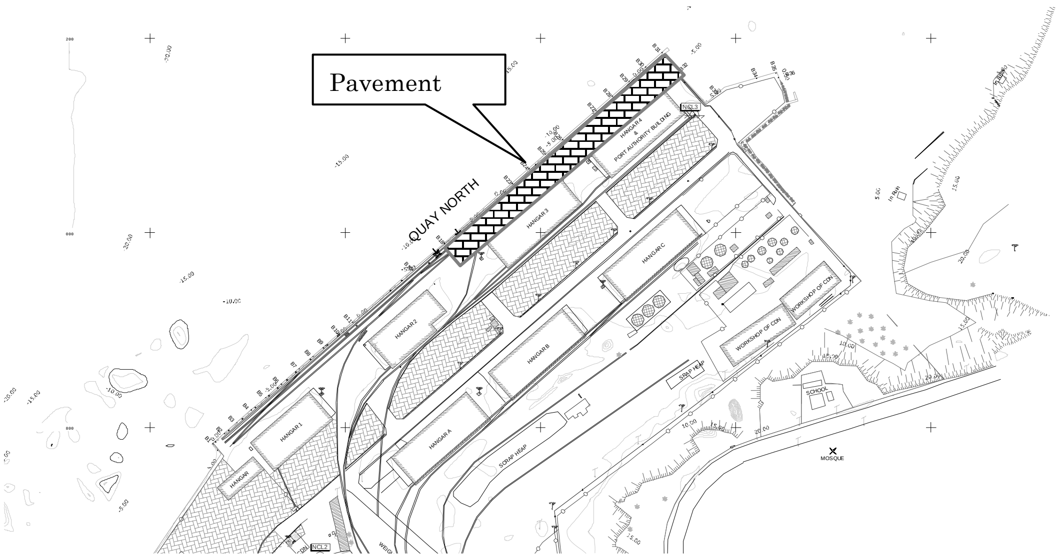
The apron in the terminal is not entirely paved as shown in Figure 4.1-26 and it should be rehabilitated for the smooth traffic of cargoes.

The area for concrete pavement for operation of reach stackers is tentatively estimated to be 8,000 m^3. The existing concrete and a soil layer of some thickness will be removed up to necessay depth to provide base courses, sub-base courses and a concrete layer. The pavement area is illustrated in Figure 4.1-27.

The rails in the apron shall be demolished since the productivity of the existing rail crane system is very low.

Source: Study Team

Figure 4.1-26 Overall view of apron in general cargo terminal



Source: Study Team

Figure 4.1-27 Area of pavement in general cargo terminal

(5) Settlement of ground elevation and outflow of filling material

Settlement of the ground is found in the block of wharf constructed with steel sheet piles. Base courses provided in the initial design are not identified in the settled area. It is considered from the present situation that inappropriate works might have been carried out. In the present stage, visual inspection by divers is not conducted. Before rehabilitation works, it should be made for confirming marks of outflow of backfilling material. The present conditions are shown in Figures 4.1-28 and 29.

Settlement of ground will be recovered with pavement works.

Source: Study Team

Figure 4.1-28 Settlement of ground

Source: Study Team

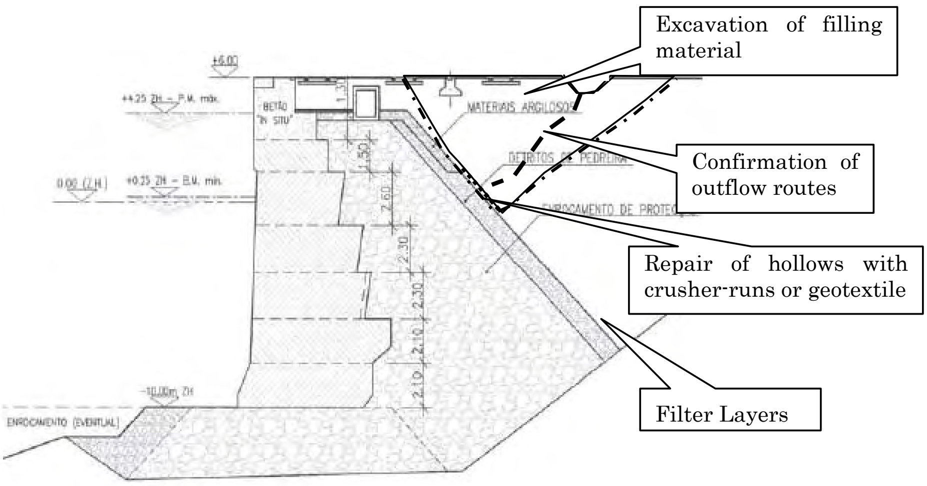
Figure 4.1-29 Dip by outflow of material to sea

There are marks of outflow of filling material at two locations in the general cargo terminal. One is located behind the wharf of concrete blocks and the other is located just behind the wharf of steel sheet piles.

In terms of dips behind the wharf shown in Figure 4.1-29, routes of outflow of filling material should be identified with excavating the filling material up to filters made of rubble stones shown in Figure 4.1-30. By confirmation of the locations, they should be repaired with smaller stones like crusher-runs or geotextile.

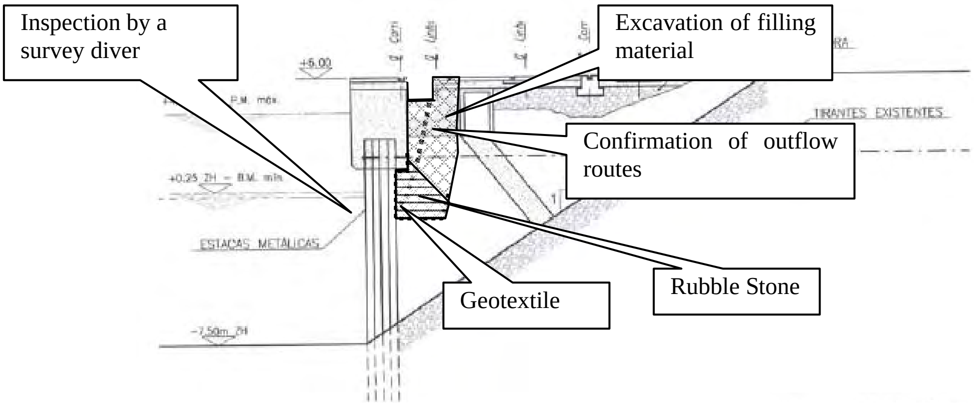
Locations of outflow of filling material should be identified by excavating the filling material up to the steel sheet piles the same as the block type structure. If holes or openings are found, they should be covered with geotextile to be held with rubble stone.

The same should be done for identifying the locations of outflow of filling material at the steel sheet pile quay shown in Figure 4.1-28. The concept is illustrated in Figure 4.1-31.



Source: Study Team

Figure 4.1-30 Method of investigation and repair of a block type quaywall



Source: Study Team

Figure 4.1-31 Method of investigation and repair of a steel sheet pile type quaywall

4.2. Alternative plans for port rehabilitation

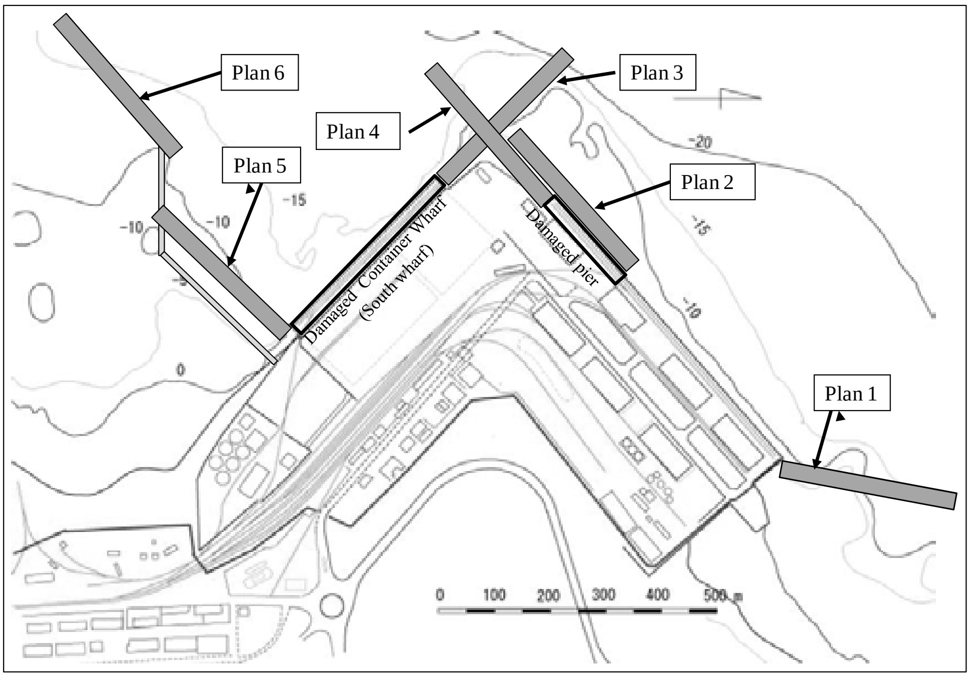
4.2.1 New construction of container berth prior to the rehabilitation of the damaged pier of the South Wharf

Based on the results of the field inspection and the structural examination, it is assessed that the damaged pier of the South Wharf can be used for more years if the pier is used with special care such as restriction of loads of the pier, slower ship berthing speed and the installation of fenders. Most scrupulous and continuous observation and monitoring of the wharf structures shall be conducted during the operation. Since the pier is the main and the busiest berthing facility of the Port, it cannot be repaired or reconstructed until alternative berthing facilities are operational. Therefore, it is recommended that a container berth should be newly constructed prior to the rehabilitation of the damaged pier and that the pier should be used for bulk cargo handling, which does not require loading heavy load and equipment on the pier. Moreover, it is bulk carriers that require a deepwater wharf because of their size.

4.2.2 Alternative layout plans for a new container pier

There are six (6) locations for the construction of a new container pier taking into consideration the connectivity with the existing container yards as shown in Figure 4.2-1. The advantage and disadvantage of each plan are summarized in Table 4.2-1

- Plan 1: Extension of the general cargo wharf to the north
- Plan 2: In front of the western end (damaged part) of the general cargo wharf
- Plan 3: Extension of the South Wharf to the west
- Plan 4: Extension of the general cargo wharf to the west
- Plan 5: New construction of a pier at the south end of the South Wharf perpendicular to the latter
- Plan 6: A detached pier along the contour line of -14m, which is connected to the South Wharf by a bridge



Source: Study Team

Figure 4.2-1 Alternative layout plans for a new container pier

Table 4.2-1 Impacts of alternative plans of a new container pier

	Impacts						
	Ship maneuvering	Container Terminal Operation	Traffic flow in the port	Requirement of dredging	Other impact	Relationship with the rehabilitaiton of the damaged piers	Environmental impacts
Plan 1	*Good*	Distant from the existing CY	Intersept oil pipeline	Dredging is required (Volume is small)	Easy to expand in the future	Completely separate project	・Located close to seagrass bed. ・Development of previously undisturbed area
Plan 2	*Good*	Connected to the existing CY	No change is required	Dredging is required (Volume is large)	Demolish or relocation of a warehouse is required	Complete rehabilitaion of damaged part of GC wharf	・Risk of marine pollution due to dredging (risk low)
Plan 3	*Fair*	Connected to the existing CY	No change is required	Dredging is required (Volume is small)	Soil is very soft, hard layer is very deep	First step of the rehabilitaion of Container Wharf	・Risk of marine pollution due to dredging (risk medium)
Plan 4	*bad*	Connected to the existing CY	No change is required	Dredging is required (Volume is large)	Demolish or relocation of a warehouse is required	First step of the rehabilitaion of Container Wharf	・Risk of marine pollution due to dredging (risk medium to high)
Plan 5	*Fair*	Connected to the existing CY	Made the onflict between the flows of container and bulk cargoes more serious	Dredging is required (Volume is medium)		Complete rehabilitaion of damaged part of GC wharf	・Risk of marine pollution due to dredging (risk high)
Plan 6	*Good*	Require bridge to the wharf	Made the onflict between the flows of container and bulk cargoes more serious	Dredging is required (Volume is small)		Complete rehabilitaion of damaged part of GC wharf	・Possible hinderance to local fishing activities. ・Development of previously undisturbed area

Source: Study Team

4.2.3 Evaluation of each plan from engineering and operational viewpoints

The soil at the western tip of the port, which is the corner between the north and the south wharves, is very soft. Thus, Plan 3 and 4 are not recommendable. In addition, Plan 4 results in difficult ship maneuvering,

The location of Plan 5 is a shallow water area. It does not take advantage of the deepwater basin of Nacala Bay. A large volume of dredging is required and the expansion of deepwater wharf seems to be more costly than Plan 1 and Plan 2. Plan 6 makes the traffic conflict between container and bulk cargoes more serious. The construction of the access bridge also requires additional funds. The location of the new container pier of Plan 1 is far away from the existing container yard. Therefore, it is also required to renovate the general cargo wharf or reclaim the rear of the pier to make new container yards near the pier.

In the light of the above evaluation, Plan 2 is recommended.

4.2.4 Evaluation of alternative plans from the viewpoint of environmental impacts

According to the sediment quality survey conducted by the Study Team, the sediments around the Port were contaminated by heavy metals and harmful organic compounds, in particular in the areas adjacent to the existing general cargo and container berths (see 2.7.3 for the results of the water and sediment quality surveys). Therefore, the volume of required capital dredging was considered as an important factor when evaluating the potential environmental impacts of each alternative. Other factors that were considered important for the evaluation were impacts on the ecosystem and fisheries.

Table 4.2-1 shows the potential environmental impacts of each alternative. Although each alternative has its advantages and disadvantages, overall Plan 2 is considered as having the least environmental impact for the following reasons:

- Volume of capital dredging is small compared to the other Plans requiring dredging (Plans 3, 4 and 5).

- There are no important habitats (e.g. coral reef, sea grass bed) at or near the site.
- Does not involve development of previously undisturbed area such as Plan 1 and 6.
- No hindrance to local fishing activities.

4.3. Formulation of Short-term Development Plan

4.3.1 Facility requirements

The capacity of berths and storage yard and transit sheds are estimated for respective types of cargoes forecasted in the year 2020.

(1) Container cargoes

1) Ship to quay handling capacity

The container cargo traffic in 2020 is estimated to be 211,000 TEUs for the Base Case and 252,000 TEUs for the Highly Improved Case (see Table 3.5-43). Base case assumes that the container handling at the quay shall employ ship gears and reach stackers as well as yard chassis, while the Highly Improved Case assumes that the quay operation shall employ container gantry cranes. It is also assumed that, with highly improved productivity, the Port should attract more transshipment containers.

The container handling capacity at the berth is estimated to be 248,857 TEU/year for the Base Case, i.e., without gantry cranes (see Table 3.6-21), while the capacity for the Highly Improved Case with quay gantry cranes, is estimated to be 359.406 TEU/year (see Table 3.6-22).

Thus, for both cases, the Port is sustainable up to 2020 with just one container berth, while it requires the capacity expansion by introducing container quay cranes before 2020 if the Port attracts transshipment container cargoes.

2) Yard capacity

The yard capacities required for the quay operation to exhibit their maximum productivity are calculated to be 5,946 TEUs for Base Case and 8,588 TEUs for Highly Improved Case (see Table 3.6-24).

(2) Bulk cargoes

1) Ship to quay handling productivities

The volumes of bulk cargoes in 2020 are estimated by commodities in Table 3.5-44. Among various commodities, minerals are expected to be handled at a new mineral terminal at Nacala-Belha. The Port is expected to handle all other bulk cargoes except minerals.

Those commodities indicated as “Other minor bulk” in Table 3.5-44 include break bulk, i.e., general cargoes. For the purpose of examining the berth requirements for dry bulk and general cargoes, the following assumptions are made:

- The export other minor bulk cargoes should be bagged cargoes, since the major export products should be agricultural products.
- The import minor bulk should be fertilizer and be handled as dry bulk cargoes.

Those quantities needed to estimate the berth requirements are summarized in Table 4.3-1:

a. Cargo volumes by commodity (in 1,000 tons)
b. The average cargo volume unloaded or loaded per ship call
c. Number of ship calls in 2020
d. Total hours needed for a ship to berth and to leave, which is assumed to be three (3) hours
e. The cargo handling productivities (ton per hour).

Table 4.3-1 Cargo volumes by commodity in 2020

Commodity	Volume (1,000 t)	Percel size (t)	Ship call (Ships)	Berthing time/ship (hours)	Cargo handling productivity (t/hour)
Wheat	662	13,950	47.5	3	240
Clinker	500	20,733	24.1	3	160
Fertilizer	389	6,781	57.4	3	160
Wood Chip	96	20,000	4.8	3	140
Bagged Cargo	214	6,781	31.6	3	50
Vehicle	133	2,200	60.5	3	98
Total	1,994				

Source: Study Team

The cargo handling productivities for respective commodities are estimated as follows:

a. Wheat: Wheat shall be handled by unloaders that having a productivity of 240t/hr.
b. Clinker: The productivity exhibited in 2009 with simultaneous operation of four ship cranes.
c. Fertilizer: The same productivity as clinker.
d. Wood chip: The productivity of 140t/hr is chosen to complete loading of 20,000 tons of wood chip within a week.
e. Bagged cargo80t/h is employed taking into considerations of the productivity of sugar loading achieved in 2008 (79.1 t/hr) .
f. Vehicle: With an assumption that the average weight of vehicle is 2.5 tons, the productivity observed in Dar es Salaam Port for pure car carrier, 39 units/hr, is employed: (2.5 t x 39 units/hr = 97.5 t/hr).

2) Required number of bulk berths

Employing the quantities shown in Table 4.3-1, the total hours needed for the unloading and loading of the cargoes expected in 2020 is calculated. The result is shown in Table 4.3-2.

Table 4.3-2 Total berth-hours and required number of berths

Commodity	Berthing and departure time (hours)	Annual operation hours (hours)	Total berth use (hours)	Annual operation hours per berth (hours)	Required number of berths
	(1)	(2)	(3) = (1) + (2)	(4)	(5) = (3) / (4)
Wheat	142	2,758	2,901		
Clinker	72	3,125	3,197		
Fertilizer	172	2,431	2,603		
Wood Chip	14	686	700		
Vehicle	180	1,359	1,539		
Dry Bulk Total	581	10,359	10,940	5,694	1.92
Bagged Cargo	95	4,280	4,375	5,694	0.77

Source: Study Team

Under the condition that the Berth Occupancy Rate (BOR) should be no larger than 65%, which is the same rate as employed for the container cargoes (see Table 3.6-26), the annual berth-hour per is calculated as 5,694 hours per berth: 24hr x 365day x 65% = 5,694hrs.

The result shows that two berths are required for the handling of dry bulk cargoes and vehicles, while one berth is required for the handling of general cargoes.

3) Required yard area and transit sheds

It is assumed that the size of stock yards and transit sheds should be large enough to stock the volume of the cargo volumes unloaded or loaded per one ship and that all the volumes should be delivered from or brought to the Port before the next ship arrives.

a. Wheat and clinker

Currently, wheat and clinker are directly delivered out of the port area by dump trucks or rail wagons. It is assumed that the same method is employed in the future. Thus no stock yard or silo is required.

b. Fertilizer

It is assumed that the entire volume of fertilizer will be handled as dry bulk cargoes and that the volume unloaded from a ship is 20,000 tons. The volume of 20,000 tons of fertilizer is estimated to be 28.600 m^3 with an assumption that the unit weight of fertilizer is 0.7 t/m^3. This volume requires 1.0ha (100m x 100 m x 3m = 30,000 m^3).

c. Wood chip

The unit weight of wood chip is 0.5 t/m^3. To stock 20,000 tons of wood chip requires 1.5 ha:

Volume unloaded per ship:	20,000 tons (20,000/0.5＝40,000m^3)
Required area of stock yard:	1.5ha (100m x 150m, with pile up height of 3m).

c. Vehicle

It is assumed that the average dimensions of vehicles are 2.5m (wide) x 8m (long) = 20m^2 and average weight is 2.5 tons.

The volume of vehicle unloaded from a ship is 22,000 tons. This correspond to 880 units (22,000 tons /2.5 ton/units ＝880 units) . For the case that 1,000 units of are brought by a pure car carrier, 20,000 m^2 (20m^2 x 1,000 units = 20,000 m^2) is required.

d. Bagged cargoes

The average volume of bagged cargo loaded to a ship is 6,781 tons. With an assumption that the unit weight of the bagged cargo is 0.8, the volume is calculated to be 8,746 m^3. With the stock height of 3 m, 2,825 m^2 (= 8,746 m^3 / 3 m) is required. An existing transit shed has a floor area of 3,800m^2 (=100 m x 38 m) and this is large enough to stock 9,100 tons of bagged cargo.

4.3.2 Layout of berths and yards

(1) Layout plan

On the basis of above discussion, the Study Team has drawn a Short-term Development Plan to cope with the cargo traffic foreseen in 2020 (see Figure 4.3-1). The components of the infrastructural works are listed in the following Section (2).

(2) Infrastructure

The project components included in the Short-term Development Plan are listed below. The numbers of the components correspond to the location number shown in Figure 4.3-1.

1) North wharf

- New container wharf , see Figure 4.3-1 [1]
  - Demolishing of warehouse No. 0, 1 and 2
  - Demolishing of the damaged pier in the North Wharf
  - Pier structure (320 m x 40 m, water depth; -14m)
  - Dredging the berth up to -14 m [2]
  - Construction of container yards [3]
- Repair of the pavement of Apron and curbstones [4]
- Repair of pavement of port road [5]

- Grading and ground leveling of open storage yard [6]

It should be noted that, though berth length of 330m is widely employed for Panamax size container carriers as discussed in the Medium/long-term Plan, the Short-term Plan herein proposes 320m. This is because the oil and gas berth at eastern half of the North Wharf, which would not be relocated in the horizon of the Short-term Plan, should be no less than 310m for the safety purposes. Even though the new container berth is 10m shorter than the standard length, the functional restriction due to the length of the berth can be minimized by installing bollards outside of the berth.

2) South Wharf

- Installation of fenders to the damaged container pier , see Figure 4.3-1 [7]
- Installation of grain unloader and belt conveyer [8]
- Container yards (Foundation for RTGs) [9]
- New access road and railway to the South Wharf (about 1 km)
  Construction of road [10]
  Rail access track to the South Wharf [11]
  Reclamation [12]
- Rail container terminal [13],
- Removal of rail container gantry crane and pavement of storage yard [14]
- Open storage of bulk cargoes [15]

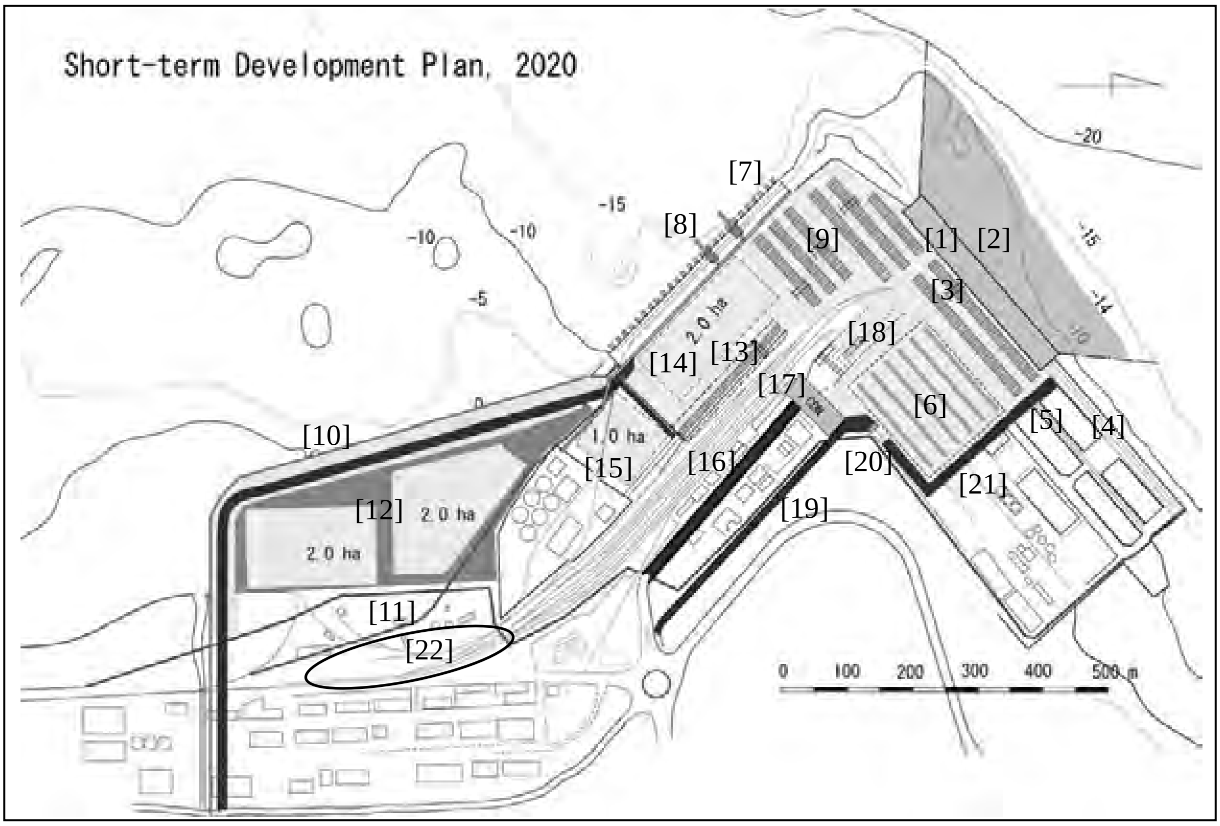
3) Main gates, road and railway

- Widening of entrance road, [16]
- Construction of One Stop Service Building (port administration building) [17]
- Construction of new gates (including truck scale) and pavement [18]
- Construction of another access road (for general cargoes) and gate [19], [20] and [21]
- Expansion of rail shunting area [22]

(3) Equipment

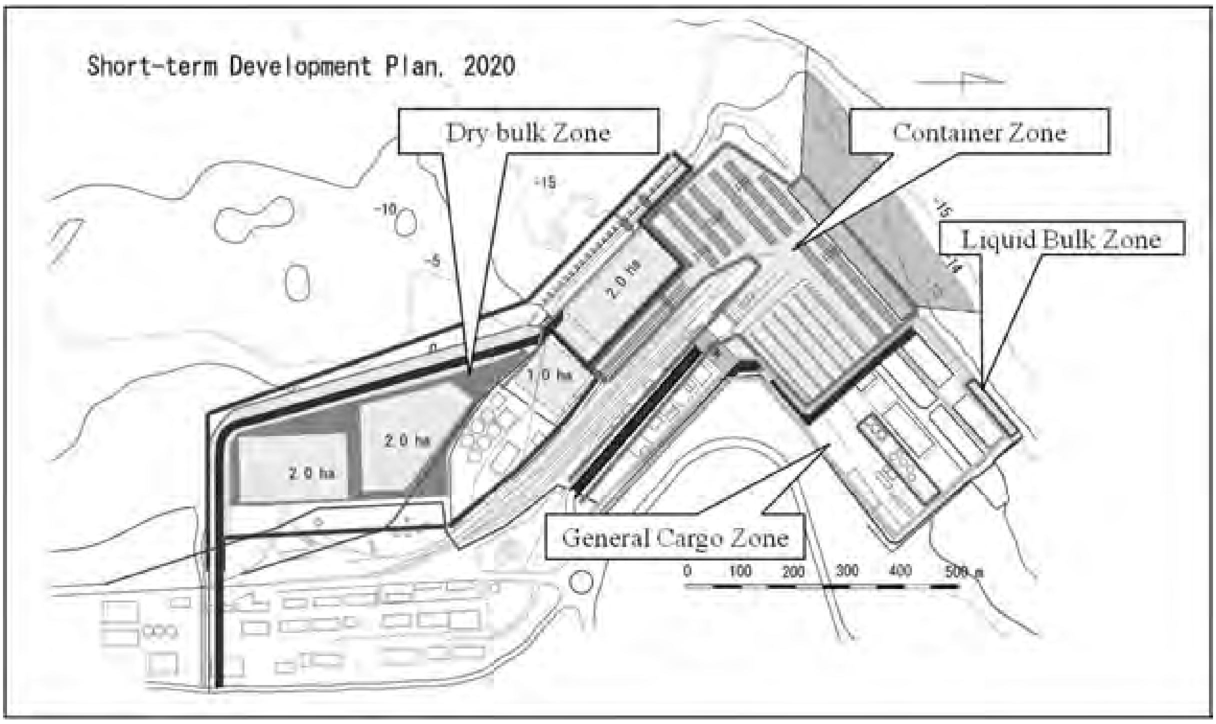
· Reach stacker	4 units
· Tractor-head and yard chassis	12 units
· RTG	8 units (four-high)
· Mobile crane	1 unit (100 ton)

In the Short-term Development Plan, the port land area is divided into four (4) zones so that no traffic conflicts occur between different types of cargoes (see Figure 4.3-2). Accordingly, the traffic flow will become smoother.



Source: Study Team

Figure 4.3-1 Short-term Development Plan (target year: 2020)



Source: Study Team

Figure 4.3-2 Zoning of port area by cargo type and the traffic flow in the Port

4.3.3 Capacity of the container yard

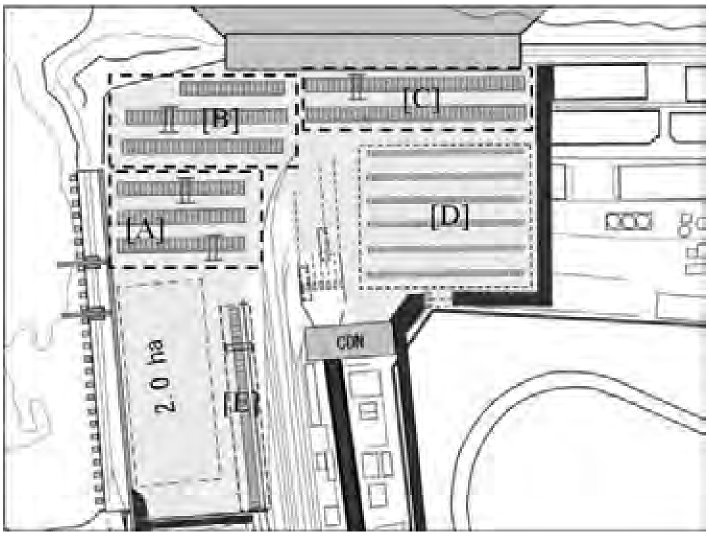
The layout of the container yard is shown in Figure 4.3-3. The capacities of the container yards are as shown in Table 4.3-3.

When the Short-term Development Plan is completed, the total capacity of the container yards is 6,716 TEUs, which is larger than the required capacity to maximize the capacity of ship-quay operation (5,946 TEUs). Since the container traffic volume in 2020 is estimated to be 209,627 TEUs for the Base Case, which is 84.2% of the capacity of ship-quay operation, the three main marshaling yards (Zone [A], [B] and [C] in Figure 4.3-3), are assessed to be large enough except for peak seasons: the total capacity of the three zones is 5,184 TEUs, which encompasses 87.2% of the required yard capacity.

Table 4.3-3 Capacities of container yards by zones

	Location	Row	Column	Ground slo	High	Sub-total	Units	Total
[A]	South Wharf (North side) CY	6	22	132	4	528	3	1,584
[B]	North Wharf CY (West side)	6	18	108	4	432	1	432
		6	28	168	4	672	2	1,344
[C]	North Wharf CY (Center)	6	38	228	4	912	2	1,824
	Sub-total			636				5,184
[D]	North Wharf open storage Yard	2	27	54	3	162	6	972
[E]	Rail Container CY	4	35	140	4	560	1	560
	Total			830				6,716

Source: Study Team



Source: Study Team

Figure 4.3-3 Layout plan of the container yard on the South Wharf

4.3.4 Storage allocation for other cargoes

(1) Dry bulk cargoes

The available storage yards for the dry bulk cargoes are the four areas shown in Figure 4.3-4.

1) Fertilizer

The storage area for fertilizer requires 1.0 ha. A substantial volume of fertilizer is the transit to Malawi and the storage area should be close to rail track. Thus Storage Area [2] should be reserved for fertilizer.

2) Wood chip

The storage yard for wood chips requires 2 ha. The origin of wood chip is Niassa Province and it is most likely that a substantial amount of wood chip is brought to the Port by the railway. Thus, Storage Area [3] should be reserved for wood chip.

(2) Vehicles

The storage yard for vehicles requires 2 ha. It is desirable to have storage area. Thus Storage Area [1] should be reserved for vehicles.

(3) General cargoes

1) Bagged cargoes

The major commodities of the bagged cargoes are sugar, beans and other agricultural products. Though these bagged cargoes tend to be containerized, transit sheds are required for respective commodities. Thus, warehouse No. 3 and 4 and warehouse C should be reserved for bagged cargoes.

2) Other general cargoes

Beside major commodities, various types of commodities will be handled at the Port: logs, heavy equipment and machines, long materials such as steel frames and reinforcing bars, etc. The eastern part of the North Wharf should be reserved for the storage of other general cargoes.

(4) Liquid bulk cargoes

Liquid bulk terminal and the storage tanks of vegetable oil, which is located at the east end of the North Wharf, will remain unchanged until 2020. The relocation of the liquid bulk terminal will be done in the Medium/long-term Development Plan for the expansion of the container terminal.

4.4. Urgent Rehabilitation Project

The Short-term Development Plan proposed in 4.3. is intended to improve the productivities in the operation of the Port. As shown in Figure 4.3-1, the Short-term Development Plan consists of various project components. Unless traffic congestion is alleviated by removing the conflict among trucks and between trucks and rail cars, it will be impossible for the project to be implemented without exacerbating the traffic congestion. Thus, it is practically impossible to implement these components at the same time because the structure that needs urgent repair is currently the busiest wharf.

Therefore, the most practical approach is to implement the Short-term Development Plan in several phases. Those project components that need to be implemented in the early stage of the project shall be packaged as the Urgent Rehabilitation Project.

4.4.1 Criteria for the selection of the project components for urgent rehabilitation

Prior to the start of the construction of the new pier at the western side of the North Wharf, it is vital to enhance the capacity of the container and the dry bulk handling at the South Wharf so that the Port will be able to handle all the container and dry bulk cargoes without using the western half of the North Wharf, which is the project site of urgent rehabilitation. To this end, those project components intended to enhance the handling capacity of the South Wharf should be completed before the construction of the new container wharf starts at the western part of the North Wharf.

Thus, those project components that are the preparatory works are chosen as the first part of the Urgent Rehabilitation Project: the package of these components is called the Urgent Rehabilitation Part-1, hereafter. The components to be implemented as the second part of the Project are those related to the construction of the new wharf. Those components that facilitate the effective use of the new wharf should also be included in the Urgent Rehabilitation Project. The package of these components is called the Urgent Rehabilitation Project Part-2.

4.4.2 Components of the Urgent Rehabilitation Project

With these criteria, the components shown in Table 4.4-1 through 4.4-2 have been chosen as the components of the Urgent Rehabilitation Project. Table 4.4-1 shows the components of Part-1, while Table 4.4-2 shows those of Part-2. The numbers in the right column indicate the number used in Figure 4.4-1 and Figure 4.4-2 to identify the location of the components. Table 4.4-3 is the list of the components to be implemented after the completion of the Urgent Rehabilitation Project.

Table 4.4-1 Project components of the Urgent Rehabilitation Project Part -1

No.	Project Component	Item No. in Fig. 4.4-1
1	By-pass access road	[1]
2	Installation of fenders	[2]
3	Foundation of RTG’s	[3]
4	Widening of entrance road	[4]
5	Gate construction	[5]
6	Pavement	[6]
7	Pavement of apron	[7]
8	Equipment (reach stacker 4, yard chassis 12, RTG 2)	

Source: Study Team

Table 4.4-2 Project components of the Urgent Rehabilitation Project Part-2

No.	Project Component	Item No. in Fig. 4.4-2
1	Landfill and ground leveling	[1]
2	Construction of rail track	[2]
3	Ground leveling	[3]
4	Repair of yard and road pavement	[4]
5	Rail container terminal	[5]
6	Container yard pavement	[6]
7	Reconstruction of wharf (320m x 40m)	[7]
8	Dredging(-14m)	[8]
9	Road pavement	[9]
10	Equipment (RTG2)	
11	Demolishing of warehouses (No. 0, 1 and 2)	[9]

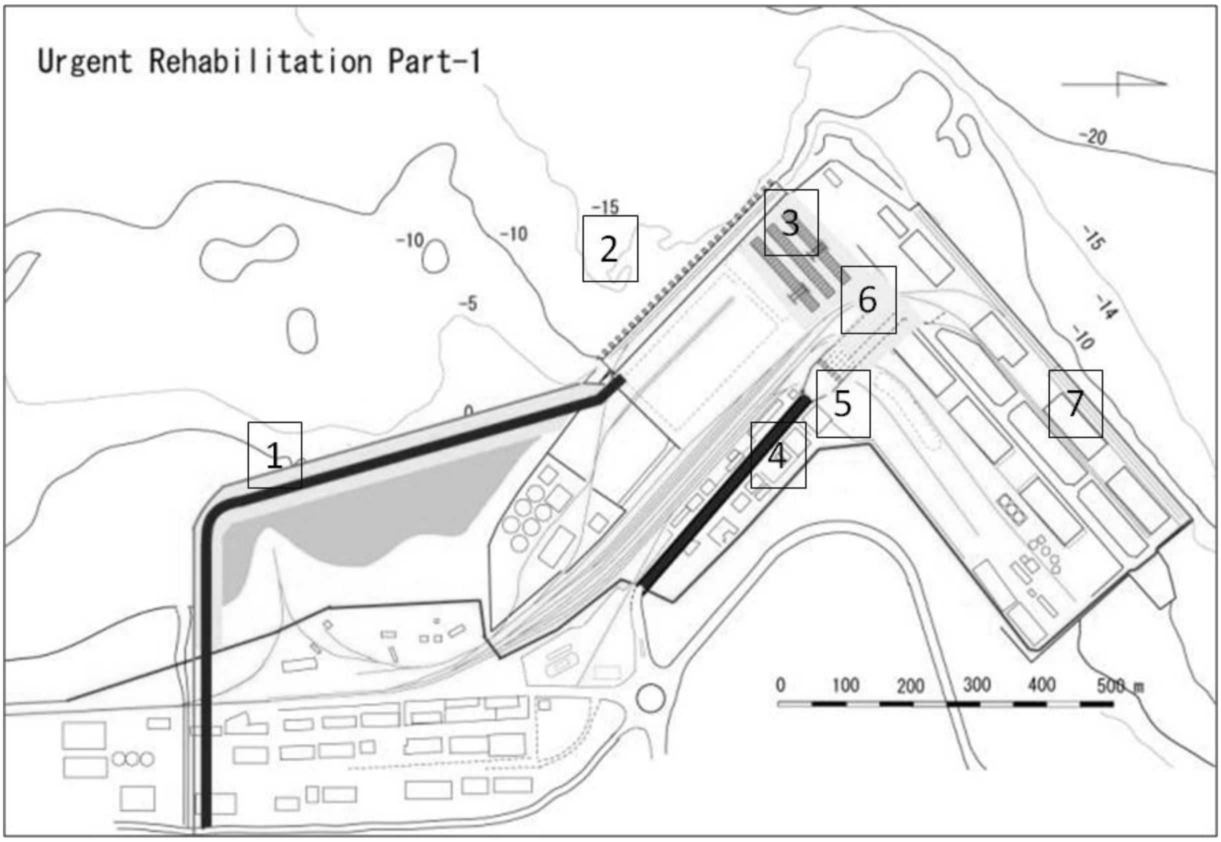
Source: Study Team

Table 4.4-3 Components to be implemented after the Urgent Rehabilitation Project

No.	Project Component	Item No. in Fig. 4.4-3
1	New access road (for GC)	[1]
2	Construction of gates	[2]
3	Demolishing hangar A & B	[3]
4	Construction and repair of road	[4]
5	Grounding of yard	[5]
6	Grain unloaders	[6]
7	Belt conveyers	[7]
8	CDN administration building	[8]
9	Expansion of rail shunting tracks	[9]

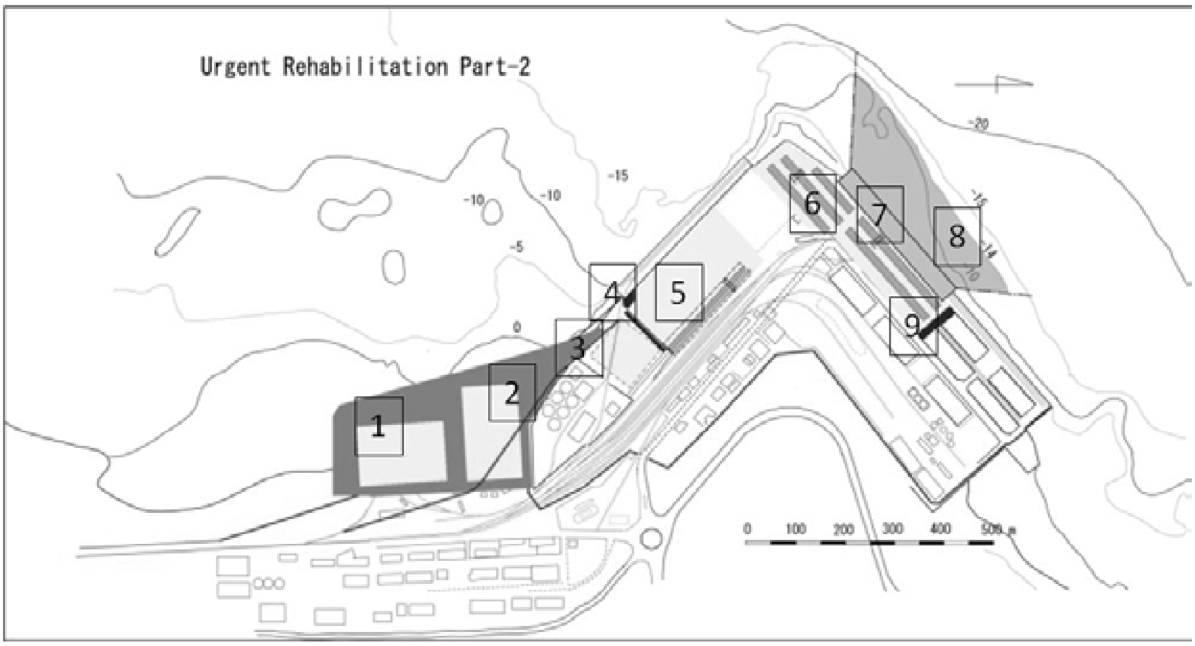
Source: Study Team

The locations of the component listed in **Table 4.4-1, 4.4-2** and **4.4-3** are shown in **Figure 4.4-1**, **4.4-2** and **4.4-3**, respectively.



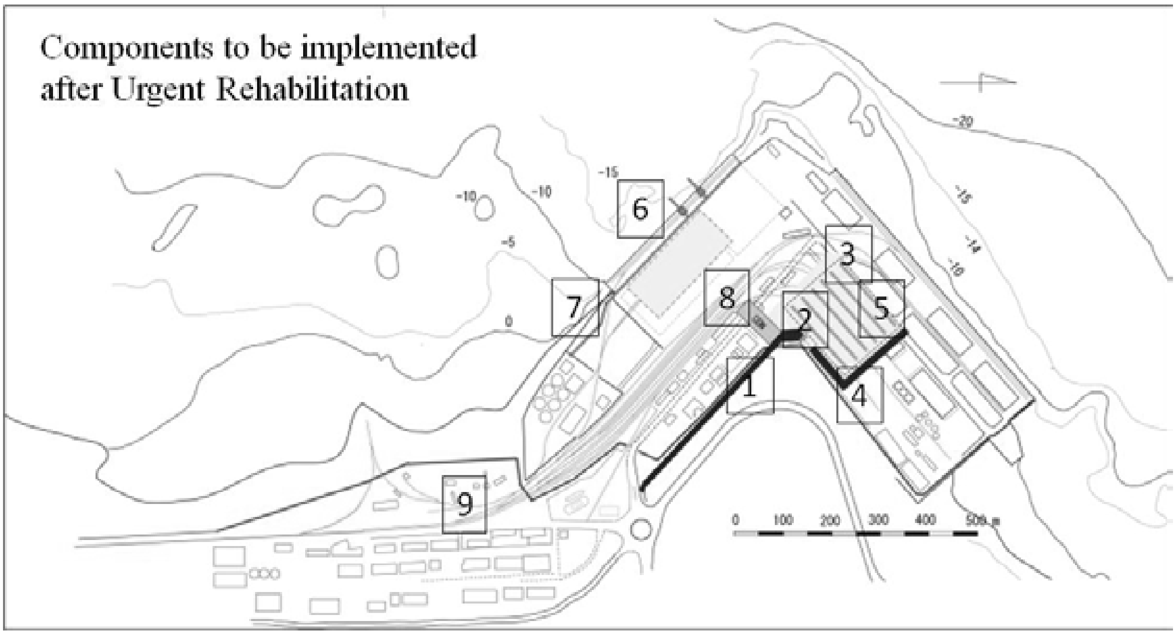
Source: Study Team

Figure 4.4-1 Components of the Urgent Rehabilitation Project (Part -1)



Source: Study Team

Figure 4.4-2 Components of the Urgent Rehabilitation Project (Part -2)



Source: Study Team

Figure 4.4-3 Components to be implemented after the Urgent Rehabilitation Project

4.5. Preliminary design

4.5.1 Design conditions

(1) Meteorological and oceanographic condition

1) Tides

- Highest water level (HWL) : + 4.40 m
- Mean sea level (MSL) : + 2.25 m
- Lowest water level (LWL) : + 0.30 m
- Chart datum line (CDL) : ± 0.00 m

2) Waves

- Wave height : 2.5 m
- Wave period : 4.5 sec
- Wave direction : North

3) Design seismic coefficient for port facilities

- Horizontal design coefficient : kh = 0.05g
- Vertical design coefficient : kv = 0.00g

(2) Subsoil conditions

The design properties of subsoil for the new container berth are determined based on the soil investigation conducted in the Study. Soil investigation was conducted at twelve locations, five on land and seven on the sea. Out of eleven locations, BH2, BH3, BH8 and BH12 are the main basis of the subsoil conditions for the new container berth.

According to the soil investigations, the BH2 boring sample shows the northern half of the new container berth is weak siltstone and the boring sample of BH3 shows that the southern half is of very soft silt and loose sand on the stiff silt and medium sandy silt. Therefore, two design subsoil conditions have been determined for the north and south section of the new container berth;

Table 4.5-1 Subsoil condition of new container berth at north side

Layer	Depth CDL (m)	Soil Properties		
		N value	Unit weight γ, γ' (kN/m^3)	Strength
Siltstone (extremely weak)	-13.4 to -19.4	N>50	γ=18, γ’=10	qu=400 kN/m^2 C= 200 kN/m^2

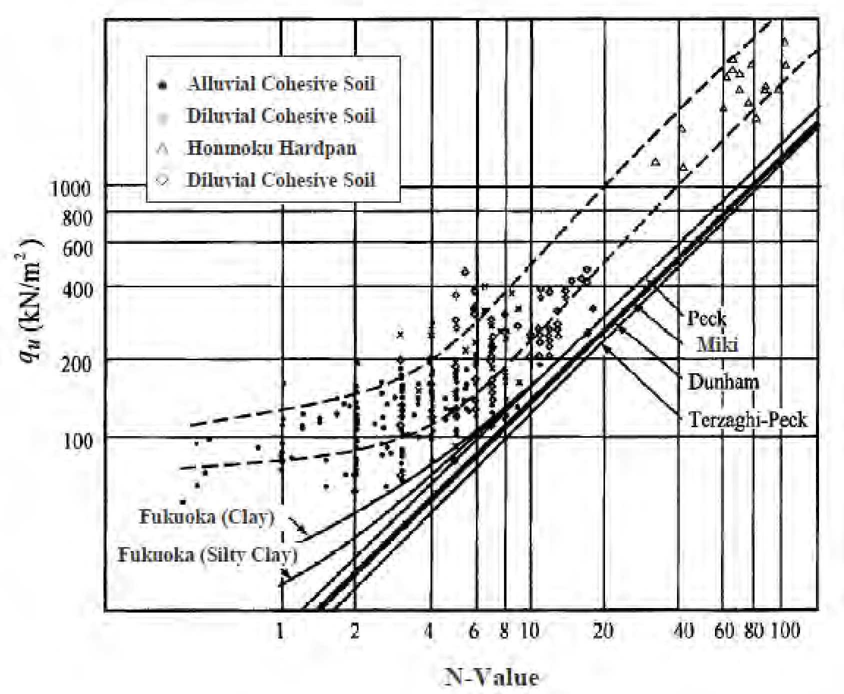
Note: Above properties are assumed based on BH2
Source: Study Team

Table 4.5-2 Subsoil condition of new container berth at south side

Layer	Depth CDL (m)	Soil Properties		
		N value	Unit weight γ, γ' (kN/m^3)	Strength (kN/m^2)
Fine to coarse Sand or Silt	-10.5 to -22.5	N_{ave}=2	γ=18, γ’=10	qu=10 Cu= 5
Fine to coarse Sand or Silt	-22.5 to 32.5	N_{ave}=20	γ=18, γ’=10	qu=220 Cu= 110

Note: Above properties are assumed based on BH3
Cu: Cohesion in unconsolidated and undrained (kN/m2)
qu : Compression strength by unconfined and undrained compression test (kN/m2)
N: Blow counts in Standard Penetration Test (SPT)
Source: Study Team

Analysis of SPT and laboratory test results has established the soil type and classification encountered in each borehole. The soil strength parameter of each major subsoil layer is obtained based on SPT. The cohesion Cu= qu/2 kN/m^2 of clayey soil was obtained from the following correlation with SPT value.



Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI

Figure 4.5-1   Correlation between N-Value and compression strength

(3) Design conditions of new container berth

1) Design container vessel

- 50,000 DWT Panamax
  Loa = 274m
  Width = 32.3m (13 rows of container stacking on deck)
  Full loaded draft = 12.7m
  TEU capacity = 3,500 to 3,900 TEU

2) Geometry of container berth

- Berth length	320 m
- Top elevation at cope-line of berth	CDL + 6.0 m (same as the existing berth)
- Planned water depth	CDL - 14.0 m
- Design water depth	CDL -15.0 m
- Apron width	40 m

3) Loading conditions

- Surcharge (normal condition)	30 kN/m^2
- Surcharge (seismic condition)	15 kN/m^2
- Ship berthing condition	Design vessel 50,000 DWT container vessel
- Ship approach velocity	0.1 m/sec
- Ship berthing angle	10 degrees
- Load on bollard	1,000 kN pull capacity
- Quay gantry crane:	

Panamax type (Total dead weight 10,000 kN, seaside wheel load 500kN/w, landside wheel load 450kN/w, total 32 wheels at 1.0m interval)

Source: Study Team

Figure 4.5-2 Wheel arrangement of quay gantry crane

4) Service life

The container berth structure including piles, beams, and tie rods will be designed for a service life of 50 years.

(4) Design criteria of materials

1) Steel material

Table 4.5-3 Allowable stress of steel materials

Structural steel (steel pipe)	SM490/SKK490/SKY490 (N/mm^2)
Axial tensile stress	185
Axial compressive stress	185 : l/r<16, 185-1.2x(l/r-16):16<l/r<79, 1,200,000/(5,000+(l/r)^2):79<l/r
Bending tensile and compressive stress	185
Examination of members simultaneously subject to axial compressive and bending compressive stress	$\sigma_c/\sigma_{ca}+\sigma_b/\sigma_{ba} < 1.0$
Steel sheet pile	SY (N/mm^2)
Bending tensile and compressive stress	180

Note: l: effective buckling length of member (cm)
r: radius of gyration of area for the gross cross-sectional area of the member (cm)
σ_c: compressive stress due to axial compressive force acting on the section (N/mm^2)
σ_b :maximum compressive stress due to bending moment acting on the section (N/mm^2)
σ_{ca}: allowable axial compressive stress relating to smallest moment of inertia (N/mm^2)
σ_{ba}: allowable bending compressive stress (N/mm^2)

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI

2) Increase of allowable stress

The allowable stress for seismic conditions will be increased by 50% for the table above.

3) Corrosion rate of steel material

The corrosion rate of steel materials to be considered is indicated in the table below:

Table 4.5-4 Corrosion rate of steel material

Corrosive environment		Corrosion rate (mm/year)
Sea Side	Above HWL	0.3
	From HWL to LWL-1.0m	0.1 ~ 0.3
	From LWL-1.0m to the sea bottom	0.1 ~ 0.2
	Below the sea bottom	0.03
Land Side	In marine atmosphere	0.1
	In soil (above the residual water level)	0.03
	In soil (below the residual water level)	0.02

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI

(5) Design conditions of oil terminal

Stability of the existing oil terminal is assessed with dynamics analysis and the apron pavement is designed on the basis of the following conditions.

1) Design oil tanker

- 50,000 DWT oil tanker (Loa = 200m, Fully loaded draft = 12.3m)

2) Geometry of container berth

- Top elevation at cope-line of berth CDL + 6.0 m (same as the existing berth)
- Design water depth CDL -10.0 m

3) Loading conditions

- Surcharge (normal condition) 30 kN/ m^2
- Surcharge (seismic condition) 15 kN/ m^2
- Ship berthing condition Design vessel 50,000 DWT bulk carrier
- Ship approach velocity 0.1 m/sec
- Ship berthing angle 10 degrees to the face line of the wharf
- Load on bollard 1,000 kN pull capacity

(6) Design conditions for pavement

1) Pavement in container yard

The load from an RTG on runways and its specifications are shown in Table 4.5-5.

Table 4.5-5 Loading conditions on RTGs' runways

RTG Size	Container Size	Lifting Capacity	Total Weight	Span	Axial Distance	Number of Wheels	kN/ Wheel
6+1 row, 4+1 high	20',40',45'	40.6 t	136 t	23.47 m	2.5 m	8	290

Source: Manufacturer's catalogue

2) Pavement in oil terminal

Since the oil terminal is occasionally used for handling bulk cargoes, the truck load of T-25, which is specified in the "Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI", is applied to the design of the apron pavement in the oil terminal. Except loads generated by bulk cargo handling, no extra surcharge load is applied.

- Maximum load per tire: 100 kN
- Maximum touching area per tire: 1,000 cm^2

4.5.2 Facilities' design

(1) New container terminal

1) Comparative evaluation on suitable type of structure

Typical types of marine berthing structures have their own characteristics for suitability to the specific subsoil conditions or adaptability to the requirements of the proposed facility including water depth of berth, which should be rationally reflected into the technical evaluation of structural stability, efficiency in construction, cost for construction and ease of maintenance during the post-construction stage.

The type of berth structure may be classified as either solid (gravity walls and sheet piled walls) or open-piled suspended deck. A variety of different types of structures were firstly examined among those that are commonly used for the projected type of berth structure for screening off depending on the following characteristics:

- Structural adaptability
- Suitability of subsoil condition
- Durability
- Construction method and period
- Overall cost

Among the several types of structures, a concrete caisson gravity wall, steel sheet pile walls and an open piled suspended concrete deck have been selected for evaluation. In addition, considering the subsoil conditions, steel sheet pile walls constructed 10 meters in front of the existing berth will be added for evaluation. As mentioned in the subsoil conditions section, subsoil conditions are divided into two areas (north and south); therefore, a preliminary design for both sides was made for a comparative evaluation.

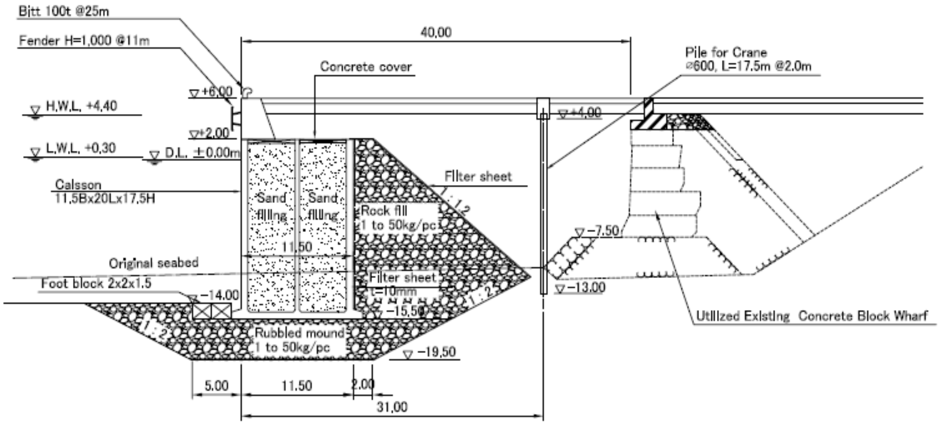
The following is the comparative evaluation with results showing that steel pipe sheet pile walls are the most common, practical and economical and are recommended for the new container berth structure.

Table 4.5-6 Comparative evaluation for various type of berth structure

		Concrete Caisson (40m widening)		Steel Sheet Pile (40m widening)		Open Pile Deck (40m widening)				Steel Sheet Pile (10m widening)	
						Vertical Pile		Vertical Pile with Anchor			
Structural Adaptability		B	Need to install on rubble mound of minimum 3m thickness. Seaside and landside crane rails rest on each different foundation. Existing pier shall be demolished only	A	Seaside and landside crane rails rest on each different foundation. Existing pier shall be demolished only.	B	Applicable for deep water. Quay gantry crane rests on the united deck. Existing pier shall be reconstructed.	B	Same as existing type of structure. Quay gantry crane rests on the united deck. Existing pier shall be reconstructed.	A	Seaside and landside crane rails rest on each different foundation. Existing pier shall be demolished only.
Suitability to Subsoil Condition	North Side	A	Suitable for subsoil conditions	B	Need to penetrate steel pile to weak siltstone	B	Same as left	-	Not applicable	B	Need to penetrate steel pile to weak siltstone
	South Side	C	Not suitable to subsoil conditions. Very soft soil shall be improved up to CDL-24m.	B	Very soft soil shall be improved up to CDL-23m.	B	Very soft soil shall be improved up to CDL-19m.	B	No soil improvement but steel piles shall be embedded up to -43.0m.	A	Very soft soil shall be improved up to CDL-17m.
Durability		A	Use only concrete members. No steel corrosion protection needed and generally maintenance-free.	B	Steel Sheet Pile materials subject to corrosion. Tidal zone is protected by heavy-duty coating.	B	Same as left	B	Same as left	B	Same as left
Construction Method		C	Floating dock (FD) and temporary submarine mound are required to fabricate concrete caisson.	A	Pile driving fleet is required. Steel sheet piles are relatively light and easy to handle for construction	A	Same as left	A	Same as left	A	Same as left
Environmental Impact		C	Many under water works and large volume of dredging therefore, big impact.	B	Relatively minor under water works and medium volume of dredging	B	Same as left	A	Minimum under water works: therefore, minimum impact.	A	Same as left
Overall Cost		C	Costly	B	Relatively costly	B	Relatively costly	B	Relatively costly	A	Most economical
Evaluation		C	Not recommendable	B	Recommendable	B	Recommendable	B	Recommendable	A	Most recommendable

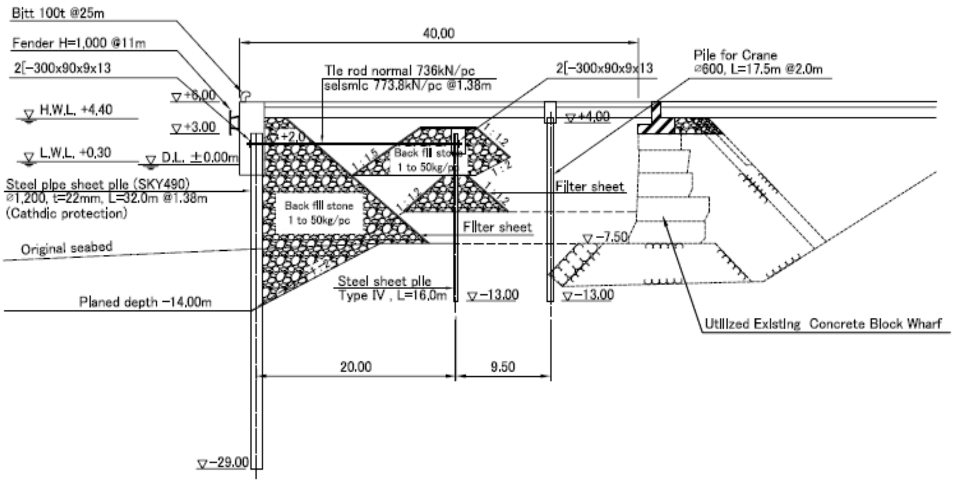
Note: A: Excellent/Appropriate, B: Fair and C: Poor
Source: Study Team

The following typical sections show the concrete caisson, steel sheet pile and open pier deck for the comparative design for the north sides.



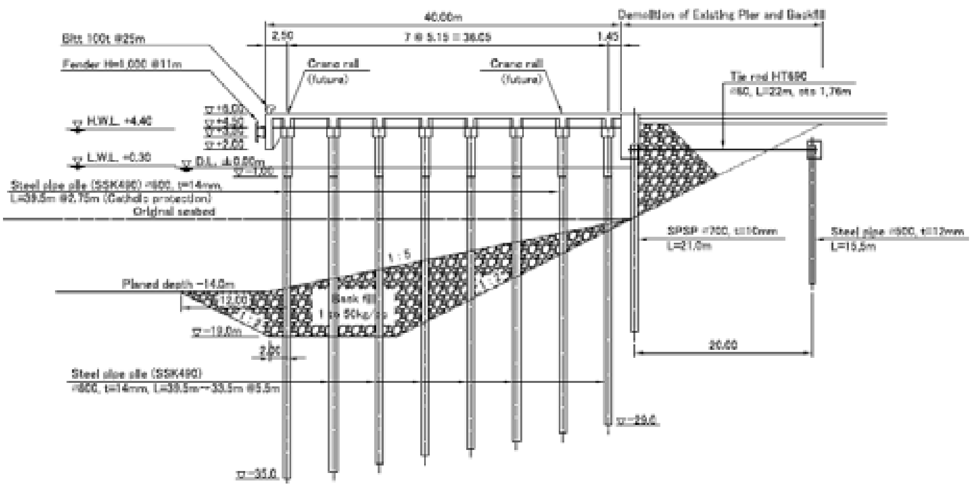
Source: Study Team

Figure 4.5-3 Concrete caisson at north side (40m widening)



Source: Study Team

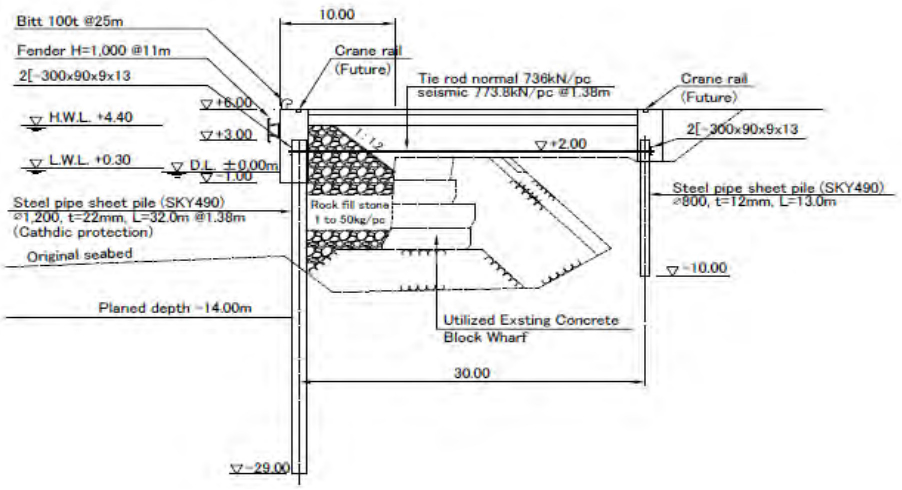
Figure 4.5-4 Steel pipe sheet pile at north side (40m widening)



Source: Study Team

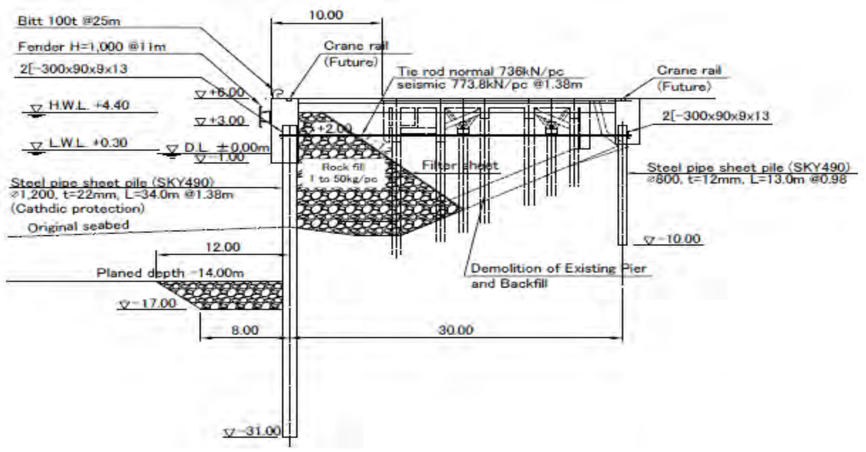
Figure 4.5-5 Open pile deck at south side (vertical pile 40m widening)

The following are typical sections of the recommended steel pipe sheet pile for the north and south sides.



Source: Study Team

Figure 4.5-6 Steel pipe sheet pile at north side (10m widening)



Source: Study Team

Figure 4.5-7 Steel pipe sheet pile at south side (10m widening)

2) Design of new container berth (steel pipe sheet pile: 10m widening)

a) Ship docking load

According to the established design method for docking fenders in Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI (JS) and BS 6349 codes of practice, the fender system is designed under the following conditions for berthing and the selection of type of fender system.

Table 4.5-7 Ship berthing condition for new container berth

Design Vessel		50,000 DWT Container vessel
Ship impact load	Ship approach velocity normal to the dock face	0.1 m/s with tug assistance
	Approach angle	10 degrees to dock face
	Berthing method	1/4 point contact to berth
	Interval	Rubber fender spaced at 11 m

Source: Study Team

The berthing energy for ships is calculated with the kinetic energy method by using the following equation:

$$Ef=(Ws \times V^2/2g) \times Ce \times Cm \times Cs \times Cc$$

where:
- Ef : Berthing energy of ship (kNm)
- g : Acceleration of gravity (m/s^2)
- Ws : Displacement tonnage of berthing ship (ton)
- V : Berthing velocity of ship (m/s)
- Ce : Eccentricity factor
- Cm : Virtual mass factor
- Cs : Flexibility factor
- Cc : Berth configuration factor

Table 4.5-8 Ship berthing energy for JS and BS

Description		Unit	JS	BS
Displacement tonnage	DWT	Ton	50,000	50,000
Length overall	Loa	M	274	274
Length between perpendiculars	Lpp	m	258	258
Breadth	B	m	32.3	32.3
Full load draft	D	M	12.7	12.7
Displacement tonnage	DTp	Ton	69,250	69,250
Specific weight of sea water	Wo	ton/m^3	1.025	1.025
Ratio of the length of the parallel side of the vessel	α		0.415	0.415
Displacement volume	Vd=DTp/Wo	m^3	67,561	67,561
Block coefficient	Cb= Vd/(Lpp*B*d)		0.6384	
Radius of gyration	R=(0.19*Cb+0.11)*Lpp	m	59.67	
Eccentricity factor	$Ce=1/(1+(L/r)^2)$		0.628	0.50
Virtual mass factor	Cm=1+ π/(2*Cb)*d/B		1.965	1.786
Softness factor	Cs		1.0	1.0
Berth configuration factor	Cc		1.0	1.0
Berthing energy	$E=(MsV^2/2)$ *Ce*Cm*Cs*Cc	kNm	427.58	309.27
Required berthing energy	Ereq	kNm	475.09 (Ereq=E/0.9)	463.90 (SF=1.5)

Source: Study Team

The required berthing energy for ships is 475.1 and 463.9 kNm as calculated for JS and BS respectively based on the above equation. Cell type rubber docking fenders 1000H with frontal frame structure, which have energy absorption of 492.0 kNm and a reaction force of 883.0 kN will be installed on the new container berth.

b) Subsoil conditions

The subsoil conditions for steel sheet pile structure (10m widening) at the south side are determined based on the distance between BH3 and BH12 and considering the existing embedded pile elevations of the open pier as indicated below. However subsoil conditions at the north side are the same as those for 40m widening;

Table 4.5-9 Subsoil condition for new container berth (10m widening)

Layer	Depth CDL (m)	Soil Properties		
		N value	Unit Weight γ, γ' (kN/m^3)	Strength (kN/m^2)
Fine to coarse Sand or Silt	-9.0 to -17.0	N_{ave}=2	γ=18, γ'=10	qu=10 Cu= 5
Fine to coarse Sand or Silt	-17.0 to 30.1 or deeper	N_{ave}=20	γ=18, γ'=10	qu=220 Cu= 110

Note: Above properties are assumed based on BH3 and BH12
Source: Study Team

c) Results of design calculation

Based on the structural outline of the steel pipe sheet pile (SPSP) as indicated in Figures 4.5-6 and 4.5-7, the results of the design calculation are described below:

i) Determination of embedment length of steel pipe sheet piles

The embedded length of steel pipe sheet piles shall be determined in such a way that the bottom end of the sheet piles is firmly fixed in the ground with an appropriated safety factor level applied. For the embedded length of a steel pipe sheet pile using the free earth support method, the equation should be satisfied for the moments caused by earth pressure and residual water pressure with respect to the tie rod setting point.

$$Mp = F \times Ma$$

where : *Mp*: moment at the tie rod setting point by the passive earth pressure (kNm/m)
Ma: moment at the tie rod setting point by the active earth pressure and residual water pressure (kNm/m)
F : safety factor

The safety factor will be set at 1.5 or more in ordinary conditions and 1.2 or more in extraordinary conditions for cases with sheet pile walls driven in sandy soil, and 1.2 or more for both ordinary and extraordinary conditions in hard cohesive soil. Based on the above method, embedded elevations of sheet pile are CDL-21.0 m for the north side and -31.0 m for the south side for the new container berth.

A sheet pile wall equipped with anchorage is strongly affected by the rigidity and embedded length of the sheet piles and the characteristics of the ground. The elastic beam analysis method of sheet piles with modified Row's method will be examined in order to prove the rigidity of the sheet pile as follows:

$$\delta s = Df/Ht > 5.0916\ \omega^{-0.2} - 0.2591$$

where:

δs : ratio of the embedded length of sheet pile to the height of the tie rod setting point
Df : embedded length of sheet pile (m)
Ht : height of the tie rod setting point above the sea bottom (m)
ω : similarity number (=ρl_h)
ρ : flexibility number (=Ht^4/EI)(m^3/MN)

E : Young's modulus of sheet pile (MN/m^2)
I : geometrical moment of inertia of sheet pile wall per unit width (m^4/m)
l_h : coefficient of sub-grade reaction to sheet pile wall (MN/m^3)

The embedded elevations calculated with this equation are CDL-29.0 m and -31.0 m for the north and south side of the new container berth respectively. Therefore, the final embedded elevations of the new container berth are CDL-29.0 m for the north side and -31.0 m for the south side.

ii) Evaluation of stress on steel piles, tie rods and anchor piles

The maximum bending moment of sheet piles, reaction force of tie rods and maximum bending moment of anchor piles are determined by using the equivalent beam method assuming a simple beam supported at the tie rod setting point and the sea bottom with the earth pressure and residual water pressure acting as the load above the sea bottom. The actual stress of the steel pipe sheet piles and anchor piles and the actual tension stress of tie rods for normal and seismic conditions are tabulated as follows considering axial stress due to the quay gantry crane and bending moment due to earth pressure and residual water pressure.

Table 4.5-10 Evaluation of the steel material and tie rod for North and South Wharves

Type of material	Description	Conditions	Actual stress (N/mm^2)		Evaluation
			Axial stress σ_c	Bending stress σ_b	$\sigma_c/\sigma_{ca}+\sigma_b/\sigma_{ba}< 1.0$
Steel pipe sheet pile (SPSP)	ϕ=1,200mm t=22mm	Normal	18	138	0.84 < 1.0
		Seismic	16	150	0.55 < 1.0
Anchor pile	ϕ=800mm, t=12mm	Normal	18	113	0.69 < 1.0, Displacement=1.24cm
		Mooring	10	160	0.60 <1.0, Displacement=1.98cm
		Seismic	10	120	0.46 <1.0, Displacement=1.34cm
Tie rod	TR-320	Normal	736 kN/set		Allowable tension : 826kN/set
		Mooring	986 kN/set		Allowable tension : 1,256kN/set
		Seismic	774 kN/set		Allowable tension : 1,256kN/set

Source: Study Team

iii) Evaluation of bearing capacity of SPSP anchor piles for quay gantry crane

The ultimate bearing capacity is calculated based on the embedded SPSP and anchor piles decided in the previous section and the actual vertical load due to the quay gantry crane based on the wheel load of the crane. The following table indicates the ratio of actual load and ultimate bearing capacity with safety factors that will be set at 2.5 or more in normal conditions and 1.5 or more in seismic conditions. The ultimate axial bearing capacity of the steel pipe piles is estimated by static capacity formulas as below:

- Equation for the ultimate bearing capacity of the piles driven into sandy ground by hammer:

$$Ru = 300 \times N \times Ap + 2 \times Na \times As$$

where:

Ru : ultimate bearing capacity of pile (kN)
Ap : toe area of pile (m2)
As : total circumferential area of pile (m^2)
N : N-value of the ground around pile toe ($N=(N_1+ N_2)/2$)
Na : mean N-value for total penetration length of pile
N_1 : N-value at the toe of pile
N_2 : mean N-value in the range from the toe of pile to the level 4B above
B : diameter or width of pile (m)

- Equation for the ultimate bearing capacity of the piles driven into clayey ground by hammer:

$$Ru = 80 \times Cp \times Ap + Ca \times As$$

where:

Cp: cohesion at pile toe (kN/ m^2)
Ca: mean adhesion for total embedded length of pile (kN/ m^2)

The adhesion value will be calculated as follows:

Ca= c: c < 100 kN/ m^2
Ca= 100 kN/ m^2 : c > 100 kN/ m^2

Table 4.5-11 Evaluation of the bearing capacity of sea side and land side piles

	Description	Location	Condition	Evaluation
				Ru/Ra >Fs=2.5 or 1.5
Seaside pile (SPSP)	ϕ=1,200mm, t=22mm	North Side	Normal	6.78 > 2.5
			Seismic	5.21 > 1.5
		South Side	Normal	5.92 > 2.5
			Seismic	4.55 > 1.5
Landside pile (Anchor pile)	ϕ=800mm, t=12mm	North Side	Normal	6.23 > 2.5
			Seismic	4.40 > 1.5
		South Side	Normal	6.23 > 2.5
			Seismic	4.40 > 1.5

Source: Study Team

(2) Rehabilitation of South Wharf

The appropriate fender system will be installed along the South Wharf for minimizing impacts from docking ships. The fenders are designed considering that the design ship is 50,000DWT with approaching velocity of 0.1m/sec.

The outline of the design process is described in the former sub-section for the new container terminal and the calculation result is shown in Table 4.5-12.

Table 4.5-12 Calculation result of berthing energy of 50,000DWT container ship

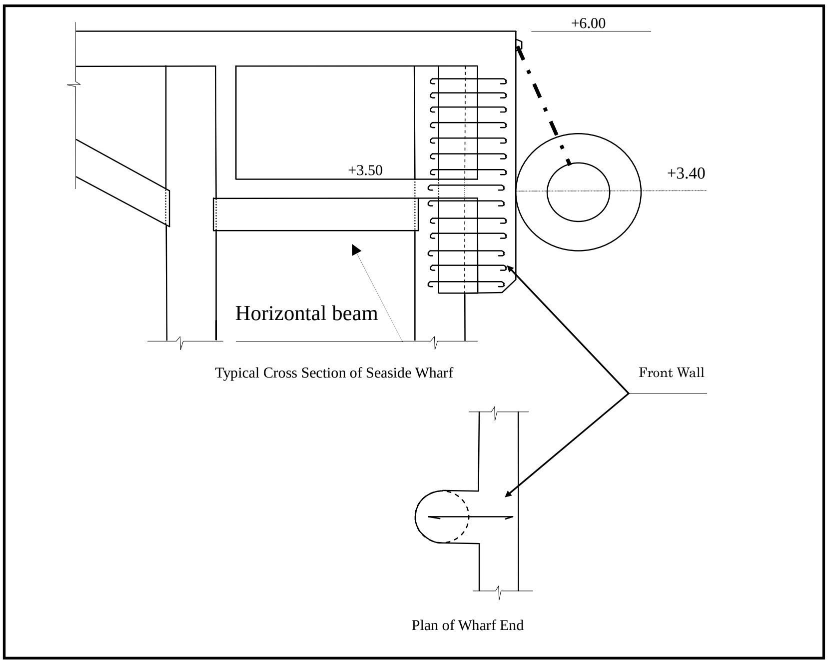
Item	Description	50,000 DWT fully loaded
Ws	Water displacement of berthing ship (ton)	61,134
V	Approach velocity of ship against the fender (m/s)	0.1
G	Acceleration gravity (m/s^2)	9.8
Ce	Eccentricity factor	0.578
Cm	Virtual mass factor	1.815
Cs	Softness factor	1.0
Cc	Berth configuration coefficient	1.0
Ef	Ship's berthing energy (kN-m)	320.4

Source: Study Team

As described in the sub-section 4.1.1-(2)-g) "Measurements for extending residual life", consideration of deteriorated concrete is required in selecting a fender type. The cylinder type is selected because the fenders can be hung with chains fitted on the sound concrete slab without drilling the damaged concrete of the front walls for their fitting.

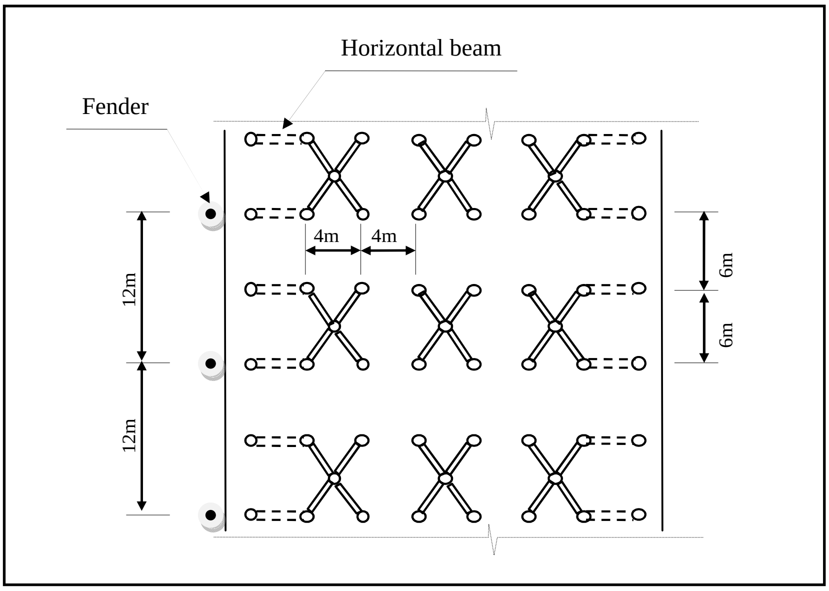
Based on the calculation results of ship's berthing energy (320.4 kN-m), a cylinder type is selected as shown in Figure 4.5-8. The figure shows that fenders are installed with chains fixed at the top slab concrete.

The locations of fenders are determined at the elevation of the horizontal beams connected with vertical piles as illustrated in Figures 4.5-8 and 4.5-9. The former figure shows a typical cross section of the existing South Wharf and schematic rebars set for fixing front walls and piles. In addition to the supporting beams, the front walls and the piles in the first row are structurally fixed with rebars. Fenders should be installed at locations of piles structurally strengthened; as a result, intervals between fenders should be 12m as shown in Figure 4.5-9.



Source: CFM & Study Team

Figure 4.5-8 Location of fixing fender



Source: CFM & Study Team

Figure 4.5-9 Intervals of fenders

(3) Rehabilitation of oil terminal

Top parts of the concrete structure of the oil terminal were seriously damaged by ships' impacts when cyclone Madia struck on 24 March 1994. The damaged wharf structure has not been repaired and inappropriate tire fenders have been installed.

At present concrete pavement behind the berth is deteriorated to be uneven surfaces with rails. Under this situation the oil terminal provides services for not only loading oil products but handling bulk cargoes when the berth is not occupied by tankers. The same operation is expected to continue beyond the discussed target years. In loading liquid oil with oil pipes no traffic of trucks is available on the apron; however, moving trucks are operated for carrying bagged or break bulk cargoes.

The uneven apron hampers safe traffic of trucks and efficient transportation of cargoes, and renovation of the apron pavement should be made.

This sub-section is concerned with assessment of structural stability of the existing wharf and rehabilitation of the existing wharf. The design of the apron pavement is discussed in the next sub-section.

1) Assessment of stability of existing wharf

The existing oil wharf structure seems to be in sound condition except the damaged cap concrete. Referring to the preliminary design document for the similar type of the wharf structure, the surcharge load is determined to be 30 kN/m^2.

Seismic force was not considered in the design process of such facilities in the design document; however, the stability is calculated with consideration of 0.05 as the seismic coefficient of the vertical loads.

a) Design conditions

- Residual sea level: CD + 1.58m
- Surcharge loads: 30 kN/m^2 in normal condition, 15kN/ m^2 in seismic condition
- Seismic force: 0.05 as horizontal seismic coefficient
- Foundation: Sandy silt stone with N>50
- Safety factor:

Table 4.5-13 Permissible safety factors

	Normal condition	Seismic condition
Against sliding	1.20	1.00
Against overturning	1.20	1.10

Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI

Safety factors are defined as below:

Safety factor against sliding $F_s \leqq f\,W/P$

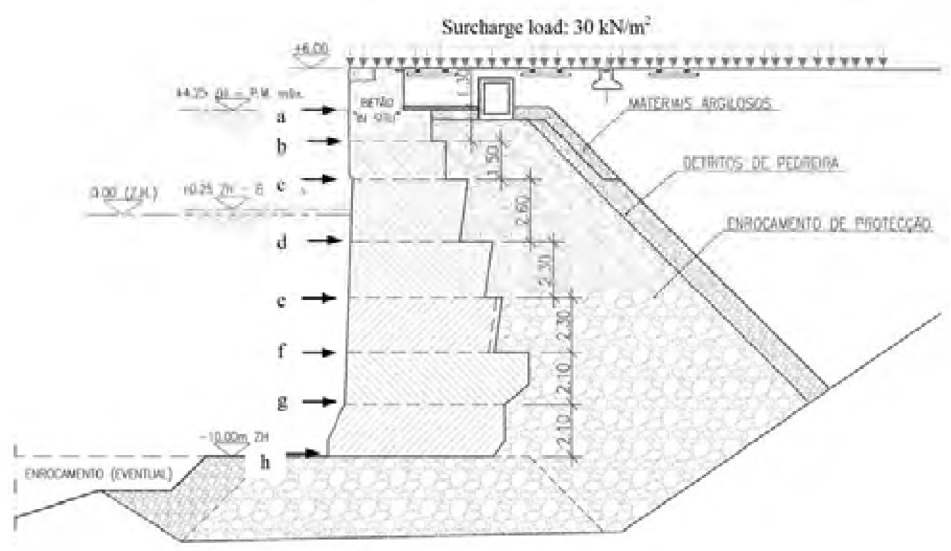
where:
W: resultant vertical force acting on the wall (kN/m)
P: resultant horizontal force acting on the wall (kN/m)
F : coefficient of friction between the bottom of the wall body and the foundation

Safety factor against overturning $F_s \leqq Wt/Ph$

where:
T: distance between the line of application of the resultant vertical forces acting on the quaywall and the front toe of the quaywall (m)
h: height of the application line of the resultant horizontal forces acting on the quaywall, above the bottom of the quaywall (m)

b) Typical cross section of oil terminal wharf

The typical cross section of the wharf is shown in Figure 4.5-10. It also shows the eight elevations from “a” to “h” for checking stability of the structure. Even at the beginning of construction, the foundation soil reserved sufficient bearing capacity to support the structure, and the foundation of the soil, N value of more than 50, has been reserving the strength to prevent circular slip failure.



Source: Study Team, PROMAN

Figure 4.5-10 Typical cross section of wharf for assessing structural stability

c) Calculation results

Stability of the structure is examined at the above eight elevations and the results are tabulated in Table 4.5-14. This table only shows the minimum safety factors against sliding and overturning among the calculation results at all the elevations.

The table shows that the oil terminal wharf is confirmed to be stable and it is concluded that the present operation at the oil terminal can continue.

Table 4.5-14 Calculation results of structural stability

		Normal condition		Seismic condition	
Against Sliding	Elevation for checking	Safety factor	Permissible	Safety factor	Permissible
	f (-5.8m)	***1.590***	***>1.2***	***1.308***	***>1.0***
Against Overturning	Elevation for checking	Safety factor	Permissible	Safety factor	Permissible
	f (-5.8m)	***2.230***	***>1.2***	(1.812)	>1.1
	h (-10.0m)	(2.234)	>1.2	***1.760***	***>1.1***

Source: Study Team

2) Rehabilitation of existing wharf

a) Replacement of cap concrete

The subject has been previously discussed in the sub-section **4.1.2 (3) Cap concrete of concrete block wharf,** regarding the repair method.

b) Installation of fenders and bollard

i) Fenders

For replacement of the existing tire fenders, the appropriate fender system will be installed along the oil berth for protecting ships from damages by impacts. The fenders are designed as the maximum size of a 50,000DWT oil tanker with approach velocity of 0.1m/sec, considering the sizes of oil tankers calling at Nacala Port range from 15,000DWT to 50,000DWT

The outline of the design process is described in the former sub-section for the new container terminal and the calculation result is shown in Table 4.5-15.

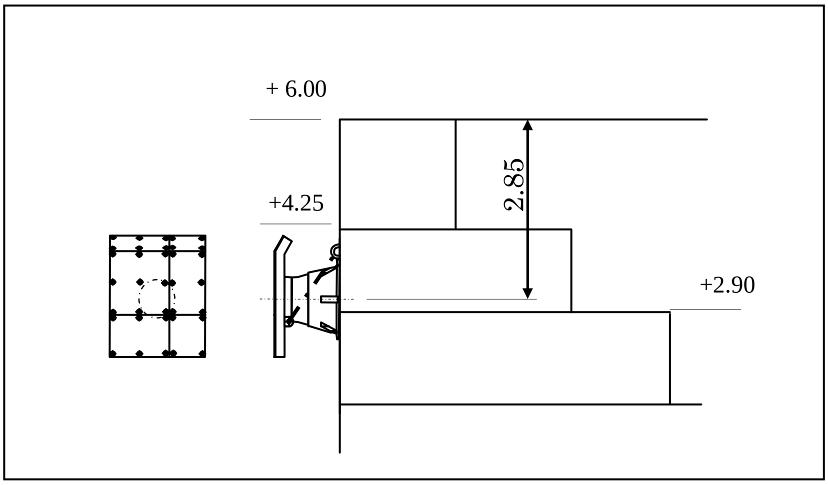
Table 4.5-15 Calculation result of berthing energy of 50,000DWT oil tanker

Item	Description	50,000 DWT Oil Tanker
Ws	Water displacement of berthing ship (ton)	56,900
V	Approach velocity of ship against the fender (m/s)	0.1
G	Acceleration gravity (m/s^2)	9.8
Ce	Eccentricity factor	0.566
Cm	Virtual mass factor	1.815
Cs	Softness factor	1.0
Cc	Berth configuration coefficient	1.0
Ef	Ship's berthing energy (kN-m)	292.3

Source: Study Team

A circle rubber fender with an anti-impact-load plate for the design ship is selected to meet the requirements stated above. An elevation for fitting fenders is determined considering the ships' sizes and the wide tidal range. As a result of discussions with Port Master, an elevation of fitting fenders is determined to be 3.15 m above CD.

The outline of the fender type and the elevation for fixing fenders are illustrated in Figure 4.5-11.



Source: Manufacturer' catalogue & Study Team

Figure 4.5-11 General dimensions of a fender and fixing elevation

The interval of fenders is calculated on the basis of a radius of curvature of a bow side of a ship and height of fenders when effective berthing energy absorbed. As a result, the interval for a 50,000DWT tanker is 19.7m while that for a 15,000DWT tanker is 19.0m. The interval for the oil terminal berth is determined to be 19.0m.

ii) Bollards

Bollards for the design ship of a 50,000DWT tanker are installed along the wharf. Bollards should be selected to bear tractive forces of 1000 kN by the design ship according to the "Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI".

As mentioned previously, 15,000DWT tankers are usually moored and an interval of bollards should be applied for the smaller tanker. Based on the same Technical Standards, the interval of bollards is determined to be 25m.

(4) Road and pavement

1) Causeway and revetment

a) Design waves

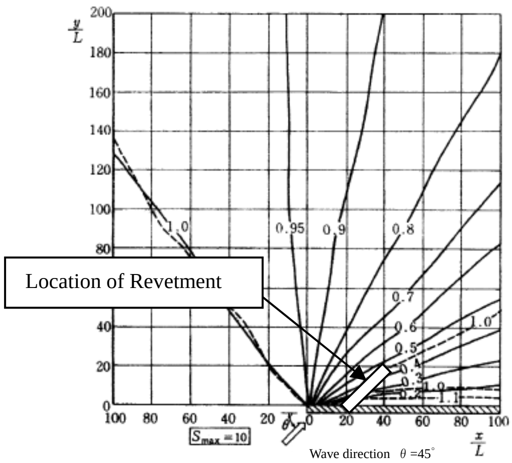
Nacala Bay is sheltered from offshore waves by a stretch of land but due to the waves generated inside Nacala Bay by the north wind, the revetment of the access road is subjected to rough waves. Wave conditions are estimated from Section 2.6.3 Oceanography as below:

- Wave height : 2.5 m
- Wave period : 4.5 sec
- Wave direction : North

b) Wave diffraction

The northern waves generated in the Nacala Bay are expected to be affected by the corner of the existing general cargo wharf and container wharf before reaching the revetment. The diffraction coefficient Kd is obtained as 0.5 from Figure 4.5-12. The wave height after diffraction is calculated as:

Hd = 2.5 x 0.5 = 1.3 m



Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI

Figure 4.5-12 Diffraction diagram (Kd) by semi-infinite obstacles

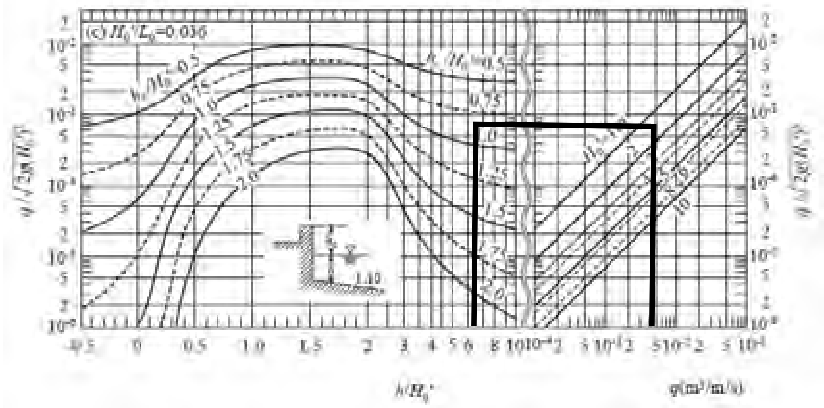
c) Crown height of revetment

The water depth at the revetment varies from CDL -4.0 m to + 2.5 m and the seabed slope is assumed at 1/10 for safety. The degree of wave overtopping q=0.005m^3/m/sec is within the allowable range for a levee with an unpaved rear slope considering the staged construction before back filling with dredged materials.

Lo = 1.56 x T^2 = 1.56 x 4.5^2 = 31.6 m
Ho'/Lo = 0.038
h/Ho' = (4.0 +4.3)/1.3 = 6.38
hc/Ho = 0.85 (from Figure 4.5-13)
hc = 0.85 x 1.3 = 1.11 m
Crown height of revetment = CDL + 4.30 + 1.11 = + 5.41 m

Say positioned at + 5.50 m

Considering the existing wharf elevation of CDL + 6.0 m, the crown height of the revetment and the top elevation of the access road shall be + 6.0 m.



Source: Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI

Figure 4.5-13 Graph for estimating the rate of overtopping for an upright seawall

d) Determination of size of armor stones

The required mass of armor units on a slope of a revetment can be expressed using the Hudson formula with a stability number as below:

$M = \rho H^3/Ns^3(Sr-1)^3$

$= 2.6 \times 1.3^3/(4.0 \times (2.6/1.03 - 1)^3) = 0.40$ t/pc

where

ρ: Density of rubble stone =2.6 t/m^3

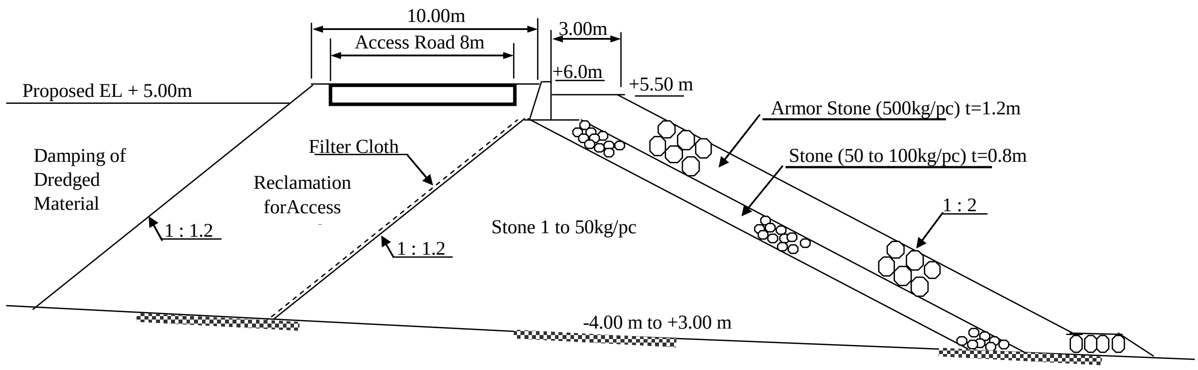
H: Wave height= 1.3 m

Ns: Stability number

($Ns^3 = K_d \cot \alpha = 2.0 \times 2.0 = 4.0$)

Sr: Specific gravity of rubble stone to sea water = 2.6/1.03

e) Typical section of revetment of access road



Source: Study Team

Figure 4.5-14 Typical section of revetment of access road

2) Pavements

The sub-section is comprehensively concerned with pavement design in the project; the pavement works in the project are composed of pavements of the aprons, container yards, a by-pass access road, etc.

a) Design standards

No standards for specified aprons of wharves are available in Mozambique and the following guideline or standards for port facilities in Japan are applied to design of pavements of aprons and container yards.

- Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI

In terms of design of pavement structure for other places, SATCC Practice for the Design of Road Pavements is mainly applied and the following design manuals in Japan are also considered.

- Manual for Asphalt Pavement in Japan, Japan Road Association
- Manual for Cement Concrete Pavement in Japan, Japan Road Association
- Manual for Interlocking Block Pavement in Japan, Japan Road Association
- American Association of State Highway and Transportation Officials (AASHTO) Standards

b) Design conditions

i) Subgrade conditions

- Apron and container yard

  The pavement of the oil terminal apron and the existing container yards will be constructed in the existing areas. The container yard behind the new container terminal wharf will be paved in the areas of the existing North Wharf apron and the existing warehouse which will be demolished. A minimum soaked CBR of 10% at 95% standard compaction will be applied for the subgrade.

- By-pass road

  The filled- up ground of the road will be constructed with fine sand mixed with small pieces of rocks from quarries and it will be compacted with vibrating rollers before laying subbase courses. Considering the situation, a minimum soaked CBR of 5% at 95% standard compaction will be applied for the subgrade and the CBR of the percentile is categorized into S3 proposed by the SATCC manual as shown below:

Table 4.5-16 Subgrade classes in SATCC manual

Subgrade Class Designation	S1	S2	S3	S4	S5	S6
Subgrade CBR Range	2	3-4	5-7	8-14	15-29	30+

Source: SATCC

ii) Design loads

The design loads of the pavement are basically adopted based on the cargo handling equipment. The information about loads of RTGs, reach stackers and chassis & tractor heads is obtained from manufacturers' catalogues and data from "Technical Standards and Commentaries for Port and Harbour Facilities in Japan, OCDI". Design loads of RTGs and reach stackers are applied with combination of self weight and a fully loaded container, that is, loads of reach stackers are indicated as maximum wheel load in the following table.

Table 4.5-17 Design loads on pavement

Area	Equipment and Vehicle	Self Weight	Maximum Wheel Load
RTG Transfer Lane	RTG	1,274 kN	323 kN
Empty Container Yard	Reach Stacker	657 kN	275 kN
Truck Passage	Chassis & Tractor Head	405 kN	117 kN (Rear axle)

Source: Study Team

iii) Pavement design

The pavements in the existing container yards are made of interlocking concrete blocks (ICB) and a smooth surface for stacking containers is generally observed. In the Urgent Rehabilitation Project, some damaged areas will be repaired but the rest will be left as is.

As RTG runways of reinforced concrete will be laid in the container yards, ICBs and base courses in the areas will be removed for laying new runways and ICB pavement will be finished and smoothly connected with the surrounding pavement.

In terms of base courses of RTG runways, soil cement stabilization with a minimum 7-day unconfined compressive strength of 3.0 MPa is applied in the base course to prevent uneven settlement as much as possible after starting operation. Crushed stone with the minimum CBR of 30 % is adopted in the design of sub-base course. “Density testing” and “in-place CBR testing” needs to be carried out during construction to check whether there is sufficient compaction of subgrades. RTG runways will be of reinforced concrete of 35cm in thickness to support 323 kN of maximum wheel load.

For the pavement of the container yard behind the New Container Terminal, pavement is of reinforced concrete to bear loads of reach stackers while lifting a fully-loaded container. The thickness of concrete is 30cm with double layers of reinforcement. Soil cement stabilization of the same specifications as above is applied to the base course in the container yard.

Pavement in the apron in the oil terminal will be of reinforced concrete of 30cm thick with single layer of reinforcement and the base course of crushed stone will be mechanically stabilized.

The by-pass road will be constructed on the filled-up ground on causeway. As there is no manufacturer of material for asphalt concrete pavement in Nacala, concrete pavements with high durability and lower costs should be selected as the capital investment. Concrete pavements are easy to maintain and repair because a small concrete mixers and materials are available in Nacala.

The subgrade will be stabilized with cement and the base course will be laid with mechanically stabilized crushed stone under the reinforced concrete of 25cm in thickness.

Typical cross sections of the pavement discussed above are tabulated in Table 4.5-18.

Table 4.5-18 Typical cross sections of pavement

Area	Type	Load	Section of Pavement
Type-1 （Container Yard） RTG Lane	RC Concrete Slab	Rubber Tyred Gantry Crane (RTG)	RC Concrete (t=35cm) Soil Cement Stabilization (t=30cm) Crushed Stone (t=30cm)
Type-2 (Container Yard) Renovation of Container Stacking Area	Interlocking Concrete Block (ICB)	Loaded Container 4 tiers height	ICB Compacted sand (t=3cm) Soil Cement Stabilization (t=30cm) Crushed stone (t=40cm)
Type-3 (Container Yard) New Container Terminal Area	RC Concrete Slab	Reach Stackers	RC Concrete (t=30cm) Soil Cement Stabilization (t=30cm) Crushed Stone (t=30cm)
Type-4 (Oil Terminal) Apron	RC Concrete Slab	Loaded Trucks for Bulk Cargoes	RC Concrete (t=30cm) Mechanically stabilized crushed stone (t=50cm) Crushed stone (t=30cm)
Type-5 By-pass Road	Asphalt Concrete	Container Trailer Trucks	RC Concrete (t=25cm) Mechanically stabilized crushed stone (t=40cm) Crushed stone (t=20cm) Subgrade Cement Stabilization (t=1m)

Source: Study Team

(5) Railways

1) Design standards

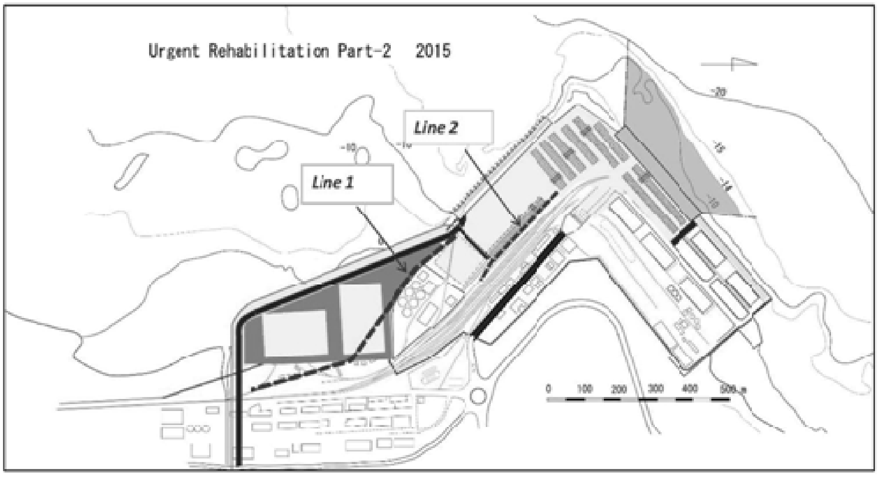
The entire railway system has been designed and constructed by CFM. In the preliminary design stage the railway system is designed based on the standards presently applied by CFM. The applicable standards for the project are listed bellow-:

- Spoonet Standards and Specifications for railways
- Transnet Standards and Specifications for railways

- UIC (International Union of Railways) Standards and Specifications
- American Association of State Highway and Transportation Officials(AASHTO) Standards

2) Design conditions

Two lines of railways are planned in the Urgent Rehabilitation Plan (Part-2) as illustrated in Figure 4.5-15. Line 1 will be laid mainly in the reclaimed and existing land, and Line 2 will be laid in the paved container yard. Considering the conditions of these foundations, the former tracks will be made with rails on ballast and the latter with rails on concrete slabs.



Source: Study Team

Figure 4.5-15 Locations of new tracks in the Urgent Rehabilitation Plan

Since the reclaimed land will be created with dredged material, subgrades for Line 1 under the tracks for Line 1 is expected to be of silty sand or fine sand, which is classified into SM in the Unified Soil Classification System, which seems to be equivalent with A-2 (AASHTO). Under this condition the subgrade shall be so compacted as to be in the range from 90% to 95% of maximum dry density according to CFM guideline. CBR tests of filling material should be conducted in the detailed design stage for finalizing the pavement design of the railways.

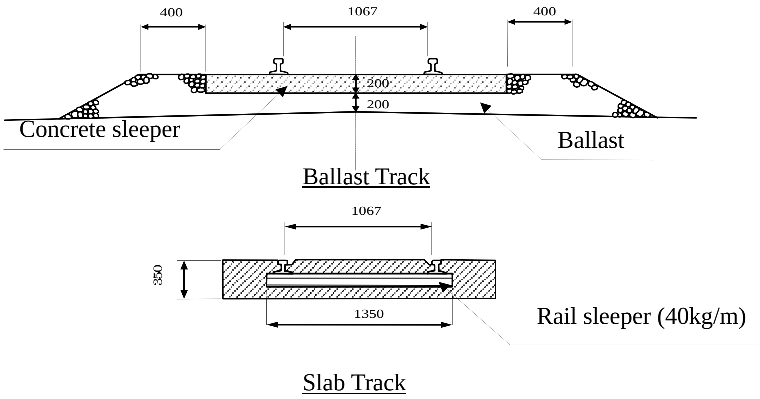
As to Line 2, the tracks will be laid on the concrete pavement and no additional consideration on subgrades will be required.

3) Design of tracks

The design of the tracks is made based on the standard design by CFM. Quality of rails shall accord with the specifications of UIC-45, namely 45kg/m. A gauge of the track shall be 1067mm.

A typical cross section of a ballast track is shown in Figure 4.5-16. Thickness of ballast under the concrete sleeper shall be 200mm or more. Sleepers of concrete plates shall be installed at 1-m intervals.

A typical cross section of a slab track is also shown in Figure 4.5-16. Sleepers of rails of 1350mm long shall be of 40kg/m and installed at 0.6-m intervals.



Source: CFM , Study Team

Figure 4.5-16 Typical cross sections of tracks

4.6. Construction plan

4.6.1 General

The construction for the Urgent Rehabilitation Project is planned in two parts (Part-1 and Part-2). The main purpose of Part-1 is to upgrade the container handling capacity for currently available wharves while the purpose of Part-2 is to start operation of a new container wharf. In the construction plan, considerations must be made to mitigate the hindrance of operations at the Port and traffic at sea. The scope of work and the estimated major construction volume is shown in Table 4.6-1.

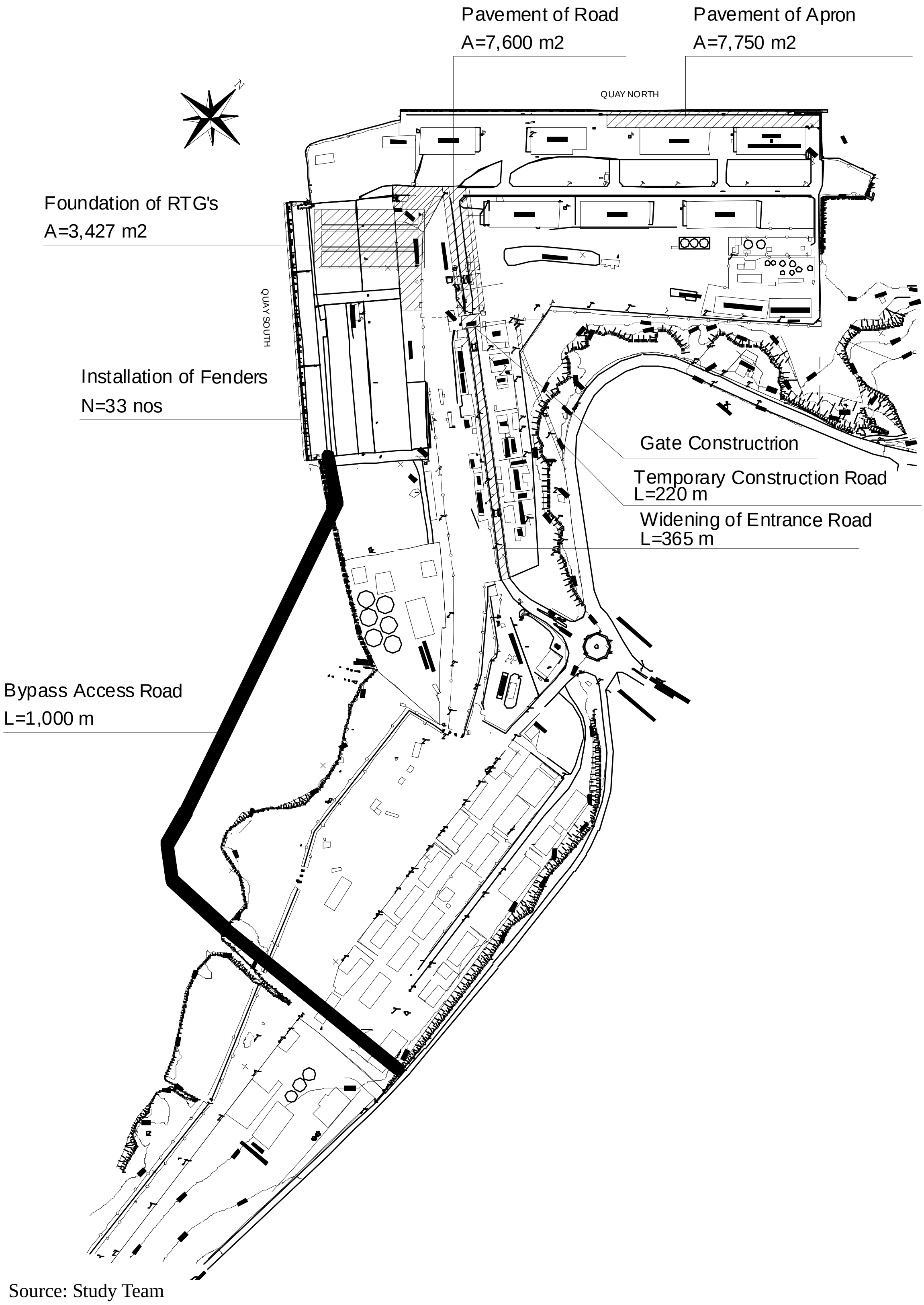
Table 4.6-1 Scope of work and estimated major construction volume

Item	Unit	Quantity	Remarks
Part-1			
1. Bypass access road			L=1,000m
Rubble deposition	m^3	47,180	
Concrete pavement	m^2	8,500	
2. Installation of fenders	nos	33	
3. Foundation of RTG's			
Concrete pavement	m^2	2,068	
4. Widening of entrance road			
Asphalt concrete pavement	m^2	740	
5. Gate construction	ls	1	
6. Pavement of road in the port			
Asphalt concrete pavement	m^2	775	
7. Pavement of apron			
Concrete pavement	m^2	7,750	
8. Procurement of equipment			
Reach stacker	nos	4	
Yard chassis	nos	12	
RTG	nos	2	
Part-2			
1. Landfill and leveling	m^3	195,000	
2. Track works	m	800	
3. Ground leveling of bulk yard	m^3	51,000	
4. Repair of yard and road pavement			
Asphalt concrete pavement	m^2	3,500	
5. Rail container terminal			
Concrete pavement	m^2	1,877	Including RTG foundation
6. Container yard pavement at the North Wharf			
Concrete pavement	m^2	29,686	Including RTG foundation
7. Reconstruction of the North Wharf			L=320m
Steel pipe piling (dia. 1200/800)	nos	615	
Concrete pavement	m^2	3,200	
8. Dredging (-14m)	m^3	195,000	
9. Procurement of equipment			
RTG	nos	3	

Source: Study Team

4.6.2 Construction plan of Part-1

The urgent rehabilitation work plan of Part-1 is shown in Figure 4.6-1.



Source: Study Team

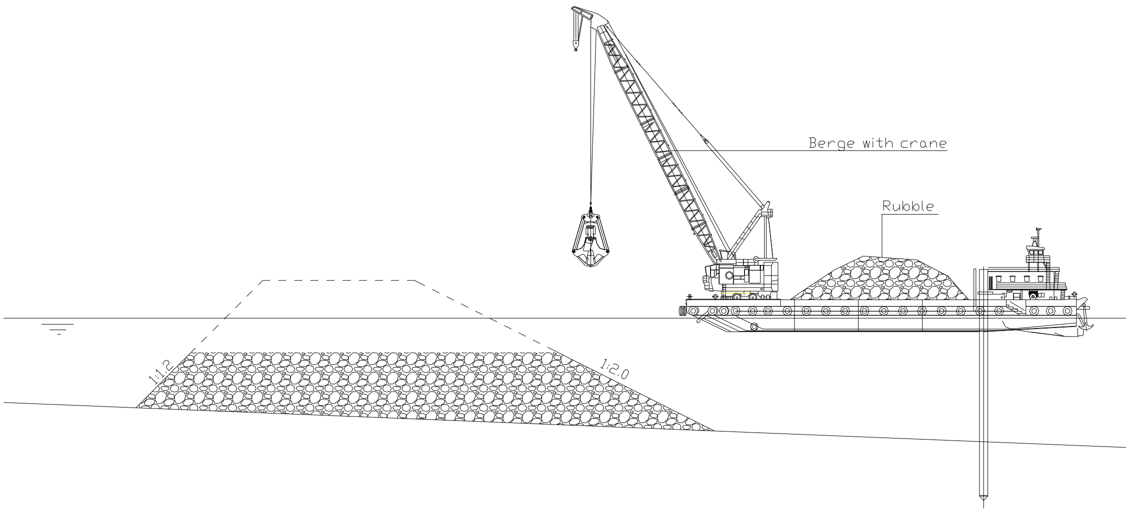
Figure 4.6-1 Urgent rehabilitation work plan of Part-1

(1) Construction of bypass access road

The access road will be constructed on the coast connecting from the existing road to the south of the South Wharf as shown in Figure 4.6-1. The main construction method is described as follows:

1) Revetment works

Rubble will be deposited with a slope gradient of 1:2.0 (sea side) and 1:12 (land side) at a fixed position by using a barge with a crane, etc. Deposited rubble will be trimmed by divers and then it will be covered by armor stone (sea side only). Before construction, the transportation routes of the barges on the sea near the Port will be decided through discussions between the contractor and the related persons in the Port. The working area will be marked by buoys. In addition, a safety patrol boat will be arranged to prevent accidents.



Source: Study Team

Figure 4.6-2 Revetment works

2) Road works

One-way backfilling work will be executed from the landside to the South Wharf. Backfill material will be dumped along the revetment. It will be spread and compacted by bulldozers, etc. Lower and upper sub-base will be laid with appropriate materials to reach the fixed degree of compaction. The access road will be paved with concrete after sub-base and gravity concrete wall works are completed.

(2) Installation of fenders

The fenders will be installed on the South Wharf by using a truck crane during times when freight vessels are not berthed at the wharf.

(3) Foundation of RTG's

In the urgent rehabilitation Part-1, additional RTGs will be procured to increase the capacity of the container yard at the South Wharf. Therefore, an RTG foundation will be required.

The existing interlocking concrete block (ICB) at the RTG foundation will be removed by backhoe. After trench excavation for the foundation, execution of lower/upper sub-base and concrete pavement will be carried out. During these executions, steel plates, etc. will be placed over the trench to allow for the operation of trailers, etc. in the yard if required.

(4) Asphalt concrete pavement

Execution of asphalt concrete pavement will be performed at the entrance road to widen and improve the existing broken pavement in the port. Since the pavement area is a heavy congestion area, partial execution, specifying the execution area and employment of a safety guard will be required to mitigate the hindrance of operations at the port.

(5) Pavement of apron

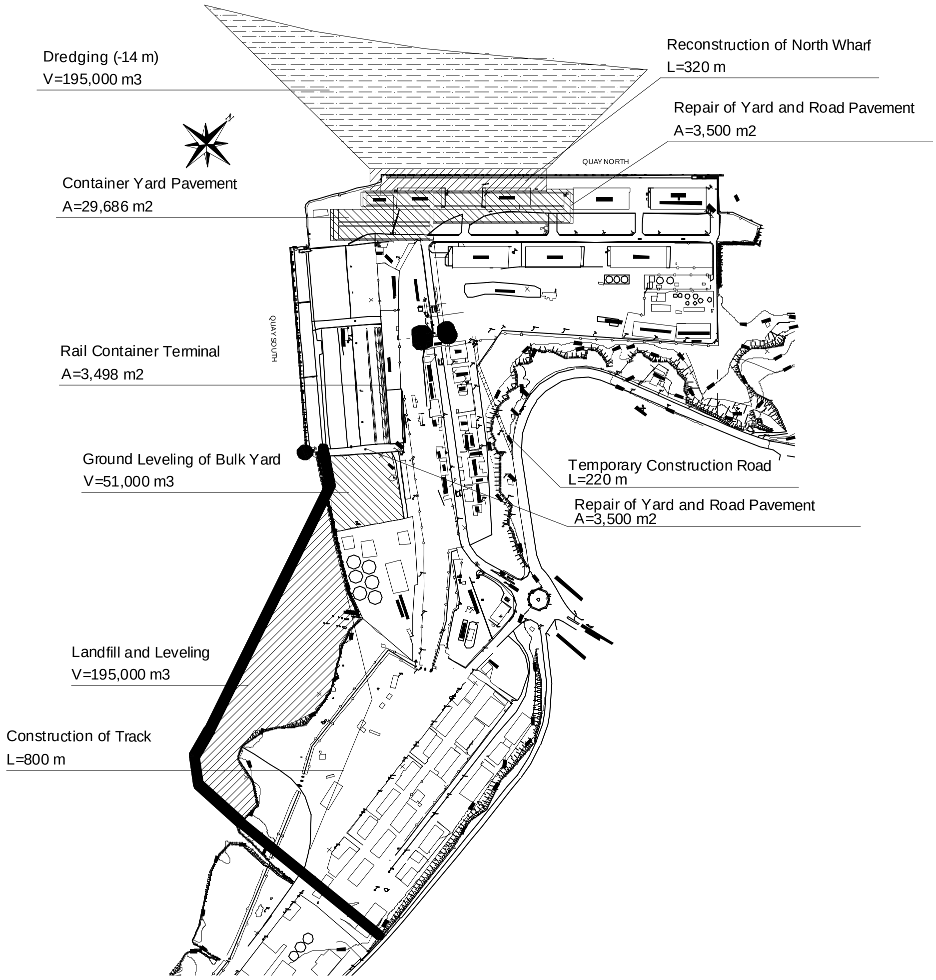
The northeast side of the North Wharf is used for oil terminals; therefore, the use of fire is strictly prohibited in this area. Accordingly, machines or work such as concrete breaking, which may cause a fire or an explosion, are not permitted in this area while an oil or gas tanker is berthed at the wharf. Therefore, it is necessary to relocate the oil handling function to the southwest side of the North Wharf temporarily for the duration of the construction. This scope of works includes the demolition of the existing structures/pavement, excavation, concrete pavement, coping concrete, installation of fenders, etc. All works should be finished within 2 months as soon as possible to mitigate the hindrance of the operation of the oil terminal.

(6) Temporary road construction related vehicles

Prior to the above construction, a temporary road and gate will be constructed between the existing road located on the east side of the entrance road of the port and the east side of the CDN office in the port as shown in Figure 4.6-1. Since all trucks and vehicles related to the construction will not pass through the gate of the Port or the entrance road, regular port operations will not be affected.

4.6.3 Construction plan of Part-2

The urgent rehabilitation work plan of Part-2 is shown in Figure 4.6-3.



Source: Study Team

Figure 4.6-3 Urgent rehabilitation work plan of Part-2

(1) Landfill and leveling

The landfill area will be enclosed by a bypass access road on the south side of the South Wharf constructed in Part-1. Dredged soil from an area near the North Wharf will be used for the landfill material. Since the dredged soil includes polluted material, according to the environmental regulations, an impermeable yard is required for the landfill to prevent leakage of pollution from the yard into seawater.

The landfill material will be transported by barge from the dredging area to a temporary stage constructed on the revetment for the bypass road. The material will be loaded onto a dump truck by crane from the barge and it will be transported to the landfill yard. Dumped material in the yard will be spread by bulldozer to an appropriate thickness and then it will be compacted by vibration roller to reach a fixed degree of compaction.

(2) Construction of rail track

A new rail track will be connected from the existing track near the crossing point of the bypass road to the track line to the new bulk yard that will be constructed in Part-2.

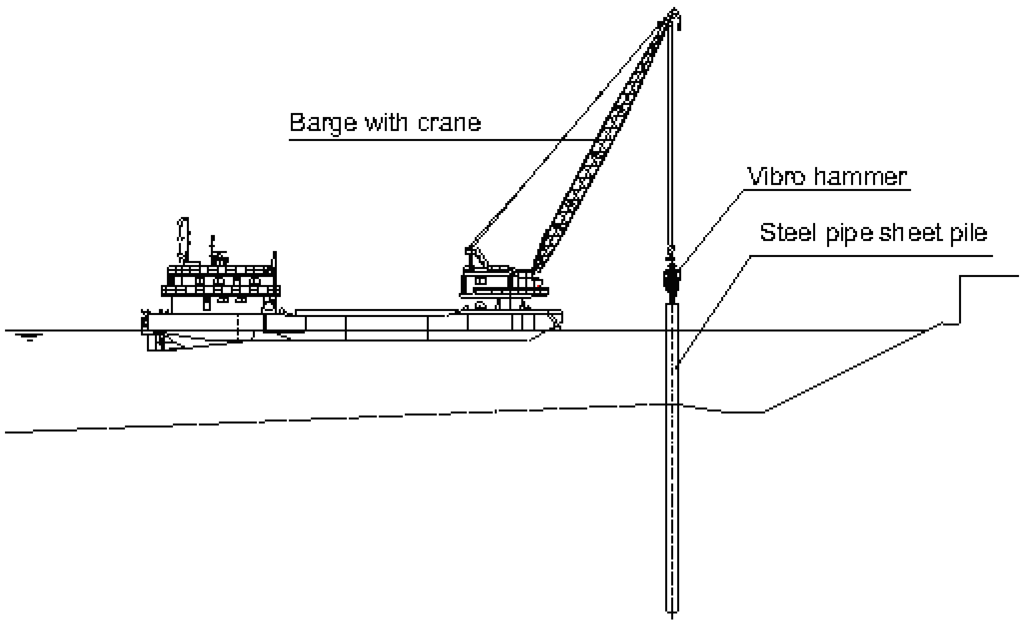
(3) Container yard pavement at the North Wharf

A new container yard will be constructed at the North Wharf to increase the capacity of loading/ unloading. In this stage of construction, existing hangers and pavement will be demolished and a new container yard will be paved with concrete in these areas. Before construction, a meeting will be held between the contractor and related persons in the Port to discuss mitigation methods to avoid hindering regular port operations. Suitable actions, such as partial execution, specifying the execution areas and employment of a safety guard will be required.

(4) Reconstruction of the North Wharf

In this stage, the southwest side of the existing berth in the North Wharf will be demolished and a new berth will be constructed by the steel pipe sheet pile method as explained in the following procedure.

- i) Demolishing the existing structure (south side: slab and concrete pier; north side: slab and concrete blocks) in the wharf using giant breakers and back hoes
- ii) Driving the steel pipe sheet pile of the front side with a vibro hammer with a crane on a barge equipped with a water-jet device for use if necessary as shown in Figure 4.6-4. Finally, the head of the pile will be driven by a monkey hammer to fix the bottom of the pile into the bearing layer
- iii) Driving the steel pipe sheet pile of the rear side with a vibro hammer with a crane on the land. Finally, the head of the pile will be driven by a monkey hammer to fix the bottom of the pile into the bearing layer
- iv) Installing the tie rods between the front piles and the rear piles
- v) Depositing and trimming the rubble behind the front pile up to the bottom of coping concrete using a barge with a crane
- vi) Placing coping concrete with the bollards and the anchors of fenders
- vii) Backfilling up to the bottom of the sub-base with the remaining rubble behind the coping concrete
- viii) Laying the sub-base and concrete pavement
- ix) Installing the fenders and the cathodic protection



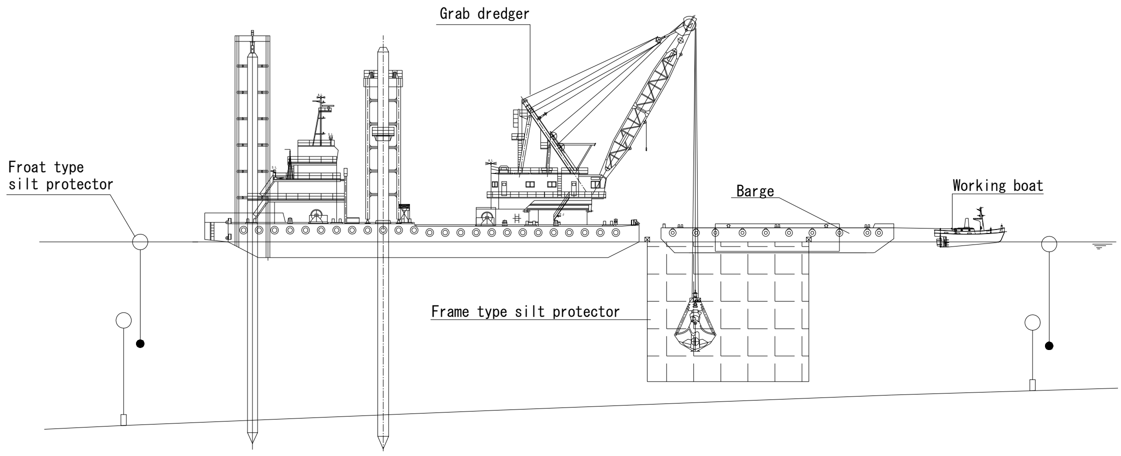
Source: Study Team

Figure 4.6-4 Driving steel pipe sheet pile

Before construction, the transportation routes of barges on the sea near the Port will be decided through discussions between the contractor and the related persons in the Port. The working area will be marked by buoys and a safety patrol boat will be arranged to prevent accidents.

(5) Dredging (-14 m)

Dredging works will be carried out by a grab dredger up to the elevation of -14 m in the area in front of the North Wharf. However, the bottom soil that will be dredged includes pollution. Therefore, it is necessary to study appropriate countermeasures according to the environmental regulations to prevent diffusion of the pollution into seawater. One example of an appropriate countermeasure is shown in Figure 4.6-5. Dredged material will be transported by barge to the landfill yard enclosed by the bypass road. Before construction, the transportation routes of barges on the sea near the port will be decided through discussions between the contractor and the related persons in the port. The working area will be marked by buoys and a safety patrol boat will be arranged to prevent accidents.

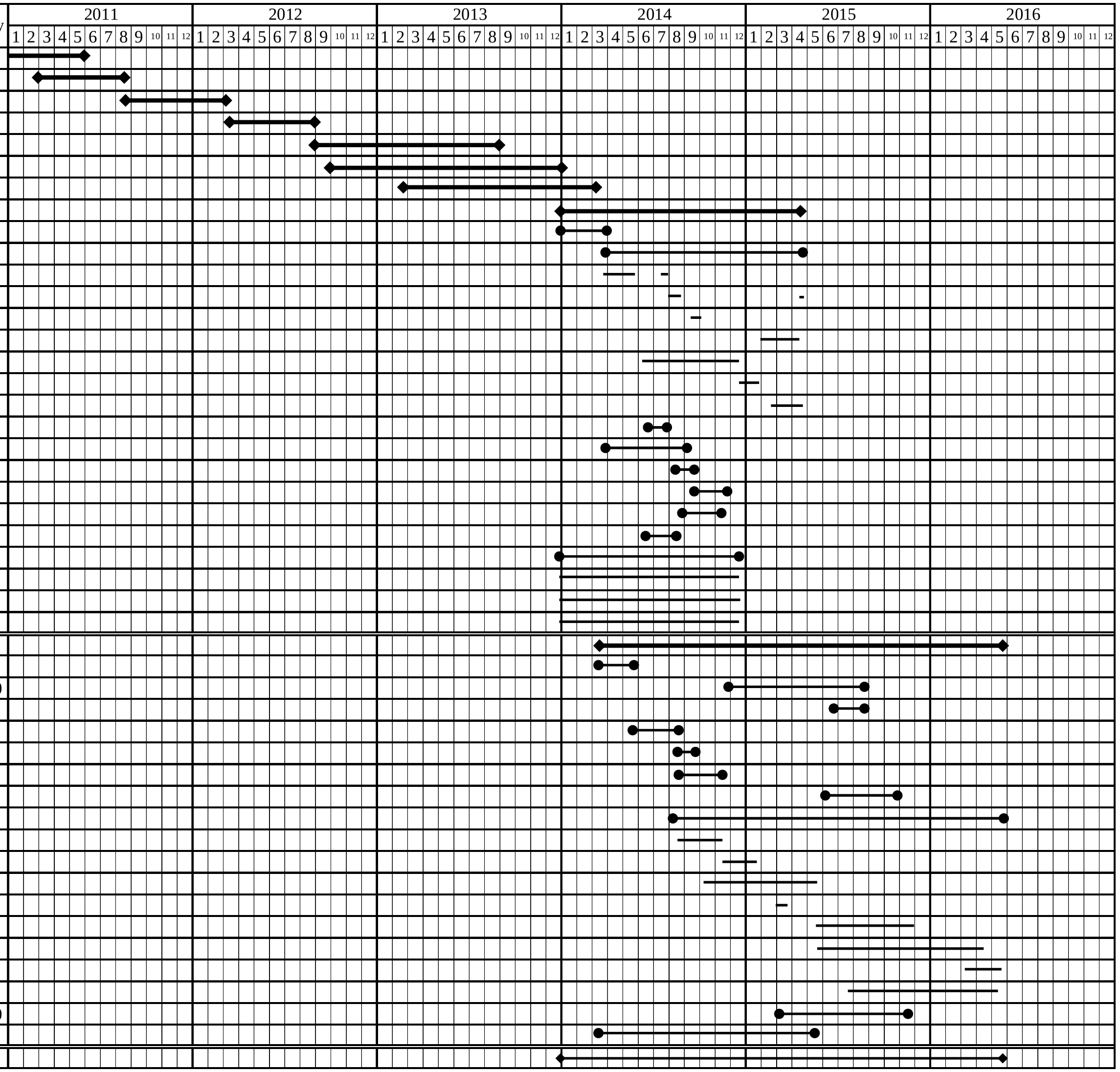


Source: Study Team

Figure 4.6-5 Dredging and silt protector

Table 4.6-2 Construction schedule

Code	Component	Unit	Quantity
P1	Feasibility Study		
P2	EIA Cirtificate		
P3	Arrangement of finance & Appraisal		
P4	Selection of Consultant		
P5	Detail Engineering		
P6	Contract procesure for Part -1		
P7	Contract procesure for Part -2		
A	Contract work part-1		
A1	Mobilization		
A2	By-pass Access Road	m	1,000
A2-1	Rubble stone deposition	m^3	47,180
A2-2	Armor stone deposition	m^3	16,423
A2-3	Sand protection mat	m^2	8,690
A2-4	Gravity wall concrete	m^3	765
A2-5	Embankment for road construction	m^3	52,292
A2-6	Sub-base (lower/upper)	m^2	8,500
A2-7	Concrete pavement	m^2	8,500
A3	Installation of Fenders	nos	33
A4	Foundation of RTG's	m^2	1,841
A5	Widening of Entrance Road	m	365
A6	Gate construction	ls	1
A7	Pavement of road in the port	m^2	775
A8	Pavement of Apron	m^2	7,750
A9	Procurement of Equipment		
A9-1	Reach Stacker	nos	4
A9-2	Yard chassis	nos	12
A9-3	RTG	nos	2
B	Contract work part-2		
B1	Mobilization		
B2	Landfill and leveling	m^3	195,000
B3	Construction of container rail track (South Wharf)	m	800
B4	Ground leveling of bulk yard (South Wharf)	m^3	51,000
B5	Repair of yard and road pavement	m^2	3,500
B6	Rail container terminal	m^2	1,365
B7	Container yard Pavement (North Wharf)	m^2	29,686
B8	Reconstruction of wharf (320m x 40m)		
B8-1	Demolition of existing structures	m^3	7,839
B8-2	Excavation	m^3	26,716
B8-3	Steel pipe/sheet pilling	nos	639
B8-4	North end block concrete	nos	24
B8-5	Coping concrete	m^3	10,218
B8-6	Backfill	m^3	79,955
B8-7	Concrete pavement	m^2	12,800
B8-8	Auxiliary works	ls	1
B-9	Dredging (-14 m) and soil disposal	m^3	195,000
B-10	Equipment (RTG)	nos	2
C	Environmental Monitoring		



Source: Study Team

4.7. Estimation of capital cost

The plan is divided into two parts: Part 1 and Part 2. Part-1 includes by-pass access road, installation of fenders, foundation of RTG's, widening of entrance road, gate construction, pavement of road in the Port, pavement of apron and firefighting system as facilities and 4 reach stackers, 12 sets of yard chassis and 2 RTG(s) are also included as equipment. Part-2 includes dredging, landfill & ground leveling, construction of rail track, ground leveling, repair of yard & road pavement, rail container terminal, container yard pavement and reconstruction of wharf as facilities and 3 RTG(s) and 1 mobile crane are also included as equipment. Furthermore, the engineering fee and physical contingency concerning these are estimated as well.

The costs for labor, material and construction equipment which were used in this estimation were based on the data of local construction firms capitalized in Maputo by South Africa and Portugal. The main supply source of these items is South African origin and the cost for items which are difficult to procure from South Africa were obtained based on the data of Japan. The cost estimation was carried out based on the data as of January 2011. Conditions of the cost estimation are as follows:

Exchange rate

1USD = 88.79JPY = 33.19MZN (The average rate in 2010)

Price escalation

Price escalation is estimated dividing into the local currency portion and two kinds of foreign currency portions (Japan and South Africa).

According to World Bank data, the average inflation rate of Mozambique was 7.08% and that of South Africa was 7.80% from 2006 to 2009. Therefore, these inflation ratios are used in the Project. However, according to the data of Construction Research Institute (Japan), the Construction Material Price Index has increased by 1.78% from 2006 to 2010 on average and this inflation rate was used.

Physical contingency

5% of the sub-total amount

Tax

Import duty and VAT are excluded in the estimation.

Others

1) By-pass access road

The by-pass access road includes revetment and road works.

2) Dredging

Contaminated soil and the hard soil (N value of about 50) are in the dredging area. As to dredging of the contaminated soil, enclosed-type grab bucket will be applied. As to dredging of the hard soil, heavy-duty grab bucket could be useful. Detailed volume of the contaminated soil and the hard soil should be ascertained in the D/D stage. In addition, the silt protection system should be used in dredging. The estimated cost includes the mobilization and demobilization charges of a grab dredger from Japan to Mozambique.

3) Disposal area

It is assumed that the dredged soil, the construction waste soil and concrete waste are disposed in the land closed by the causeway for the by-pass access road. The confined disposal facility should be constructed in a part of this area for preventing dispersion of the contaminant.

4) Environmental consideration work

The costs for the silt protection system and the construction of the confined disposal facility are included in the project cost.

5) Engineering fee

All the necessary costs for the D/D, tender assistance and supervision of construction are included in the engineering fee.

The estimated result is shown in Table 4.7-1.

Table 4.7-1 Cost estimation of Urgent Rehabilitation Project

Items	Cost Estimation (USD)
Part 1	**69,678,000**
Facilities	**57,561,000**
Mobilization & Temporary works	2,325,000
By-pass Access Road	32,338,000
Installation of Fenders	5,176,000
Foundation of RTG's	3,647,000
Widening of Entrance Road	450,000
Gate Construction	2,287,000
Pavement of Road in the Port	410,000
Pavement of Apron	5,521,000
Loading & unloading arm for liquid	3,932,000
Firefighting System	1,475,000
Equipment	**12,117,000**
Reach Stacker*4	4,215,000
Yard Chassis*12	3,951,000
RTG*2	3,951,000
Part 2	**160,911,000**
Facilities	**150,637,000**
Mobilization & Temporary works	1,162,000
Dredging, Landfill & Ground Leveling	25,413,000
Construction of Rail Track	1,234,000
Ground Leveling	195,000
Repair of Yard and Road Pavement	702,000
Rail Container Terminal	2,041,000
Container Yard Pavement	16,350,000
Reconstruction of Wharf	99,137,000
Environment Consideration Work	4,403,000
Equipment	**10,274,000**
RTG*3	5,927,000
Mobile Crane*1	4,347,000
Engineering Fee	**16,395,000**
(Subtotal)	246,984,000
Physical Contingency	**12,349,000**
Total Cost Estimation	**259,333,000**

Source: Study Team

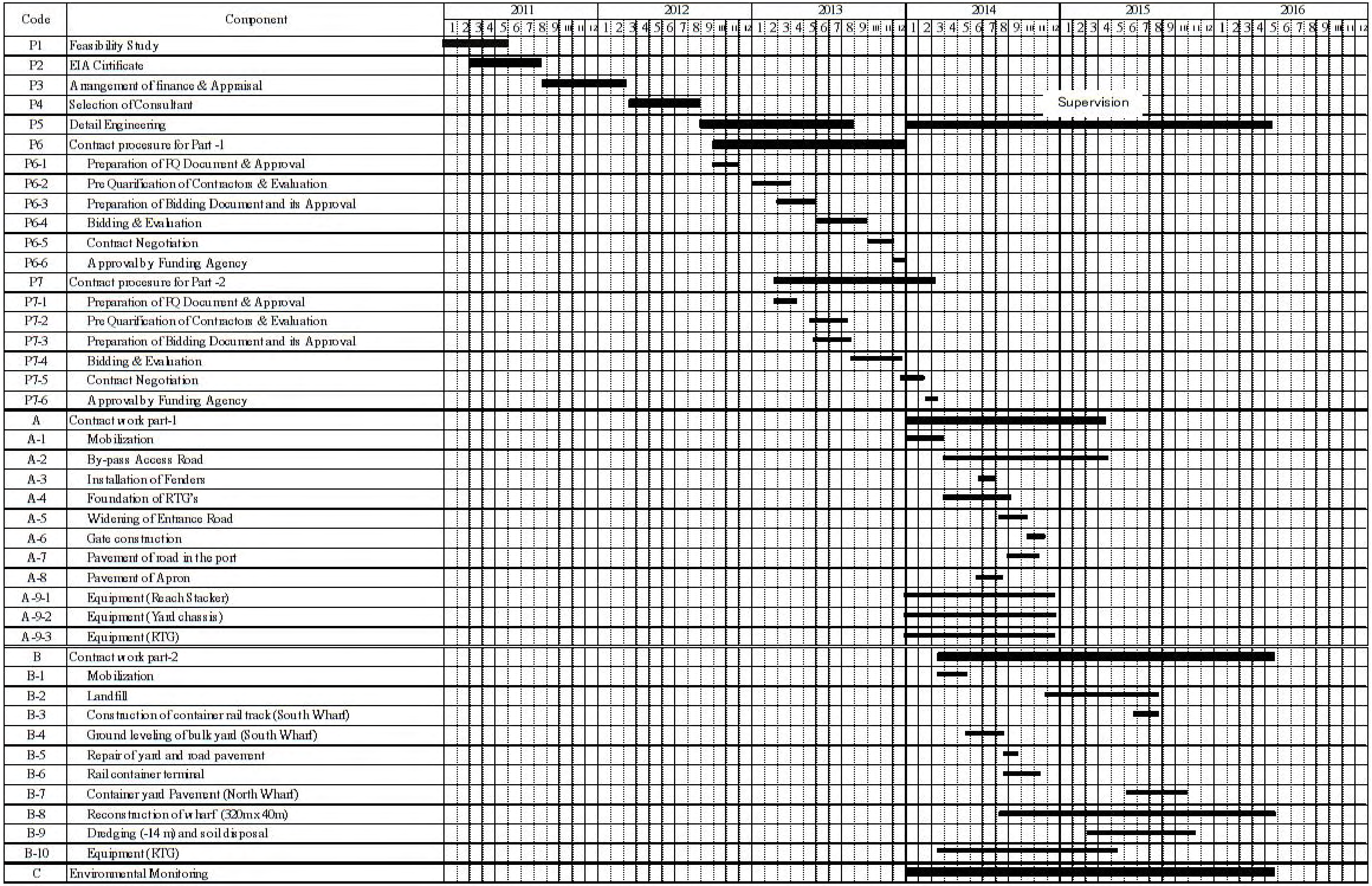
4.8. Implementation schedule

The implementation schedule covering the preparatory stage of the project and construction stage has been prepared based on the construction plan presented in 4.6 and also taking into consideration the time required for the EIA approval, arrangement of finance, selection of consultant, contract bidding and approval of the contract by financing agencies. Figure 4.8-1 is the work schedule exhibited in a bar chart.

Milestones of the project implementation are as follows:

- Completion of the feasibility study;	June 2011
- EIA approval;	August 2011
- Completion of financial arrangements;	March 2012
- Selection of consultant;	August 2012
- Detail design;	Start, September 2012, Completion, August 2013
- Contract procedure for Part-1;	Start, October 2012, Completion, December 2013
- Contract procedure for Part-2;	Start, February 2012, Completion, March 2014
- Construction work Part-1;	Start, January 2014, Completion, April 2015
- Construction work Part-2;	Start, March 2014, Completion, May 2016

The schedule is very tight. All efforts should be made by the agencies concerned to ensure the project is implemented on schedule.



Source: Study Team

Figure. 4.8-1 Implementation schedule

4.9. Project packages

The Urgent Rehabilitation Project can be implemented in one package. However, taking into consideration the time needed for the preparatory procedures such as obtaining EIA approval, financing, detailed engineering and contract procedures, which is estimated at almost three (3) years, the whole Urgent Rehabilitation Project should be completed in two years so that the Port can catch up with the growth in demand.

The construction sites of Part-1 and Part-2 are at different locations, i.e., at the South and the North Wharves, respectively. Therefore, Part-1 and 2 can be implemented independently from each other. In addition, the facilities to be completed in Part-1 should be turned over to the owner of the facilities unless it is necessary to wait for the completion of Part-2 components. Therefore, it is recommended to implement the project in two packages, namely, Part-1 and Part-2.

The project can also be implemented in three packages by packaging the procurement and installation of equipment. However, in such case, careful coordination among the three packages is very important to avoid interruptions of construction that may occur during the installation of the equipment.

4.10. Economic analysis

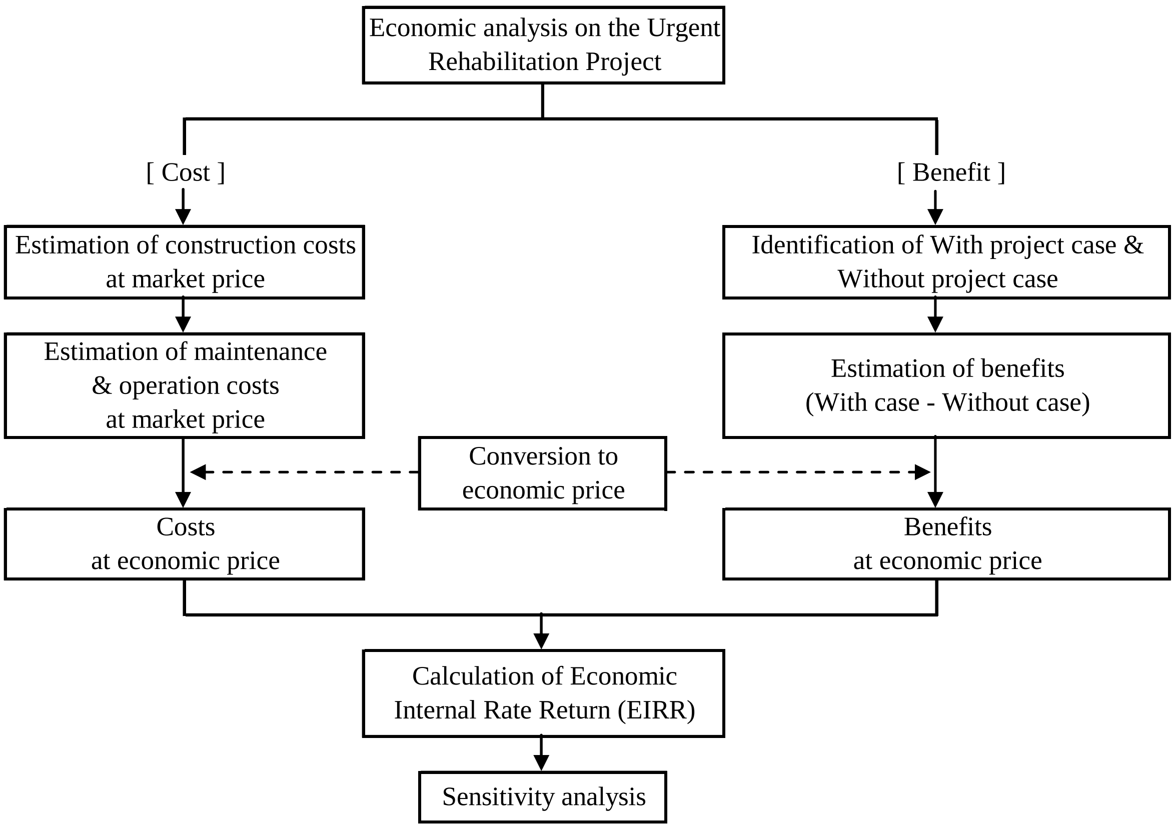
In this section, feasibility of the Urgent Rehabilitation Project (hereafter called as the "Project") is evaluated with an established method of economic analysis from the socio-economic viewpoint for both Mozambique alone and Southern Africa as a whole.

4.10.1 Economic feasibility of the Project

In this sub section, feasibility of the Project is evaluated using a Cost Benefit Analysis (CBA) method from the viewpoint of socio-economics for Mozambique.

(1) Methodology

Cost Benefit Analysis (CBA) is a method of economic analysis to quantify the effect of public investment in view of national economic benefit. In the analysis, future situation identified as "Without Project Case" is assumed which is the case that the concerned project would not be carried out. The national benefit is calculated based on the comparison between the "With Project Case" and the "Without Project Case". All benefits and costs at market price are converted to the economic price in order to eliminate distortions due to political economic factors such as import duties or government subsidies, etc. The feasibility of the project is evaluated with the calculated Economic Internal Rate Return (EIRR). The procedure of the economic analysis is shown in the Figure 4.10-1 as below.



Source: Study Team

Figure 4.10-1 Flowchart of the economic analysis

(2) Underlying assumptions

1) Implementation schedule

Implementation schedule of the Project is assumed as per the aforementioned descriptions in 4.8.

2) Project life period

The project life period is assumed to be 40 years starting from the year 2012 until 2051.

3) Exchange rate of foreign currencies

Exchange rate of foreign currencies is assumed as below:

USD/Yen	88.79
USD/MZN	33.19
MZN/Yen	2.68

(3) Calculations of costs

1) Components of costs

Costs are divided into 2 major categories; one is the investment cost and the other is maintenance and operation cost. The investment is for engineering, construction works, cargo handling equipment, including contingency allowances. Land acquisition cost can be neglected as the entire project area is government's property. Maintenance & operation cost is for maintenance/repair for the facilities and cargo handling, spreading through the period after commissioning of facilities.

2) Investment cost

Investment cost consists of capital expenditures for initial investment and post-commission investments.

a) Initial investment

The amount of initial investment is summarized in Table 4.10-1 below. The amount relevant to price escalations is excluded from the cost, because the amount is used for the calculations of EIRR in which the factor of inflation is conceptually incorporated.

Table 4.10-1 Summary of initial investment cost

('000 USD)

Item		Cost
Construction materials	Imported	87,994
Construction materials	Domestic	20,182
Machinery for construction	Imported	42,066
Skilled labors	Imported	11,848
Unskilled labors	Domestic	586
Others	Imported	18,452
Stevedoring equipmets	Imported	21,693
S.Total		202,821
Engineering		14,557
Contingency (5% of the s.total above)		10,141
Total		227,519

Source: Study Team

b) Post commission investments

After the commission of the Project, the cargo handling equipment needs to be renewed at certain intervals subject to the type of equipment.

3) Maintenance and operation cost

The cost for maintenance and operations per annum is assumed as follows:

Infrastructure	: 1% of the construction costs
Equipment	: 2% of the cargo handling equipment cost

Electric, fuel & utilities : 2% of the cargo handling equipment cost
PMB/TOC personnel cost for additional staff and labors: USD 4,863,000/year

As the vessel traffic at the Port is increased with the Project, some additional tug boats may be required. The fuel cost of the additional tug boats is assumed as a variable cost of USD692 per additional vessel call. Number of vessel calls generated by the Project is identified as the balance of the With and Without Cases. The capital expenditure for the additional tug boats is not included in the Project cost itself, on assumption that the expenditure amount is borne by PMB or TOC.

4) Conversion to economic price

a) Economic prices

For the economic analysis, prices of goods & services are defined as "economic prices". Economic prices are usually identical to the international market prices as those are exposed to severe global competition. Conversely, domestic prices are considered to be influenced by a government's interventions such as import duties (border distortion), domestic taxes or other government subsidies (domestic distortion), etc. Those distortions need to be eliminated from the prices for the analysis by converting domestic prices into economic prices with "price conversion factors".

b) Price conversion factors

Price conversion factors (CF) for this analysis are referred to the previous study of "The Preparatory Survey on Road Improvement Plan in Nacala Development Corridor (N13: Cuamba-Mandimba-Lichinga) in the Republic of Mozambique" as follows:

Imported construction materials	0.84
Domestic construction materials	1.00
Unskilled labor	0.41
Machinery and skilled labor	1.00
Fuel/oil	0.95
Imported cargo handling equipments	0.84

Conversion of prices of the Project costs in use of the CFs above is indicated in the Table 4.10-2 below.

Table 4.10-2 Price conversion of the costs

('000 USD)

Item		Original amount	CF	Economic price
Construction materials	Imported	87,994	0.84	73,915
Construction materials	Domestic	20,182	1.00	20,182
Machinery for construction	Imported	42,066	1.00	42,066
Skilled labors	Imported	11,848	1.00	11,848
Unskilled labors	Domestic	586	0.41	240
Others	Imported	18,452	0.84	15,500
Stevedoring equipmets	Imported	21,693	0.84	18,222
S.Total		202,821		181,973
Engineering		14,557	1.00	14,557
Contingency (5% of the s.total above)		10,141	1.00	10,141
Total		227,519		206,672

Source: Study Team

5) Summary of costs

Table 4.10-3 summarizes the yearly item-wise Project cost after the conversion.

Table 4.10-3 Summary of costs

(unit: '000 USD)

		Initial Investment	Additional Investment	Personnel cost	Maintenance		Operations		Total
					Infra-structures	Equipments	Fuel /utilities	Additional tugs	
1	2012	2,969	0	0	0	0	0	0	2,969
2	2013	3,235	0	0	0	0	0	0	3,235
3	2014	78,378	0	0	0	0	0	0	78,378
4	2015	101,593	0	0	0	0	0	0	101,593
5	2016	20,497	0	4,863	1,598	364	364	138	27,825
6	2017	0	0	4,863	1,598	364	364	169	7,358
7	2018	0	0	4,863	1,598	364	364	199	7,389
8	2019	0	0	4,863	1,598	364	364	229	7,419
9	2020	0	0	4,863	1,598	364	364	270	7,460
10	2021	0	0	4,863	1,598	364	364	323	7,513
11	2022	0	0	4,863	1,598	364	364	339	7,528
12	2023	0	0	4,863	1,598	364	364	339	7,529
13	2024	0	5,644	4,863	1,598	364	364	340	13,174
14	2025	0	0	4,863	1,598	364	364	341	7,531
15	2026	0	0	4,863	1,598	364	364	343	7,533
16	2027	0	0	4,863	1,598	364	364	345	7,535
17	2028	0	0	4,863	1,598	364	364	348	7,537
18	2029	0	10,583	4,863	1,598	364	364	350	18,122
19	2030	0	7,937	4,863	1,598	364	364	343	15,470
20	2031	0	0	4,863	1,598	364	364	345	7,534
21	2032	0	0	4,863	1,598	364	364	345	7,534
22	2033	0	0	4,863	1,598	364	364	345	7,534
23	2034	0	5,644	4,863	1,598	364	364	345	13,178
24	2035	0	0	4,863	1,598	364	364	345	7,534
25	2036	0	0	4,863	1,598	364	364	345	7,534
26	2037	0	0	4,863	1,598	364	364	345	7,534
27	2038	0	0	4,863	1,598	364	364	345	7,534
28	2039	0	0	4,863	1,598	364	364	345	7,534
29	2040	0	5,821	4,863	1,598	364	364	345	13,355
30	2041	0	0	4,863	1,598	364	364	345	7,534
31	2042	0	0	4,863	1,598	364	364	345	7,534
32	2043	0	0	4,863	1,598	364	364	345	7,534
33	2044	0	16,227	4,863	1,598	364	364	345	23,761
34	2045	0	7,937	4,863	1,598	364	364	345	15,471
35	2046	0	0	4,863	1,598	364	364	345	7,534
36	2047	0	0	4,863	1,598	364	364	345	7,534
37	2048	0	0	4,863	1,598	364	364	345	7,534
38	2049	0	0	4,863	1,598	364	364	345	7,534
39	2050	0	0	4,863	1,598	364	364	345	7,534
40	2051	0	0	4,863	1,598	364	364	345	7,534
Total		206,672	59,793	175,068	57,521	13,120	13,120	11,652	536,945

Source: Study Team

(4) Forecast of handling volume of the Port

1) Handling capacity of the Port

Cargo handling capacity of the Port is assumed for containers and bulk respectively as follows:

- **Capacity limit in With Case**

Containers	248,857 TEU
Bulk	2,131,000 MT

- **Capacity limit in Without Case**

Containers	105,400 TEU
Bulk	
Wheat	332,400 MT
Clinker	286,500 MT
Bagged cargoes	134,200 MT
Fertilizer	82,600 MT
Wood chip	NIL
Vehicles	NIL

2) Handling volume of the Port

In accordance with the demand forecasts described from 3.5.2 to 3.5.4 and also the capacity limit of the Port as stated in 1) above, handling volume of the Port is assumed for containers and bulk respectively as follows. As the actual figures for the year 2008 and forecast for the year 2020 and 2030 are given, the figures for each year are calculated with “linear interpolation” method.

a) Containers

Handling volume of containers is calculated for the With Case and Without Case respectively.

i) With Case

In the With Case, operational productivity is improved from the year 2016 and the capacity reaches the limit of 248,857 TEU in 2022.

Table 4.10-4 Container handling volume in With Case

(unit: '000 TEU)

		International ex. Moz local						Transit			Cabotage						Tranship			Total		
		Laden			Empty			Laden			Laden			Empty								
		Export	Import	S.Total	Export	Import	S.Total	Export	Import	S.Total	Outbound	Inbound	S.Total	Outbound	Inbound	S.Total	Laden	Empty	S.Total	Laden	Empty	Total
1	2012	27	17	45	6	14	21	5	6	10	0	4	4	4	1	5	3	2	5	62	27	90
2	2013	31	19	50	6	16	22	5	6	11	0	4	4	4	1	5	4	2	6	69	30	99
3	2014	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
4	2015	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
5	2016	42	23	66	7	14	21	17	29	46	1	5	6	6	2	8	7	4	11	124	32	157
6	2017	46	25	71	7	15	22	19	32	51	1	6	6	7	2	8	8	4	12	136	34	170
7	2018	50	26	76	7	16	23	20	36	56	1	6	7	7	2	9	8	5	13	147	36	184
8	2019	54	27	81	7	17	24	22	39	61	1	7	7	8	2	10	9	5	14	159	38	197
9	2020	58	29	86	7	17	25	24	42	66	1	7	8	8	2	11	10	5	15	170	40	211
10	2021	67	34	100	8	20	28	25	46	72	1	8	9	10	2	12	11	6	17	192	47	239
11	2022	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
12	2023	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
13	2024	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
14	2025	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
15	2026	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
16	2027	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
17	2028	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
18	2029	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
19	2030	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
20	2031	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
21	2032	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
22	2033	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
23	2034	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
24	2035	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
25	2036	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
26	2037	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
27	2038	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
28	2039	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
29	2040	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
30	2041	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
31	2042	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
32	2043	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
33	2044	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
34	2045	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
35	2046	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
36	2047	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
37	2048	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
38	2049	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
39	2050	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249
40	2051	70	35	105	8	21	30	26	48	75	1	9	10	10	3	13	11	6	17	200	49	249

Source: Study Team

ii) Without Case

In the Without Case, productivity improvement doesn't happen throughout the project life, reaching the capacity limit of 105,400 TEU in 2014.

Table 4.10-5 Container handling volume in Without Case

(unit: '000 TEU)

		International ex. Moz local						Transit			Cabotage						Tranship			Total		
		Laden			Empty			Laden			Laden			Empty								
		Export	Import	S.Total	Export	Import	S.Total	Export	Import	S.Total	Outbound	Inbound	S.Total	Outbound	Inbound	S.Total	Laden	Empty	S.Total	Laden	Empty	Total
1	2012	27	17	45	6	14	21	5	6	10	0	4	4	4	1	5	3	2	5	62	27	90
2	2013	31	19	50	6	16	22	5	6	11	0	4	4	4	1	5	4	2	6	69	30	99
3	2014	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
4	2015	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
5	2016	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
6	2017	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
7	2018	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
8	2019	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
9	2020	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
10	2021	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
11	2022	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
12	2023	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
13	2024	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
14	2025	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
15	2026	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
16	2027	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
17	2028	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
18	2029	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
19	2030	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
20	2031	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
21	2032	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
22	2033	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
23	2034	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
24	2035	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
25	2036	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
26	2037	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
27	2038	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
28	2039	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
29	2040	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
30	2041	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
31	2042	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
32	2043	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
33	2044	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
34	2045	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
35	2046	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
36	2047	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
37	2048	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
38	2049	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
39	2050	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105
40	2051	33	20	53	6	17	24	5	7	12	0	4	5	5	1	6	4	2	6	73	32	105

Source: Study Team

b) Bulk

Handling volume of bulk is calculated for the With Case and Without Case respectively.

i) With Case

In the With Case, operational productivity is improved from the year 2016 and the capacity reaches the limit of 2,131,000 MT in 2021.

Table 4.10-6 Bulk handling volume in With Case

(unit: '000 MT)

		Mozambique								Transit					Domestic		Total					
		Export			Import						Import				Outbound							
		Wood chip	Others	S.Total	Clinker	Wheat	Vehicle	Others	S.Total	Export	Wheat	Vehicle	Others	S.Total	Wheat	S.Total	Wood chip	Clinker	Wheat	Vehicle	Others	Total
1	2012	0	18	18	256	181	0	59	496	22	104	0	118	222	0	0	0	256	285	0	217	758
2	2013	0	18	18	287	209	0	57	552	22	124	0	120	243	0	0	0	287	332	0	217	836
3	2014	0	18	18	287	209	0	56	551	22	124	0	121	245	0	0	0	287	332	0	217	836
4	2015	0	18	18	287	209	0	54	549	22	124	0	123	247	0	0	0	287	332	0	217	836
5	2016	64	95	159	378	291	41	52	762	61	183	48	265	496	0	0	64	378	474	89	474	1,478
6	2017	72	105	177	409	318	46	51	823	66	203	54	285	542	0	0	72	409	521	100	506	1,607
7	2018	80	115	195	439	345	51	49	884	70	223	60	304	587	0	0	80	439	568	111	538	1,736
8	2019	88	124	212	470	373	56	48	946	75	242	66	324	632	0	0	88	470	615	122	571	1,865
9	2020	96	134	230	500	400	61	46	1,007	80	262	72	343	677	0	0	96	500	662	133	603	1,994
10	2021	117	147	264	440	458	69	51	1,015	82	254	78	354	689	81	81	117	440	793	147	633	2,131
11	2022	117	147	264	415	483	69	56	1,015	82	254	78	349	689	81	81	117	415	818	147	633	2,131
12	2023	117	147	264	372	525	69	61	1,015	82	254	78	344	689	81	81	117	372	861	147	633	2,131
13	2024	117	147	264	329	568	69	66	1,015	82	254	78	339	689	81	81	117	329	904	147	633	2,131
14	2025	117	147	264	286	611	69	66	1,015	82	254	78	339	689	81	81	117	286	946	147	633	2,131
15	2026	117	147	264	244	654	69	66	1,015	82	254	78	339	689	81	81	117	244	989	147	633	2,131
16	2027	117	147	264	201	696	69	66	1,015	82	254	78	339	689	81	81	117	201	1,032	147	633	2,131
17	2028	117	147	264	158	739	69	66	1,015	82	254	78	339	689	81	81	117	158	1,074	147	633	2,131
18	2029	117	147	264	115	782	69	66	1,015	82	254	78	339	689	81	81	117	115	1,117	147	633	2,131
19	2030	117	147	264	30	867	69	66	1,015	82	254	78	339	689	81	81	117	30	1,203	147	633	2,131
20	2031	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
21	2032	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
22	2033	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
23	2034	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
24	2035	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
25	2036	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
26	2037	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
27	2038	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
28	2039	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
29	2040	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
30	2041	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
31	2042	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
32	2043	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
33	2044	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
34	2045	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
35	2046	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
36	2047	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
37	2048	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
38	2049	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
39	2050	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131
40	2051	117	147	264	0	897	69	66	1,015	82	254	78	339	689	81	81	117	0	1,233	147	633	2,131

Source: Study Team

ii) Without Case

In the Without Case, productivity improvement doesn't happen throughout the project life. Bagged cargoes and fertilizer reach the capacity limit in 2009, then wheat and Clinker reach the capacity limit in 2013. Wood chip and vehicles cannot be handled throughout the project life due to the space shortage.

Table 4.10-7 Bulk handling volume in Without Case

(unit: '000 MT)

		Mozambique								Transit					Domestic		Total					
		Export			Import					Export	Import				Outbound							
		Wood chip	Others	S.Total	Clinker	Wheat	Vehicle	Others	S.Total		Wheat	Vehicle	Others	S.Total	Wheat	S.Total	Wood chip	Clinker	Wheat	Vehicle	Others	Total
1	2012	0	18	18	256	181	0	59	496	22	104	0	118	222	0	0	0	256	285	0	217	758
2	2013	0	18	18	287	209	0	57	552	22	124	0	120	243	0	0	0	287	332	0	217	836
3	2014	0	18	18	287	209	0	56	551	22	124	0	121	245	0	0	0	287	332	0	217	836
4	2015	0	18	18	287	209	0	54	549	22	124	0	123	247	0	0	0	287	332	0	217	836
5	2016	0	18	18	287	209	0	52	548	22	124	0	124	248	0	0	0	287	332	0	217	836
6	2017	0	18	18	287	209	0	51	546	22	124	0	126	250	0	0	0	287	332	0	217	836
7	2018	0	18	18	287	209	0	49	544	22	124	0	128	251	0	0	0	287	332	0	217	836
8	2019	0	18	18	287	209	0	48	543	22	124	0	129	253	0	0	0	287	332	0	217	836
9	2020	0	18	18	287	209	0	46	541	22	124	0	131	255	0	0	0	287	332	0	217	836
10	2021	0	18	18	287	209	0	51	546	22	124	0	126	250	0	0	0	287	332	0	217	836
11	2022	0	18	18	287	209	0	56	551	22	124	0	121	245	0	0	0	287	332	0	217	836
12	2023	0	18	18	287	209	0	61	556	22	124	0	116	240	0	0	0	287	332	0	217	836
13	2024	0	18	18	287	209	0	66	561	22	124	0	111	235	0	0	0	287	332	0	217	836
14	2025	0	18	18	265	209	0	66	539	22	124	0	111	235	0	0	0	265	332	0	217	814
15	2026	0	18	18	218	209	0	66	492	22	124	0	111	235	0	0	0	218	332	0	217	767
16	2027	0	18	18	171	209	0	66	445	22	124	0	111	235	0	0	0	171	332	0	217	720
17	2028	0	18	18	124	209	0	66	398	22	124	0	111	235	0	0	0	124	332	0	217	673
18	2029	0	18	18	77	209	0	66	351	22	124	0	111	235	0	0	0	77	332	0	217	626
19	2030	0	18	18	30	209	0	66	304	22	124	0	111	235	0	0	0	30	332	0	217	579
20	2031	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
21	2032	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
22	2033	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
23	2034	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
24	2035	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
25	2036	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
26	2037	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
27	2038	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
28	2039	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
29	2040	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
30	2041	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
31	2042	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
32	2043	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
33	2044	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
34	2045	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
35	2046	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
36	2047	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
37	2048	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
38	2049	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
39	2050	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549
40	2051	0	18	18	0	209	0	66	274	22	124	0	111	235	0	0	0	0	332	0	217	549

Source: Study Team

(5) Identification of Benefits

The benefits of the Project are identified by comparison between the "With Case" and the "Without Case" from the viewpoint of contribution to the national economic. Following benefits are envisaged.

1) Saving of interest on container cargoes

Once the operational productivity of the container terminal is improved in the year 2016 with the Project, the time for cargo handling at the Port will be reduced from 2.83 days of Current

Productivity to 0.74 days of Improved Productivity per vessel for export/import respectively. This reduction of cargo handling times will have an effect to shorten the lead time of both exportation and importation of container cargoes, which will reduce the payment of interest by the exporters/importers, then finally will improve price-competitiveness of export goods in the global market and reduce the consumer prices of import goods.

From this viewpoint, the benefit is identified as the reduction of interest on the FOB value of export cargoes and CIF value of import cargoes for the difference of cargo handling times between Current (Without Case) and Improved Productivity (With Case). Cabotage containers will also have this benefit, as most of those containers are eventually transshipped to/from the deep-sea vessels for export/import.

2) Saving of inland transportation costs

With the Project, the handling capacity of the Port is enhanced in 2016, which enables the Port to handle additional cargoes of both containers and bulk. Without the Project, those additional cargoes cannot be handled at the Port and need to be shifted to some other ports at the extra cost for inland transportation. Such extra movements of cargoes will cause dissipation of resources such as manpower, hardware and fuel, which will have a negative effect on the national economy.

Most critical problem will occur with the import/export cargoes to/from the immediate hinterland of the Port; i.e. the 3 northern provinces of Nampula, Niassa and Cabo Delgado. The alternative port must be Beira, in consideration of the quality/capacity of port facilities and the availability of vessels deployed for various trade lanes. Among the 3 provinces, the cargoes to/from Cabo Delgado may be shifted to Pemba, as the distance is far shorter than Beira and the port is presumed to accommodate that additional volume of Cabo Delgado. The transit cargoes to/from Malawi and Zambia will also be shifted to Beira; however the extra inland cost on those cargoes will be nominal, taking the small difference of the distances into consideration.

In the sense stated in 1) above, interest amount on the value of shifted cargoes for the longer transit time should also be counted in the extra costs.

The benefit is identified as follows:

- The difference of the net cost of inland transportation by trucks between the Port and Beira multiplied by the difference of cargo volume between With and Without Case.
- Interest on the value of shifted cargoes for the difference of inland transit times.

3) Securing profit from transshipment containers

Without the Project, the overflow cargoes of local origins may be shifted to other ports as stated in 1) above. However the transshipment containers must be shifted to other nearest ports such as Dar es Salaam, Mutsamudu etc., as those containers are mainly transferred between East Asia trade lanes and South Asia/Middle East trade lanes in which the Port is geographically located at a junction point. In this sense the alternative junction ports must be north of the Port and out of Mozambique. Beira is not assumed as the junction port in this case, as it is in far south forcing shipping lines to bear the cost for deviations from South Asia/Middle East trade lanes.

The benefit is identified as the amount of TOC's profit derived from additional transshipment containers with the Project.

4) Unquantifiable effects

As stated in 2) above, transit cargoes to/from Malawi and Zambia may be shifted to Beira in the Without Case.

However, as a result of continuous shifts of cargoes from Nacala, the handling volume of Beira will sooner or later reach its operational capacity limit. Once the volume of the shifts exceeds the operational limit of Beira, the cargoes overflowed from Beira then need to be diverted to other alternative ports out of Mozambique.

With the Project, such national loss of overflow cargoes can be avoided and the added value gained by the handling that cargo in the Port shall contribute to enhancing the country's GDP.

Since it is rather difficult to identify the capacity limit of Beira, the effects of avoiding loss of overflow transit cargoes cannot be quantified and is not taken into account in the economic analysis.

(6) Calculations of benefits

1) Saving of interest on container cargoes

For the calculation, cargo value is referred to INE's data for 2009 as USD8,065/TEU on FOB basis for exports and USD 8,092/TEU on CIF basis for imports.

Table 4.10-8 shows the calculation of the amount of interest.

Table 4.10-8 Benefit of saving of interest on container cargoes

		Throughput of With Case ('000 TEU)				Cargo value ('000 USD)			Benefit of Interst ('000 USD)
		International ex. Moz local		Cabotage					
		Export	Import	Out-bound	In-bound	Export	Import	Total	
1	2012	27	17	0	4	248,516	143,482	391,998	0
2	2013	31	19	0	4	282,774	155,533	438,307	0
3	2014	33	20	0	4	299,568	164,770	464,338	0
4	2015	33	20	0	4	299,568	164,770	464,338	0
5	2016	42	23	1	5	385,548	191,686	577,234	560
6	2017	46	25	1	6	419,806	203,737	623,543	605
7	2018	50	26	1	6	454,064	215,788	669,852	650
8	2019	54	27	1	7	488,322	227,839	716,161	695
9	2020	58	29	1	7	522,580	239,890	762,470	740
10	2021	67	34	1	8	606,304	279,982	886,286	860
11	2022	70	35	1	9	632,394	292,030	924,425	897
12	2023	70	35	1	9	632,394	292,030	924,425	897
13	2024	70	35	1	9	632,394	292,030	924,425	897
14	2025	70	35	1	9	632,394	292,030	924,425	897
15	2026	70	35	1	9	632,394	292,030	924,425	897
16	2027	70	35	1	9	632,394	292,030	924,425	897
17	2028	70	35	1	9	632,394	292,030	924,425	897
18	2029	70	35	1	9	632,394	292,030	924,425	897
19	2030	70	35	1	9	632,394	292,030	924,425	897
20	2031	70	35	1	9	632,394	292,030	924,425	897
21	2032	70	35	1	9	632,394	292,030	924,425	897
22	2033	70	35	1	9	632,394	292,030	924,425	897
23	2034	70	35	1	9	632,394	292,030	924,425	897
24	2035	70	35	1	9	632,394	292,030	924,425	897
25	2036	70	35	1	9	632,394	292,030	924,425	897
26	2037	70	35	1	9	632,394	292,030	924,425	897
27	2038	70	35	1	9	632,394	292,030	924,425	897
28	2039	70	35	1	9	632,394	292,030	924,425	897
29	2040	70	35	1	9	632,394	292,030	924,425	897
30	2041	70	35	1	9	632,394	292,030	924,425	897
31	2042	70	35	1	9	632,394	292,030	924,425	897
32	2043	70	35	1	9	632,394	292,030	924,425	897
33	2044	70	35	1	9	632,394	292,030	924,425	897
34	2045	70	35	1	9	632,394	292,030	924,425	897
35	2046	70	35	1	9	632,394	292,030	924,425	897
36	2047	70	35	1	9	632,394	292,030	924,425	897
37	2048	70	35	1	9	632,394	292,030	924,425	897
38	2049	70	35	1	9	632,394	292,030	924,425	897
39	2050	70	35	1	9	632,394	292,030	924,425	897
40	2051	70	35	1	9	632,394	292,030	924,425	897

Source: Study Team

2) Saving of inland transportation costs

a) Container cargoes

For the calculation, the difference of truck charges and transit times are assumed as per the Table 4.10-9. The truck charge per km on the difference basis is given as USD2.48/km.

Table 4.10-9 Assumption of truck charges and transit times

Province	From city	To Nacala				To Beira				Difference			
		Distance (km)	Charge (USD/TEU)	Time (hours) 2012-2029	Time (hours) 2030-2051	Distance (km)	Charge (USD/TEU)	Time (hours) 2012-2029	Time (hours) 2030-2051	Distance (km)	Charge (USD)	Time (hours) 2012-2029	Time (hours) 2030-2051
Nampula	Nampula	197	670	3	3	1,018	2,750	29	29	821	2,080	26	26
Niassa	Lichinga	855	2,540	48	26	1,676	4,530	58	52	821	1,990	10	26
Average		526	1,605	26	15	1,347	3,640	44	41	821	2,035	18	26

Charge per km:	2.48

Source: Study Team

Average net cost per km of Mozambican truck companies is estimated as USD1.15/km in case of used trucks. Net cost portion in the truck charge of USD2.48/km is given as 46.5%.

As the amount of benefit also needs to be converted to the economic price, the CFs used in (3)-4)-b) are again applied to the component-wise conversion of the net cost as shown in Table 4.10-10 below. The weighted average CF is given as 0.84.

Table 4.10-10 Net truck cost and price conversion

Cost component	Cost/km (USD)	Portion	CF	Weighted CF
Fuel/lubricants	0.396	34.4%	0.95	0.33
Capital cost	0.269	23.4%	0.84	0.20
Unsilled labor	0.118	10.2%	0.41	0.04
Skilled labor	0.028	2.4%	1.00	0.02
Maintennce/tyres	0.305	26.5%	0.84	0.22
Insurance	0.034	3.0%	1.00	0.03
Others	0.002	0.2%	1.00	0.00
Total	1.152	100.0%		**0.84**

Source: “Republic of Mozambique: Railways and Ports Restructuring Project Transport Cost Study” by Jacobs Consultancy in October 2005, arranged by the Study Team

Portion of the cargoes originated from Cabo Delgado among the northern 3 provinces is assumed as 22.3% which is the share of provincial GDP among the three, reported by UNDP in 2004. In the calculations of benefit, this portion shall be excluded. Cargo value and interest rate are as per 1) above.

Table 4.10-11 shows the calculation of the amount of benefit.

Table 4.10-11 Benefit of saving of inland transportation costs (containers)

		Throughput balance between With & Without, excluding Cabo Delgado ('000 TEU)				Benefit amount ('000 USD)						
		Laden		Empty		Difference of truck cost			Interest on cargo value			Total
		Export	Import	Export	Import	Laden	Empty	S.Total	Export	Import	S.Total	
1	2012	0	0	0	0	0	0	0	0	0	0	0
2	2013	0	0	0	0	0	0	0	0	0	0	0
3	2014	0	0	0	0	0	0	0	0	0	0	0
4	2015	0	0	0	0	0	0	0	0	0	0	0
5	2016	3	1	0	-1	7,862	-1,095	6,766	30	10	40	6,806
6	2017	5	2	0	-1	11,091	-744	10,347	42	15	57	10,404
7	2018	6	2	0	-1	14,321	-392	13,929	54	19	73	14,002
8	2019	8	3	0	0	17,551	-41	17,510	66	24	90	17,600
9	2020	9	3	0	0	20,780	311	21,091	78	28	106	21,197
10	2021	12	5	1	1	29,455	1,697	31,152	107	43	150	31,303
11	2022	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
12	2023	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
13	2024	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
14	2025	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
15	2026	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
16	2027	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
17	2028	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
18	2029	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
19	2030	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
20	2031	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
21	2032	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
22	2033	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
23	2034	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
24	2035	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
25	2036	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
26	2037	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
27	2038	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
28	2039	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
29	2040	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
30	2041	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
31	2042	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
32	2043	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
33	2044	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
34	2045	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
35	2046	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
36	2047	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
37	2048	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
38	2049	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
39	2050	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438
40	2051	13	6	1	1	32,126	2,149	34,274	116	48	164	34,438

Source: Study Team

b) Bulk cargoes

Benefit for bulk cargoes is calculated based on the following assumptions,

Cargo weight per trip : 22.4 MT
Truck charge level : 70% of container truck charge
Cargo value : USD901/MT for exports on FOB basis (INE statistics 2009)
USD533/MT for imports on CIF basis (INE statistics 2009)

The remaining assumptions are the same as those for containers. Table 4.10-12 shows the calculation of the amount of benefit.

Table 4.10-12 Benefit of saving of inland transportation costs (bulk)

		Volume balance between With & Without, excluding Cabo Delgado ('000 MT)			Benefit amount ('000 USD)		
		Export	Import	Total	Difference of truck cost	Interest on cargo value	Benefit Total
1	2012	0	0	0	0	0	0
2	2013	0	0	0	0	0	0
3	2014	0	0	0	0	0	0
4	2015	0	0	0	0	0	0
5	2016	110	166	276	6,856	65	6,921
6	2017	123	215	339	8,411	79	8,490
7	2018	137	264	401	9,966	92	10,058
8	2019	151	313	464	11,521	105	11,626
9	2020	165	362	527	13,076	119	13,195
10	2021	191	364	555	13,789	128	13,917
11	2022	191	360	552	13,693	127	13,819
12	2023	191	356	548	13,596	126	13,722
13	2024	191	353	544	13,505	125	13,630
14	2025	191	370	561	13,920	129	14,048
15	2026	191	406	597	14,827	135	14,962
16	2027	191	443	634	15,734	142	15,876
17	2028	191	479	670	16,641	149	16,789
18	2029	191	516	707	17,548	156	17,703
19	2030	191	552	743	18,454	162	18,617
20	2031	191	575	767	19,033	167	19,200
21	2032	191	575	767	19,033	167	19,200
22	2033	191	575	767	19,033	167	19,200
23	2034	191	575	767	19,033	167	19,200
24	2035	191	575	767	19,033	167	19,200
25	2036	191	575	767	19,033	167	19,200
26	2037	191	575	767	19,033	167	19,200
27	2038	191	575	767	19,033	167	19,200
28	2039	191	575	767	19,033	167	19,200
29	2040	191	575	767	19,033	167	19,200
30	2041	191	575	767	19,033	167	19,200
31	2042	191	575	767	19,033	167	19,200
32	2043	191	575	767	19,033	167	19,200
33	2044	191	575	767	19,033	167	19,200
34	2045	191	575	767	19,033	167	19,200
35	2046	191	575	767	19,033	167	19,200
36	2047	191	575	767	19,033	167	19,200
37	2048	191	575	767	19,033	167	19,200
38	2049	191	575	767	19,033	167	19,200
39	2050	191	575	767	19,033	167	19,200
40	2051	191	575	767	19,033	167	19,200

Source: Study Team

3) Securing profit from transshipment containers

Profit/revenue ratio of TOC is assumed as 12.3% as per the profit ratio of CDN-Port in 2009. TOC's revenue per transshipment container is assumed as USD85/TEU as per CDN's current tariff rate for transshipment containers. CF for economic price conversion is 0.86 based on CDN's cost component and CFs as aforementioned in (3)-4)-b). Table 4.10-13 shows the calculation of the amount of benefit.

Table 4.10-13 Benefit of securing profit from transshipment containers

		Balance of tranship containers between With & Without ('000 TEU)			Benefit as TOC's profit ('000 USD)
		Laden	Empty	Total	
1	2012	0	0	0	0
2	2013	0	0	0	0
3	2014	0	0	0	0
4	2015	0	0	0	0
5	2016	3	2	5	41
6	2017	4	2	6	50
7	2018	4	2	7	59
8	2019	5	3	8	68
9	2020	5	3	9	77
10	2021	7	4	10	94
11	2022	7	4	11	100
12	2023	7	4	11	100
13	2024	7	4	11	100
14	2025	7	4	11	100
15	2026	7	4	11	100
16	2027	7	4	11	100
17	2028	7	4	11	100
18	2029	7	4	11	100
19	2030	7	4	11	100
20	2031	7	4	11	100
21	2032	7	4	11	100
22	2033	7	4	11	100
23	2034	7	4	11	100
24	2035	7	4	11	100
25	2036	7	4	11	100
26	2037	7	4	11	100
27	2038	7	4	11	100
28	2039	7	4	11	100
29	2040	7	4	11	100
30	2041	7	4	11	100
31	2042	7	4	11	100
32	2043	7	4	11	100
33	2044	7	4	11	100
34	2045	7	4	11	100
35	2046	7	4	11	100
36	2047	7	4	11	100
37	2048	7	4	11	100
38	2049	7	4	11	100
39	2050	7	4	11	100
40	2051	7	4	11	100

Source: Study Team

(7) Calculations of EIRR

Calculation of net benefit and EIRR is shown in Table 4.10-14 below. EIRR is given as 13.50%. When a discount rate of 10.00% is applied, present value of benefits amounts to USD 268,579,000.

Table 4.10-14 Calculation of net benefit and EIRR

(unit: '000 USD)

		Costs	Benefits					Net Benefit
			Saving of interest on container cargoes	Saving of inland transportation costs (containers)	Saving of inland transportation costs (bulk)	Securing profit from tranship containers	Total	
1	2012	2,969	0	0	0	0	0	-2,969
2	2013	3,235	0	0	0	0	0	-3,235
3	2014	78,378	0	0	0	0	0	-78,378
4	2015	101,593	0	0	0	0	0	-101,593
5	2016	27,825	560	6,794	6,921	41	14,316	-13,509
6	2017	7,358	605	10,387	8,490	50	19,531	12,173
7	2018	7,389	650	13,979	10,058	59	24,746	17,357
8	2019	7,419	695	17,572	11,626	68	29,961	22,542
9	2020	7,460	740	21,165	13,195	77	35,176	27,716
10	2021	7,513	860	31,256	13,917	94	46,127	38,614
11	2022	7,528	897	34,388	13,819	100	49,205	41,676
12	2023	7,529	897	34,388	13,722	100	49,107	41,578
13	2024	13,174	897	34,388	13,630	100	49,015	35,842
14	2025	7,531	897	34,388	14,048	100	49,433	41,903
15	2026	7,533	897	34,388	14,962	100	50,347	42,814
16	2027	7,535	897	34,388	15,876	100	51,261	43,726
17	2028	7,537	897	34,388	16,789	100	52,175	44,637
18	2029	18,122	897	34,388	17,703	100	53,088	34,966
19	2030	15,470	897	34,438	18,617	100	54,052	38,582
20	2031	7,534	897	34,438	19,200	100	54,636	47,101
21	2032	7,534	897	34,438	19,200	100	54,636	47,101
22	2033	7,534	897	34,438	19,200	100	54,636	47,101
23	2034	13,178	897	34,438	19,200	100	54,636	41,457
24	2035	7,534	897	34,438	19,200	100	54,636	47,101
25	2036	7,534	897	34,438	19,200	100	54,636	47,101
26	2037	7,534	897	34,438	19,200	100	54,636	47,101
27	2038	7,534	897	34,438	19,200	100	54,636	47,101
28	2039	7,534	897	34,438	19,200	100	54,636	47,101
29	2040	13,355	897	34,438	19,200	100	54,636	41,281
30	2041	7,534	897	34,438	19,200	100	54,636	47,101
31	2042	7,534	897	34,438	19,200	100	54,636	47,101
32	2043	7,534	897	34,438	19,200	100	54,636	47,101
33	2044	23,761	897	34,438	19,200	100	54,636	30,874
34	2045	15,471	897	34,438	19,200	100	54,636	39,164
35	2046	7,534	897	34,438	19,200	100	54,636	47,101
36	2047	7,534	897	34,438	19,200	100	54,636	47,101
37	2048	7,534	897	34,438	19,200	100	54,636	47,101
38	2049	7,534	897	34,438	19,200	100	54,636	47,101
39	2050	7,534	897	34,438	19,200	100	54,636	47,101
40	2051	7,534	897	34,438	19,200	100	54,636	47,101
Total		536,945	31,009	1,133,902	606,575	3,403	1,774,888	1,237,943

EIRR	**13.50%**
Present value of benefits at 10.00% discount rate ('000 USD)	**268,579**

Source: Study Team

(8) Sensitivity analysis

For the sensitivity analysis, following factors are considered as the hidden risk in the Project.

- Case A : Initial investment costs overrun by 10%
- Case B : Lower benefits by 10%
- Case C : Initial investment costs (+10%) + Benefits (-10%)

Result of the EIRR calculations for the cases above is shown in the Table 4.10-15.

Table 4.10-15 EIRR of sensitivity analysis

Basic case		13.50%
Case A	Initial investment costs (+10%)	12.47%
Case B	Benefits (-10%)	12.14%
Case C	Benefits (-10%) + Initial investment cost (+10%)	11.17%

Source: Study Team

It is commonly understood among the funding agencies that 10% to 12% would be the threshold of EIRR applicable to the infrastructure projects in developing countries. As the EIRR calculated above exceeds that rate level in every case, the Project is deemed to be economically viable.

Further to the above, the Study Team has calculated an auxiliary EIRR for an extreme case where the initial investment costs overrun by 20% and the benefits decrease by 20%. The result of the calculation for this case gives a lower EIRR of 9.00%.

In order to verify the viability of the Project in the extreme case above, the Study Team makes an attempt to calculate a virtual EIRR to cover the greater region of southern Africa, from the perspective that the Project would benefit the greater area including neighboring landlocked countries than Mozambique alone. The details will be described in section 4.10.2.

4.10.2 Impact of the project on the regional economy of southern Africa

When the Project is regarded as a multi-national infrastructure development project, it is expected to generate some benefits beyond national borders. In this sub section, the Study Team evaluates the amount of those benefits from multi-national viewpoint.

(1) Identification of benefits

As simulated in 3.5.2 (2) by use of the OCDI Model, when the Port improves its operational productivity, it will attract more cargoes to/from Malawi and Zambia, as a result of the exporters/ importers' selection of gate ports in terms of cost and time they may spend for their inland logistics.

It was observed that most of those additional cargoes would be shifted from Durban. This is because the burden of inland transportation cost to the exporters/importers is very heavy with Durban and those traders would seek an opportunity to use any closer gate port at lower inland cost.

Operational improvement of the Port would bring a reasonable solution to those traders. That solution will also bring the optimal allocation of resources to the economy of Southern Africa, instead of inefficient mobilization of goods across a long distance.

Such shift from Durban to the Port is more significant with Malawi cargoes, while the same with Zambia is found quite nominal.

Benefit is identified as the difference of net cost of inland transportation by trucks between

Malawi/Durban and Malawi/the Port, multiplied by the difference of cargo volume of Malawi/Durban between the With and Without Case. It should be noted that the time for inland transportation will become longer with the Port and the traders shall bear some additional cost for interest on cargo value, which will reduce the advantageous effect to some extent.

(2) Calculation of benefits

Following inland costs and transit times once used for the demand forecast in 3.5.2 (2) are again applied to the calculations, as summarized in Table 4.10-16. 0.84 of CF is applied as per 4.10.1 (6)- 2)- a).

Table 4.10-16 Inland costs and transit times for Malawi cargoes

		Malawi /Nacala	Malawi /Durban	Difference
Cost (USD/TEU)	Export	1,889	5,296	-3,407
	Import	2,752	5,296	-2,544
Time (day)	Export	6.32	3.10	3
	Import	6.32	3.10	3

Source: Study Team

For the calculation of interest, cargo value is assumed as USD8,065/TEU for exports on FOB basis, and USD8,092/TEU for imports on CIF basis (INE statistics 2009).

The result of calculations is shown in Table 4.10-17 below.

When the discount rate is assumed as 10.00%, present value of benefits amounts to USD 70,843,000, which is 26.3% of the same of Mozambique given in Table 4.10-14.

Table 4.10-17 Calculation of benefit

		TEU balance (With - Without)			Inland Cost Savings ('000 USD)			Interest Savings ('000 USD)			Benefits Total ('000 USD)
		Export	Import	Total	Export	Import	Total	Export	Import	Total	
1	2012	0	0	0	0	0	0	0	0	0	0
2	2013	0	0	0	0	0	0	0	0	0	0
3	2014	0	0	0	0	0	0	0	0	0	0
4	2015	0	0	0	0	0	0	0	0	0	0
5	2016	-1,426	-1,177	-2,603	4,095	2,523	6,618	-20	-16	-36	6,582
6	2017	-1,753	-1,410	-3,163	5,033	3,023	8,055	-24	-20	-44	8,011
7	2018	-2,080	-1,643	-3,722	5,971	3,522	9,493	-29	-23	-52	9,441
8	2019	-2,406	-1,876	-4,282	6,908	4,022	10,930	-34	-26	-60	10,870
9	2020	-2,733	-2,109	-4,842	7,846	4,521	12,367	-38	-29	-68	12,300
10	2021	-2,702	-2,007	-4,709	7,757	4,302	12,059	-38	-28	-66	11,994
11	2022	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
12	2023	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
13	2024	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
14	2025	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
15	2026	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
16	2027	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
17	2028	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
18	2029	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
19	2030	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
20	2031	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
21	2032	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
22	2033	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
23	2034	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
24	2035	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
25	2036	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
26	2037	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
27	2038	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
28	2039	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
29	2040	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
30	2041	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
31	2042	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
32	2043	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
33	2044	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
34	2045	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
35	2046	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
36	2047	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
37	2048	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
38	2049	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
39	2050	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
40	2051	-2,671	-1,904	-4,575	7,668	4,083	11,751	-37	-27	-64	11,687
Total		-93,231	-67,355	-160,586	267,650	144,414	412,064	-1,300	-942	-2,242	409,822

Present Value of benefits at 10.00% discount rate ('000 USD)	70,843

Source: Study Team

(3) Calculation of virtual EIRR for southern Africa

EIRR for southern Africa as a whole is virtually calculated by incorporating the benefits above into the original benefits of Mozambique. The calculation result of the virtual EIRR is given for each case of the aforementioned sensitivity analysis as per the Table 4.10-18 below.

Table 4.10-18 Virtual EIRR of southern Africa

Basic case		17.05%
Case A	Initial investment costs (+10%)	15.79%
Case B	Benefits (-10%)	15.82%
Case C	Benefits (-10%) + Initial investment cost (+10%)	14.62%

Source: Study Team

EIRR for the extreme case where the initial investment costs overrun by 20% and the benefits decrease by 20% is given as 12.42%.

4.11. Financial plan

4.11.1 Debt sustainability of Mozambique

In May 27, 2010, IMF and the World Bank published jointly the result of debt sustainability analysis for Mozambique based on end-2009 debt stocks indicates. The result is summarized as follows:

> Under the baseline scenario, all debt indicators remain well below their respective thresholds, including in the longer term. However, the debt indicators rise significantly towards their respective thresholds over the next five years, as the authorities make use of the already contracted Portuguese credit lines and step up their borrowing on non-concessional terms to address the country's infrastructure gap.
>
> The present value (PV) of the public and publicly guaranteed (PPG) external debt is projected to rise from 17 percent of GDP in 2009 to about 31 percent in 2015, still noticeably below the relevant debt burden threshold of 40 percent. It would then decline below 25 percent by 2030. In terms of exports, the PV of PPG debt increases from 67 percent in 2009 to about 112 percent by 2015—against a threshold of 150 percent—before falling to 68 percent by 2030. Relative to government revenues, with a debt burden threshold of 250 percent, the PV of PPG debt would rise from 94 percent in 2009 to 154 percent in 2015, before declining to 104 percent by 2030.
>
> Debt service on PPG external debt would rise from nearly 2 percent of exports in 2009 to 7½ percent in 2016 before decreasing towards 4 percent by 2030, thus remaining well below the 20 percent threshold. Debt service on PPG external debt would rise from below 3 percent of fiscal revenues in 2009 to over 11 percent in 2016 before falling towards 6 percent by 2030.

Thus, it is assessed that Mozambique continues to face a low risk of debt distress, and that its external debt levels are expected to remain below their indicative thresholds for debt distress. The increase of external debt through the implementation of the Urgent Rehabilitation Project in Nacala Port is expected to remain within the margin to the indicative thresholds. The Project is expected to increase export and GDP minimizing negative impacts on the country's debt sustainability mainly through:

- Promotion of export from Nacala SEZ;
- Promotion of export of agricultural products from the Northern Provinces;
- Promotion of export of forestry products from the Northern Provinces; and
- Promotion of the logistics industry related to the Port and the Corridor.

However, it should be noted that the scale of the Project is not very small considering the scale of the country's GDP, and that if the Port fails to improve operational efficiency and to materialize abovementioned outcomes, the negative impact of the Project on the debt sustainability would not be negligible. Therefore, it is important that the Government be making its utmost effort to intensify the competitiveness of the Port, and continuously monitor the operational efficiency of the concessionaire of the Port.

4.11.2 Financial plan of executing agencies

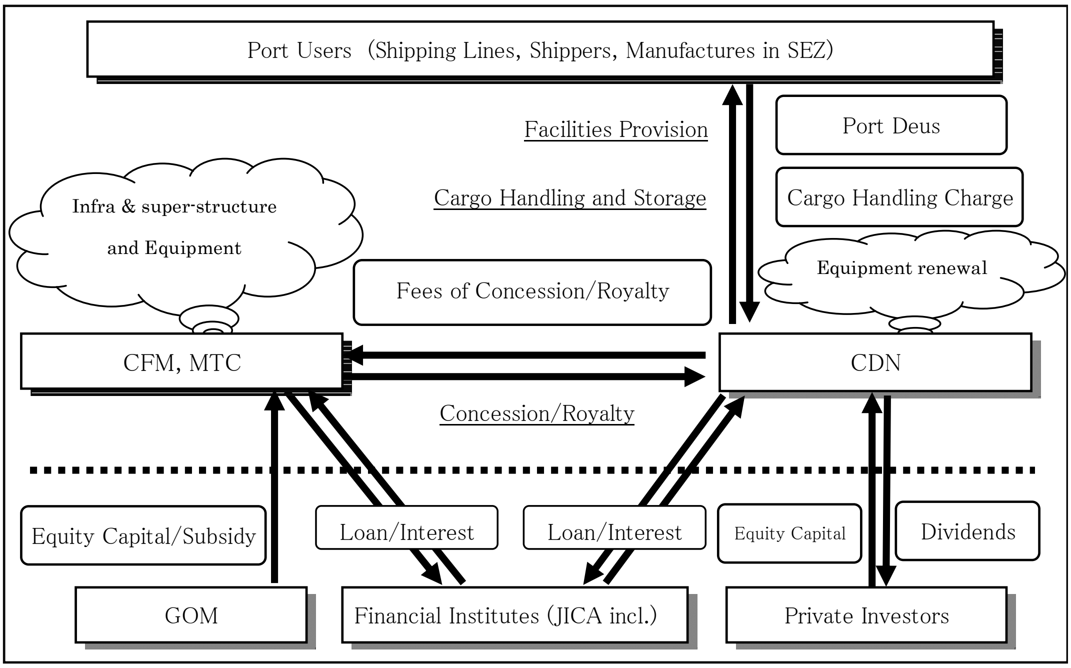
In this sub-section, information and a basic direction for financing is described to precede the Urgent Rehabilitation Project. Detailed verifications of the financial plan and financial capacity, based on a cash flow analysis of the said Project, are stated in the sub-section of "4.14.2 Financial scheme" through the financial analysis.

(1) Project financial structure

As seen in the economic analysis, the proposed Project (the Urgent Rehabilitation Project) is feasible and sound from the viewpoint of the national economy. Therefore, the Project shall be implemented by securing the necessary funding. It is obvious, however, that the Project requires huge amounts of funding to complete, and neither the port authority nor a potential private terminal operator can necessarily provide the entire amount of required funding by each entity acting alone.

In the case of "the Urgent Port Rehabilitation Project", a financially independent single entity has been envisaged, which owns the equity capital, constructs and rehabilitates the port facilities, and operates the marine terminals' functioning as an investor, administrator and port service provider. The entity is an imaginary entity, not a legal entity, and is further divided into the two components as legal entities, viz. the port management body (PMB) and the potential private terminal operator company(s) (TOC) at the Port, for financing plan and financial analysis. The PMB of the Project is, however, defined as a merely financial management body under a concession agreement of the Port because CFM and MTC have no function body of a normal port authority at present. In other words, they are the grantor (PMB) and the lessee(s) (TOC) in terms of lease/concession contract.

Thus, in the first step, the financial structure is made on the above-mentioned imaginary entity that implicitly includes the port management body (PMB: MTC and CFM) and the potential private terminal operator company(s) (TOC: CDN). In the second step, the financial structure is made for the grantor and a potential lessee(s)/concessionaire(s) respectively by assuming contract conditions in terminals within the newly constructed and rehabilitated area of the Port. The structure of the Urgent Rehabilitation Project from the financial viewpoint is shown in the figure below.



Source: Study Team

Figure 4.11-1 Structure of Urgent Rehabilitation Project from financial viewpoint

(2) Potential lenders

The potential financial resources required for PMB to invest in the said Project are supposed as those from the GOM, bi-lateral financial institutes including JICA, and multi-lateral financial institutes including AfDB. For TOC, the potential financing institutions for the Project will be commercial banks.

1) Yen Loan

Information on Yen-Loan can be obtained through the website of JICA. Terms and conditions of Yen Loan vary according to income category. Economies with GNI per capita of under US$ 995 are classified as low income countries, and GNI per capita of Mozambique is US$ 440 in 2009, according to the World Development Indicators of the World Bank. Therefore, Mozambique is categorized into low income country group, according to the DAC and the World Bank Classification system. In addition, Mozambique is categorized into the Least Developed Countries (LDC) category by the United Nations.

Table 4.11-1 Major economies classified by income category

Category	Countries
LDC (Least Developed Countries)	Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Cape Verde, Central African Republic, Chad, Comoros, Congo (D.R. ex Zaire), Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea Bissau, Haiti, Kiribati, Lao People's Democratic Republic, Lesotho, Liberia, Madagascar, Malawi, Maldives, Mali, Mauritania, **Mozambique**, Myanmar, Nepal, Niger, Rwanda, Samoa, Sao Tome & Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, Sudan, Tanzania, Timor-Leste *, Togo, Tuvalu, Uganda, Vanuatu, Yemen, Zambia.

Source: World Bank

Terms and conditions of Yen Loans, as of November 2010, are shown in the table below. Effective from 1 April 2010, for Interest-free Approximation cases, the interest rate is 0.01%, and the repayment period and grace period are 40 years and 10 years, respectively. Interest during construction is included in the Yen Loan. The terms and conditions of the Yen Loan are also applicable to the consultancy fee of the detailed design of the project.

Table 4.11-2 Terms and conditions of Yen Loans

Category	GNI per Capita (2008)		Standard/ Option	Interest Rate (%)	Repayment Period (Yr)	Grace Period (Yr)	Conditions for Procurement
LDC	Under US$975	Interest-free Approximaton		0.01	40	10	Untied
	Others	General Terms	Standard	0.70	30	10	Untied
			Option 1	0.65	25	7	
			Option 2	0.60	20	6	
			Option 3	0.55	15	5	
		Preferential Terms	Standard	0.55	40	10	Untied
			Option 1	0.45	30	10	
			Option 2	0.40	20	6	
			Option 3	0.30	15	5	

Source: JICA

In general, the non-eligible portion of the Yen Loan is borne by the Mozambique side. The non-eligible portion is i) land acquisition fee, ii) administration cost and iii) tax/duty. Furthermore, the maintenance and operation cost is also the financial burden of the Mozambique side.

2) AfDB Loan

Information on AfDB-Loan, lending rate, general conditions and so on, can be obtained through the website of AfDB. The currency of AfDB Loan is USD, EUR, Yen and ZAR. Lending rates for a sovereign guaranteed loan as of 1st August 2010 are summarized in the table below.

Table 4.11-3 Lending rate for sovereign guarantee loan of AfDB

INDICATIVE RATE	USD	EUR	YEN	ZAR
Fixed Base Rate as of 25-Jun.-10	3.460%	3.127%	1.520%	8.157%

Variable Spread Loans (VSL) and Enhanced Variable Spread Loans (EVSL)	Loans approved before 4-May-2005 & loans approved after 21-Jan.-2009				
	(1-Aug.-2010 to 31-Jan.-2011)			(1-Aug.-10 to 31-Jan.-11)	(1-Nov.-10 to 31-Jan.-11)
	USD	EUR	YEN	ZAR	
Floating Base Rate (a)	0.678%	1.145%	0.441%	6.705% ***	6.585% **
Funding Margin [benefit (-)/cost (+)] (b)	0.060%	0.000%	0.000%	-0.240%	-0.240%
* Lending Spread (c)	0.400%	0.400%	0.400%	0.400%	0.400%
Applicable Lending Rate (a+b+c)	1.138%	1.545%	0.841%	6.865%	6.745%

(*) The applicable Lending Spread is 50bps for VSL approved before 4-May-05 and 40bps for VSL & EVSL approved after 21-Jan.-09

(**) 3m Jibar rate; (***) 6m Jibar rate

Fixed Spread Loans (FSL)	Loans approved between 4-May-2005 and 21-Jan.-2009			
	(1-Aug.-2010 to 31-Jan.-2011)			
	USD	EUR	YEN	ZAR
Floating Base Rate (a)	0.678%	1.145%	0.441%	6.705% ***
**** Lending Spread (b)	0.400%	0.400%	0.400%	0.400%
Applicable Lending Rate (a+b)	1.078%	1.545%	0.841%	7.105%

(****) The applicable Lending Spread is 40bps for FSL approved between 4-May-05 and 2-Jun.-08 and 20bps for FSL approved between 2-Jun.-08 and 21-Jan.-09

(***) 6m Jibar rate

Variable Rate Loans (VLR)	For all Variable Lending Rate Loans (VLR)				
	(1-Jul.-2010 to 31-Dec.-2010)				
	USD	EUR	YEN	CHF	UAC
Variable Base Rate (a)	7.090%	6.520%	4.470%	3.770%	6.450%
***** Lending Spread (b)	0.500%	0.500%	0.500%	0.500%	0.500%
Applicable Lending Rate (a+b)	7.590%	7.020%	4.970%	4.270%	6.950%

(*****) The applicable Lending Spread for VRL approved before 4-May-05 = 50bps

Source: AfDB

In case of an application for a variable interest rate, the interest rate is a total of Floating Base Rate, Funding Margin and Lending Spread. The repayment period and grace period are 20 years and 5 years, respectively.

A borrower (Mozambique side) generally has a burden of 10% of the project cost, excluding tax such as VAT, but that percentage is negotiable; according to an infrastructure specialist of AfDB in Mozambique.

3) Commercial bank loan

The potential lender for TOC is assumed as commercial banks and investors. According to the financial department of CDN, the average interest rate of commercial banks is 10% for long-term loans (US$) and the average repayment period is 10 years for capital investments, such as the purchasing of equipment.

4.12. Financial analysis

4.12.1 FIRR of the Project

(1) Financial evaluation

Financial feasibility of the Project is to be analyzed through an estimated FIRR (Financial Internal Rate of Return) to assess the financial soundness of the Project by indicating the discount rate, which leads discounted cost and revenue to be equivalent through the project's life.

$$\sum(B_i-C_i)/(1+r)^{i-1}=0$$

Where, B_i: revenue of i-th year,
C_i: cost of i-th year,
r: discount rate

In this calculation, revenue from financing activity is excluded from total revenue, and depreciation cost and repayment of loan are excluded from cost.

A weighted average interest of various loans used for the Project is used as the criteria.

(2) Premise for financial analysis of the Project

A financially independent single entity has been envisaged, which owns the equity capital, rehabilitates existing port facilities, constructs new structures, and operates the marine terminals; functioning as an investor, administrator and port service provider. The entity is an imaginary entity, not a legal entity.

1) Project life

Considering the service life of the port facilities, the Project life in the financial analysis is assumed to be 40 years from the year 2012 in which engineering services for the Urgent Rehabilitation Project will commence. We call this year (2012) the 'Base Year'. Neither inflation nor an increase in nominal wages is considered during the operation period of the Project's life.

All costs and revenues are indicated as of 2010, when the price survey was conducted (US$ 1.00= MT 33.19).

2) Covered project and cost

The scope of the financial analysis covers the Urgent Rehabilitation Project, which handles both container and dry bulk cargo of the Port. The Project's major components, their implementation schedule and the capital cost are summarized as follows:

Table 4.12-1 Development schedule and capital cost

	Executed by	Work period (yr)	Operation (yr)	Cost (000 US$ / %)	
Facilities: Part 1	PMB	2014~2015	2015~	57,562	80%
Equipment: Part 1	PMB	2014~2014	2015~	12,117	
Facilities: Part 2	PMB	2014~2016	2016~	150,637	
Equipment: Part 2	PMB	2014~2015	2016~	10,274	
Engineering Fee	PMB	2012~2016	---	16,395	
Physical Contingency	PMB	---	---	12,350	
Initial Investment (Project Cost)				259,335	
Renewal Equipment	TOC	At the time after depreciation		63,888	20%
(VAT of initial investment)	*GOM*	---		*44,087*	---

Source: Study Team

From the start of operations and through the Project life, equipment that will be procured in the initial stage will be renewed when their use life expires. The shorter ones (8-10 years) are tractors and reach stackers. Longer lives (15-25 years) are assumed to be chassis, RTGs and mobile cranes.

The Study Team estimates operating costs based on information from CFM and CDN. The table below shows annual personnel costs and numbers of staff, by position.

Table 4.12-2 Manning schedule of PMB

PMB	'000 USD/yr	# of staff: Cnt, Blk		'000 USD/yr
General Manager	100.000	1	0	100.000
Deputy General Manager	80.000	1	1	160.000
Secretary	15.000	1	1	30.000
Manager	50.000	2	2	200.000
Assist. Manager	30.000	2	2	120.000
Staff	20.000	6	4	200.000
TOTAL		13	10	**810.000**

Source: Study Team

Table 4.12-3 Manning schedule of TOC

TOC	'000 USD/yr	# of staff: Cnt, Blk		'000 USD/yr
CEO (office manager)	120.000	1	0	120.000
CFO (treasurer)	96.000	1	0	96.000
Corporate Secretary	15.000	1	0	15.000
Operation Stuff				
Manager	60.000	1	1	120.000
Assist. Manager	36.000	4	3	252.000
EDP Stuff				
Manager	60.000	1	1	120.000
Staff	25.000	3	2	125.000
Maintenance & Repair				
Manager	60.000	1	1	120.000
Assist. Manager	36.000	4	2	216.000
Accounting				
Manager	60.000	1	0	60.000
Staff	25.000	3	2	125.000
General Affair & Personnel				
Manager	60.000	1	0	60.000
Staff	25.000	3	2	125.000
TOTAL		25	14	**1,554.000**
Labor	'000 USD/yr	# of staff: Cnt, Blk		'000 USD/yr
Ship,Yard Operation				
Boss	24.000	6	5	264.000
G.C.Operator	12.000	8	10	216.000
RTG & Heavy	12.000	20	5	300.000
Lift Equip. Operator	10.000	10	0	100.000
Tractor Driver	8.000	26	25	408.000
Longshore Worker	7.000	24	60	588.000
Marine Clerk	6.000	16	10	156.000
M&R				
Boss	12.000	2	1	36.000
Mechanic	8.000	6	10	128.000
Electrician	8.000	4	2	48.000
Storage Operation				
Boss	12.000	1	1	24.000
Driver & Worker	7.000	5	3	56.000
Clerk	6.000	2	1	18.000
TOTAL		130	133	**2,342.000**

Source: Study Team

Other operating costs of the Port are shown in Table 4.12-4.

Table 4.12-4 Other operating cost

	PMB	TOC
Administration and Other Cost	-	100% of Personnel cost
Maintenance Cost	Infrastructure: 1% of the total project cost Equipment: 2% of the equipment cost Electric, fuel & utilities: 2% of the equipment cost	
Depreciation	Civil structure (Port facilities): 40 years, Equipment: 8 - 25 years	

Source: Study Team

3) Revenues

The port tariff applying to the financial model is summarized in Table 4.12-5 which is based on the current tariff table of the Port. Container handling charges summarized below are set at 80% of the current charge, taking competition from nearby ports in the future into consideration. The average cost per TEU at the Port, which consists of below “Harbor Due” and “Container Handling Charge”, is US$ 243.

Table 4.12-5 Port tariff (Summary)

Unit: US$

Harbor Due			
Entrance Fee	600.00/ each	Pilotage Dues per GT	0.02/ GT
Quay Due	0.04/day* GT	Harbor Towage ditto per service per GT	0.05/ GT
Mooring/Unmooring	75.00/ service		
Container Handling Charge			
Stevedoring Container (Loading / Unloading)		Handling Container (Loading / Unloading)	
Containers NE	52.00/ TEU	Container NE (FCL)	164.00/ TEU
Reefers Container	60.00/ TEU	Reefer Container	220.00/ TEU
Empty Container	48.00/ TEU	Direct Transshipment	96.00/ TEU
Hatch opening and closing	60.00/ each		
Container Storage			
Laden & Empty (first 7days)	6.00/ TEU	With Refrigerated Cargo	45.00/ TEU
Dry Bulk Cargo Handling Charge			
Stevedoring Cargo (Loading / Unloading)		Handling Cargo	
Wood chip	10.00/ ton	Wood Chip (Loading)	3.50/ ton
Clinker & Wheat	4.00/ ton	Clinker & Wheat (Unloading)	3.15/ ton
Vehicle	4.00/ ton	Vehicle	6.00/ ton
Others (Fertilizer, bag)	4.00, 8.00/ ton	Others (Fertilizer, bag)	3.15, 5.00/ ton
Cargo Storage			
Loading (1st week)	0.30/ ton or m^3*week	Unloading (1st week)	0.40/ ton or m^3*days

Source: Operation Department of CDN

Regarding container handling at the terminal, the capacity of the container terminal after the Project is estimated at around 249,000 TEUs. Volume demand at the Port will reach its capacity in 2022. The capacity of the current container terminal is estimated to be about 105,400 TEUs, which is applied as a capacity of “Without-the-project” case.

The container handling volume, taking the difference between “With-the-project” case and

"Without-the-project" case into account, is calculated below and summarized in the tables:

* 2015-2021: (Forecast Volume) minus ("Without-the-project" case)
* 2022-2051: (Capacity of the Port) minus ("Without-the-project" case)

Table 4.12-6 Calculated container volume including empty container

<table>
<tr><th rowspan="2">Year</th><th rowspan="2">TEU</th><th colspan="3">Box</th><th colspan="2">Reefer Box</th></tr>
<tr><th>20ft</th><th>40ft</th><th>Over 40ft</th><th>20ft</th><th>40ft</th></tr>
<tr><td>2015
|
2021</td><td>23,207
|
133,190</td><td>14,606
|
64,578</td><td>3,914
|
31,604</td><td>209
|
1,690</td><td>231
|
1,023</td><td>62
|
501</td></tr>
<tr><td>2022
|
2051</td><td>143,457</td><td>66,456
|
5,122</td><td>35,512
|
64,646</td><td>1,899
|
3,456</td><td>1,053
|
81</td><td>563
|
1,024</td></tr>
</table>

Note: TEU/ Box rate increasing 0.02 per year, as of year 2015 set its 1.22
Source: Study Team

The Study Team estimated future average vessels and calls as follows.

Table 4.12-7 Call ships of container

Year	Container Ship size (GRT)	Container Call ship/year
2015-2021	1305TEU (16,000)	52-317
2022-2051		340

Source: Study Team

Calculated volume of dry bulk cargo handled at the container and general cargo terminal is summarized in the below table. The calculation method is the same as mentioned in the container case. Capacity for the handling of dry bulk cargo under the Project is estimated by each cargo type.

Table 4.12-8 Calculated terminal capacity and dry bulk volume

Cargo Type	Capacity ('000 ton)		Year 2015-2051
	With case	WO case	Unit: '000 ton
Wood Chip	2,131.0	---	56.0 - 117.4
Clinker		286.5	70.0 - 213.5 - 0.0
Wheat		332.4	100.0 – 900.2
Vehicle		---	78.0 - 147.5
Others		216.8	220.0 - 416.0

Source: Study Team

Study team also estimated future average vessels and calls as follows.

Table 4.12-9 Call ships of dry bulk cargo

Cargo Type	DB Ship size (DWT)	DB Call ship/year
Wood Chip	20,000 (-2029), 45,000 (2030-)	2 – 6, 3
Clinker	20,733	3 – 10 – 0
Wheat	13,950	8 – 65
Vehicle	2,200 (-2029), 2,640 (2030-)	36 – 67 56
Others	6,781	14 – 61

Source: Study Team

4) Conditions of fund raising

The Study Team assumes the Project will be funded by a loan syndication of bilateral financial agencies such as the Yen Loan of JICA and a multilateral financial agency such as AfDB Loan.

Main conditions of the each loan are summarized as follows:

- Bilateral (JICA Loan: Yen)

Amount : 20% of the Project cost
Loan period : 40 years, including a grace period of 10 years
Interest rate : 0.01%

- Multilateral (AfDB Loan: USD)

Amount : 70% of the Project cost
Loan period : 25 years, including a grace period of 5 years
Interest rate : 1.5%*
(*assumed: floating base rate 1.00%, lending spread 0.45% and funding margin 0.05%)

Taking the mentioned above conditions into account, conditions of the joint financing loan are assumed as below:

Amount : 90% of the Project cost
Loan period : 30 years, including a grace period of 5 years
Interest rate : 1.1% (≒ 0.01% × 0.20 + 1.5% × 0.70)
Repayment : Fixed amount repayment of principal

In accordance with a general term of this joint financing loan, GOM is required to bear 10 % of the project cost and taxes such as VAT. The Study Team makes the following assumptions:

- Government subsidy and a national bank

Amount 1 : taxes such as a VAT
Interest rate 1 : 0.00% (government subsidy)

Amount 2 : 10% of the Project cost
Loan period : 30 years, including a grace period of 5 years
Interest rate 2 : 1.1% (national bank)
Repayment : Fixed amount repayment of principal

Regarding renewal equipment, it is assumed that TOC borrows funds from commercial banks to procure renewal equipment at the time of its expiry. Conditions of the loan based information of CDN are shown below:

- Domestic fund (Bank loan: USD)

Amount : 100% of renewal investment cost
Loan period : 10 years
Interest rate : 10.0%
Income tax : 32%
Repayment : Fixed amount repayment of principal

As mentioned in Table 4.12-1, a portion of the Project cost is 0.80 and that of the renewal investment cost is 0.20, respectively. Therefore, a weighted average cost of capital on the Project, which also includes an investment cost of renewal equipment, is calculated as follows:

- Weighted average cost of capital on the Project

2.3% ≒ 1.1% × 0.80 + 10.0% × 0.20 × (1-0.32)

(3) Results in base case and sensitivity analysis

The result of FIRR, based on the premises mentioned above, is 12.8% and Net Present Value is 667 million USD; under weighted average cost of capital on the Project: 2.3%.

In order to see if the Project is still financially viable if some factors vary, the following cases are examined as sensitivity analyses:

- Case A: The initial investment cost increases by 10%
- Case B: The demand decreases by 10%
- Case C: The initial investment cost increases by 10% and the demand decreases by 10% (Worst case scenario)

Resulting FIRRs in Cases A, Case B and Case C in the above sensitivity analyses are shown in the table below.

Table 4.12-10 FIRR of sensitivity analysis

Threshold level	Case A	Case B	Case C
2.3 %	11.7%	11.9%	10.8%

Source: Study Team

The resulting FIRR is 12.8% above the weighted average capital cost of the Project. In addition, even in the sensitivity analyses, all of the cases substantially exceed the weighted average cost of capital. Thus, the Project under an envisaged financially independent single entity is judged financially viable.

4.12.2 Financial soundness of the executing agency

The envisaged entity mentioned in sub-section 4.12.1 is further divided into the two bodies as legal entities, viz. the PMB (MTC and CFM) and a potential TOC(s) (CDN) at the Port. In other words, they are the grantor (PMB) and a lessee(s) (TOC) in terms of lease/concession contract.

(1) Financial model

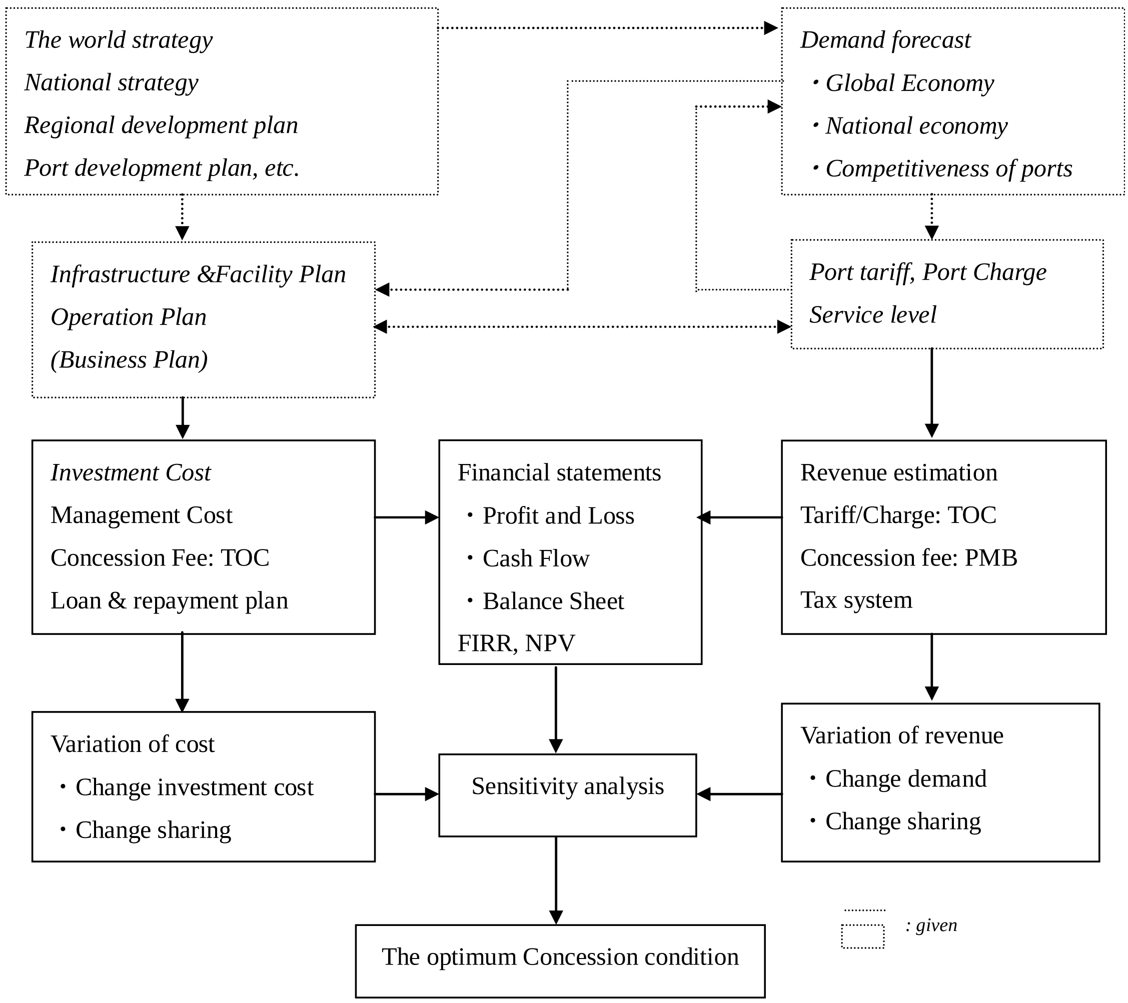
We use the Excel program to show the financial model, which is called “Ides-financial model for port concession”, and is composed of the financial model for DBT (Dry Bulk Terminal), the CNT (Container Terminal) and Consolidated Financial Statements of both terminals.

The model consists of the following;

- **Risk Analysis:** inputting concession conditions to get the corresponding financial indicators for various cases, each of which is linked with a sensitivity analysis sheet.
- **Sensitivit**y: comprehensive table for sensitivity analysis showing major input data and outputs for each case.
- **TOC:** estimated financial statements (income statement, cash flow statement and balance sheet of concessionaire (TOC) for each year of concession period.
- **PMB:** estimated financial statements of conceding authority (PMB)
- **all:** consolidated financial statements of PMB and TOC
- **Reinvestment & Repayment:** itemized reinvestment & repayment schedule both of TOC and PMB
- **Depreciation:** calculation of itemized depreciation cost during concession period
- **Operating Cost:** calculation of operating cost both for TOC and PMB during concession period
- **Port Demand:** estimation of port demand (cargo & vessel) during the concession period for each item corresponding to port tariff and port charge
- **Port Charge:** calculation of fee during concession period corresponding to each item of charge
- **Port Tariff:** calculation of fee during concession period corresponding to each item of port due
- **Local Loan Repayment:** repayment schedule of loans other than syndication loan

- **Initial Loan Repayment:** repayment schedule of syndication loans (principal and interest) corresponding to respective loan condition
- **Cost Allocation:** construction and procurement cost, and disbursement schedule corresponding to work schedule

These 14 sheets are linked together to get the estimated financial statements and sensitivity sheet based on the calculation steps shown in below figure.



Source: Study Team

Figure 4.12-1 Procedure of financial analysis

The model is for port concession and is applied to estimate the financial conditions of Concessionaire (TOC) and Conceding Authority (PMB) during the Project life under the concession scheme.

PMB implements all the initial investment of the Project and receives concession fees from TOC for repayment of the loan. Revenue of PMB in the Project is only concession fees.

TOC operates container and bulk terminals after the Project is completed and earns revenues from pilotage, towage and berthing etc., for vessels, and stevedoring to/from vessel, handling and cargo storage at yard. Regarding equipment which will expire, TOC procures replacement equipment to avoid a decrease in profitability.

Financial statements are based on English Accounting (GAAP: Generally Accepted Accounting Principle) and calculated automatically by inputting investment costs, throughput of terminal by cargo items, terminal charges, vessels (type, size, number), itemized operating expenses and maintenance expenses etc.

(2) Additional premise used in the financial model

1) Concession fee

As for revenue of PMB and expenditure of TOC, the Study Team gave due consideration to the following matters regarding concession fixed and variable fee;

- TOC who operates the container and bulk terminal pays a fixed fee to PMB as a lease fee of facilities and equipment of the Project. The fee is assumed to be US$ 8.6 million per annum through the Project life (year one is a grace period).
- TOC also pays variable fee to PMB every year. The amount will be subject to share of TOC's revenue as follows;
  - 15% of gross annual returns during years one to five,
  - 20% of gross annual returns during years six to ten,
  - 25% of gross annual returns from year eleven to end of concession period.

Total of concession fixed fee during concession period covers loan repayment amounts for the initial investment and the interest. The main reason for the high percentage of the concession variable fee is that the initial investment is assumed to be executed by PMB without any private partnership, so the variable fee is a counter value for PMB who takes the risk of initial investment.

PMB refunds the debt loan based on the concession fixed and variable fees to the loan syndication through GOM semi-annually. Current concession fees are not included in the amount of the said fee, because the cash flow of the Project is targeted and estimated by the difference between "With-the-project" case and "Without-the-project" case. Therefore, the concession fixed fee will be paid to PMB in 2016, when the Project is completed and operations start with all the new facilities and equipment. The concession variable fee is paid to PMB from 2015 at the same percentage (15%) of the current concession agreement in that period.

2) Debt for capital cost of PMB

Fund raising of PMB is assumed as a syndicate (joint financing) loan which consists of JICA and AfDB. For funding the ineligible portion of 10% of the Project cost, it is assumed that the national bank of Mozambique lends the amount to PMB as mentioned in the above previous sub-section. Main conditions of the loans are summarized as follows.

- Joint financing loan

Amount	: 90% of the Project cost
Loan period	: 30 years, including a grace period of 5 years
Interest rate	: 1.1% (≒ 0.01% × 0.20 + 1.5% × 0.70)
Repayment	: Fixed amount repayment of principal

- National bank loan

Amount	: 10% of the Project cost
Loan period	: 30 years, including a grace period of 5 years
Interest rate	: 1.1% (national bank)
Repayment	: Fixed amount repayment of principal

3) Debt for capital cost of TOC

For TOC's fund raising, renewal equipment investment is assumed to be raised by domestic fund. Condition of loan is assumed as follows.

- Domestic fund

Amount	: 100% of renewal equipment investment
Loan period	: 10 years
Interest rate	: 10.0%

Income tax *: 32%*
Repayment : Fixed amount repayment of principal

(3) Financial soundness of each entity

1) FIRR and NPV

As a base case, FIRR and NPV, for financial analysis, are evaluated under our forecast demand, and the results are shown in below table.

Concession fee is set at US$ 8.6 million/year (fixed fee) and variable fee is 15~25% of TOC's revenue, taking both financial conditions into account.

The resulting FIRR of PMB on Base case and sensitivity analysis exceeds the interest rate of the loan as threshold level. In addition, NPV of PMB and TOC also shows positive results.

Table 4.12-11 FIRR and NPV of the Project

	Threshold level	Base case	Case A	Case B	Case C
FIRR: PMB	*1.1 %*	6.1%	5.8%	6.0%	5.6%
NPV: PMB	---	316 M US$	315 M US$	310 M US$	309 M US$
NPV: TOC	---	193 M US$	180 M US$	170 M US$	158 M US$

Note: FIRR of TOC, unavailable for a little cash-out on the initial stage of investment
Source: the Study Team

2) Financial efficiency

Financial efficiency is to be analyzed through evaluation of the following financial indicators besides FIRR and NPV during the concession period;

- Return on Net Fixed Asset
  - Net operating income/net fixed asset (%)

This indicator is to evaluate the profitability of the Project, and it is necessary to maintain the value over the weighted average interest of loans used for the Project.

Return on Net Fixed Asset of PMB is high because the concession fixed fee is set to cover the Project cost including loan interest. The variable fee is set at 20%-25% as a counter value for PMB.

TOC also receives good value even though TOC has to pay large concession fees to PMB.

- Operating Ratio & Working Ratio
  - Operating cost/operating revenue (%) (O.R)
  - (Operating cost – depreciation cost)/operating revenue (%) (W.R)

These indicators are to evaluate the effectiveness of the business operation and in case of port business, under 70~75% for O.R and under 50~60% for W.R, are said to be necessary for effective organization.

O.R and W.R of PMB are under 70~75% and 50~60%, respectively over the operation period. On the other hand, figures for TOC are over the threshold percentage from the first to fourth year but come below the percentage after the fifth year.

- Debt Service Coverage Ratio (DSCR)
  - (Operating revenue +depreciation cost)/total repayment amount for long term loan

This indicator is to evaluate whether operating revenue can cover the necessary repayment amount for a long term loan and is necessary to be over 1.0 and desirably over 1.75.

DSCR of PMB is almost higher than 1.0 through the Project life except for the second and third years from the start of repayment. PMB has to monitor the TOC operation and cash flow from a viewpoint of the financial aspect as the conceding authority to collect concession fees for loan repayment. A method for control of cash flow is described in the following sub-section "4.14.2 Financial scheme of the operation in Nacala Port".

That of TOC is also over 1.75 because TOC does not have a large debt for investment in the Project life.

3) Financial soundness

As to the cash flow, PMB has cash shortages of about US$ 0.2~0.5 million/year up to 2014 indicated in the below table, the shortages from 2012 to 2014 are caused by running costs for the Project preparation and implementation. It is assessed that PMB has a capacity to bear the expense based on revenues shown in Table 2.5-22 of sub-section 2.5 (5).

Table 4.12-12 Statement of cash flow of PMB from 2012 to 2020

Statement of Cash Flows ($'000s) of PMB	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cash Beginning	0	(157)	(314)	(770)	808	5,546	4,206	3,813	4,322
Cash Inflow	2,759	3,160	139,396	97,328	34,134	12,066	12,896	13,682	17,163
CASH FLOWS FROM OPERATING ACTIVITIES	(157)	(157)	(456)	1,578	11,485	12,066	12,896	13,682	17,163
Operating Income	(157)	(157)	(1,726)	(6,541)	3,366	3,947	4,777	5,563	9,044
[Total No cash Items included in Net Income (Depreciation)]	0	0	1,270	8,119	8,119	8,119	8,119	8,119	8,119
CASH FLOWS FROM FINANCING ACTIVITIES	2,916	3,317	139,852	95,750	22,649	0	0	0	0
Cash Outflow	2,916	3,317	139,852	95,750	29,396	13,406	13,289	13,173	13,056
CASH FLOWS FROM INVESTING ACTIVITIES	2,916	3,317	139,852	95,750	22,649	0	0	0	0
CASH FLOWS FROM FINANCING ACTIVITIES	0	0	0	0	6,746	13,406	13,289	13,173	13,056
Cash Inflow - Cash Outflow	**(157)**	**(157)**	**(456)**	**1,578**	4,738	(1,340)	(394)	509	4,107
Cash Ending	(157)	(314)	(770)	808	5,546	4,206	3,813	4,322	8,429

Source: Study Team

On the other hand, TOC will have profits from the first year of operation of the Project with new facilities and equipment because of the first year's grace period.

4) Conclusions

Both PMB and TOC are judged financially viable under the said conditions of concession fixed and variable fee.

4.12.3 Financial impact of the project on railway operation

CDN-port has earned profits every year since operation started but CDN-rail which operates, manages and maintains railways of the Corridor has been in large debt. In September 2010, Insitec Group sold their interests in CDN to Vale Mozambique. Vale Mozambique has a plan to rehabilitate the railway and to construct a new port terminal for coal mining. The plan will decrease the financial burden of the railway sector for CDN, so it is expected to enable them to focus on railway operations for container and bulk cargo.

This sub-section, therefore, states a break-even analysis of railway operation.

(1) Cost for break-even analysis

1) Cost of locomotives and wagons

'Financial statements for the six months ended 30 June 2009' of CDN states operating lease expenses amounting to MT 10,693,862, which is about US$ 323,000, for three locomotives. There is also a purchasing option after the lease period of five years for US$ 3 million. That being the residual value of the three locomotives and a lease charge of US$ 800 per day per locomotive is stipulated. Hence, the Study Team estimates a unit price of locomotive as follows:

US$ 2.56 million = US$ (0.323 + 0.0008*365days*5years*3units + 3) million / 3 units

And a unit price of wagon is assumed US$ 0.3 million.

It is assumed that one locomotive has 40 wagons. Sub-total cost of a locomotive and wagons is US$ 14.56 million. The capacity of cargo railway per fleet is estimated as 1,600 tons of bulk cargo and 80 TEU of containers. Maintenance days are set as 15 days per year; which means there are 350 working days. Hence, capacity per year can be calculated as follows on the assumption that it takes two days for a one way trip between the Port and Malawi:

280,000 ton = 1,600ton*350days/2days, for bulk cargo and
14,000 TEU = 80TEU*350days/2days, for container.

Demand forecast in 2020 is 757,000 tons of bulk cargo and 48,000 TEU of containers. Therefore, 3 sets for bulk cargo and 4 sets for containers, a total of 7 sets, are needed. Now there are 2 locomotives and the fleet wagons, so required set number of locomotives and wagons is five. Total cost for 5 sets of locomotives and wagon is calculated as below:

US$ 72.80 million = US$ 14.56 million * 5 sets
Depreciation period of 10 years is applied; at 5 sets per year it is US$ 7.28 million.

2) Personnel and Fuel cost

Personnel cost of railway is assumed as US$ 3.9 million per annum, which is the equivalent amount of the Port.

Fuel cost of railway in 2008 is calculated as approximately MT 99.5 million based on a financial statement of CDN in 2008 and an annual report of CDN-port in 2008.

MT 99.5 million = MT 116.9 million (CDN total) – MT 17.4 million (CDN-port)

Cargo volume transported by rail in 2008 was about 245,000 tons, which is assumed as 145,100 tons of dry bulk and 99,900 tons of containers, respectively. Therefore, the Study Team sets the unit price of fuel consumption to US$ 12 per ton, US$ 161 per TEU of full container and US$ 80 per TEU of empty container.

3) Concession fee

- Concession fixed fee:
  - US$ 2.5 million from 2010 to 2014, and
  - US$ 3.0 million from 2015 to 2019.
- Concession variable fee:
  - 7.5% of gross annual returns from 2010 to 2014, and
  - 10% of gross annual returns from 2015 to 2019.

In this break-even analysis, US$ 3.0 million as concession fixed fee and 10% of returns as the variable fee are used.

4) Other cost

Maintenance cost of locomotive and wagon is assumed at 10% of the total lease fee of locomotive and wagon. And other incidentals such as communication costs are assumed to be 50% of personnel cost.

(2) Revenue for break-even analysis

Revenue from the railway tariff is calculated in the table below.

Table 4.12-13 Railway tariff

Commodity	to border	from border
	Per Ton (Bulk cargo) and TEU (container) US $	
Bulk cargo	52.53	23.96
Full Containers (Over 12,5 tons) Empty Containers	779.00 319.00	440.62 161.00

Source: CDN

Cargo volume used in this analysis is transit cargo to/from Malawi in 2020 and 2030 described in the sub-section of "3.4.1 Demand Forecast".

(3) Result and evaluation

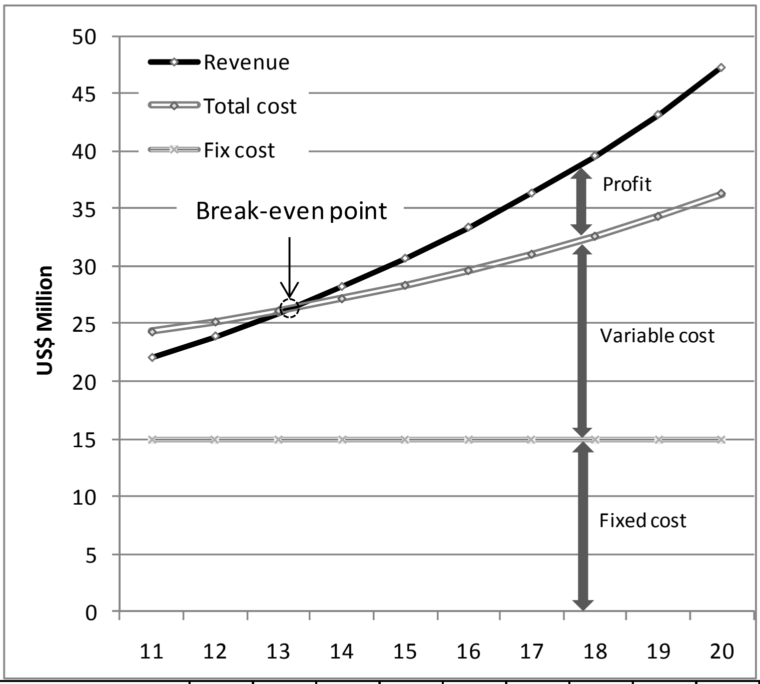
Unit revenues and costs are calculated based on the abovementioned data and information. Based on the analysis, the following unit rates are determined as components of the business structure of railway operation, and will be applied to the calculation of revenue and cost for future activities.

Table 4.12-14 Unit revenue and cost of railway operation

Bulk cargo:	Revenue (to border)	52.5	US$/Ton
	Revenue (from border)	24.0	US$/Ton
	Variable Cost (concession variable fee, to border)	5.3	US$/Ton
	Variable Cost (concession variable fee, from border)	2.4	US$/Ton
	Variable Cost (fuel)	12.0	US$/Ton
Container cargo:	Revenue (full container, to border)	779.0	US$/TEU
	Revenue (full container, from border)	440.6	US$/TEU
	Revenue (empty container, to border)	319.0	US$/TEU
	Revenue (empty container, from border)	161.0	US$/TEU
	Variable Cost (concession variable fee, full container, to border)	77.9	US$/Ton
	Variable Cost (concession variable fee, full container, from border)	44.1	US$/Ton
	Variable Cost (concession variable fee, empty container, to border)	31.9	US$/Ton
	Variable Cost (concession variable fee, empty container, from border)	16.1	US$/Ton
	Variable Cost (fuel, full container)	161.0	US$/TEU
	Variable Cost (fuel, empty container)	80.0	US$/TEU
Fixed Cost	(including locomotive/wagon, personnel, concession fixed, maintenance and incidentals)	14.9	US$ million

Source: Study Team

Using the numbers in the unit revenue and cost, break-even analysis is shown in the below figure. As shown in the figure, revenue of the break-even point is about US$ 26 million in 2013 under forecasted cargo volume.



Cargo type by direction | year		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Bulk ('000 ton),	to border	30	33	37	41	46	51	56	62	69	77
Bulk ('000 ton),	from border	235	265	298	335	377	424	477	537	604	680
Full Cnt ('000 TEU),	to border	11	11	12	13	13	14	15	16	17	18
Full Cnt ('000 TEU),	from border	14	15	16	18	19	21	22	24	26	28
Empty Cnt ('000 TEU),	to border	1	1	1	1	1	1	1	1	1	1
Empty Cnt ('000 TEU),	from border	0	0	0	0	0	0	0	0	0	1
Revenue (US$ million)		22.0	23.9	25.9	28.2	30.6	33.3	36.3	39.5	43.1	47.2

Source: Study Team

Figure 4.12-2 Break-even analysis of railway operation

4.13. Evaluation of environmental and social impacts

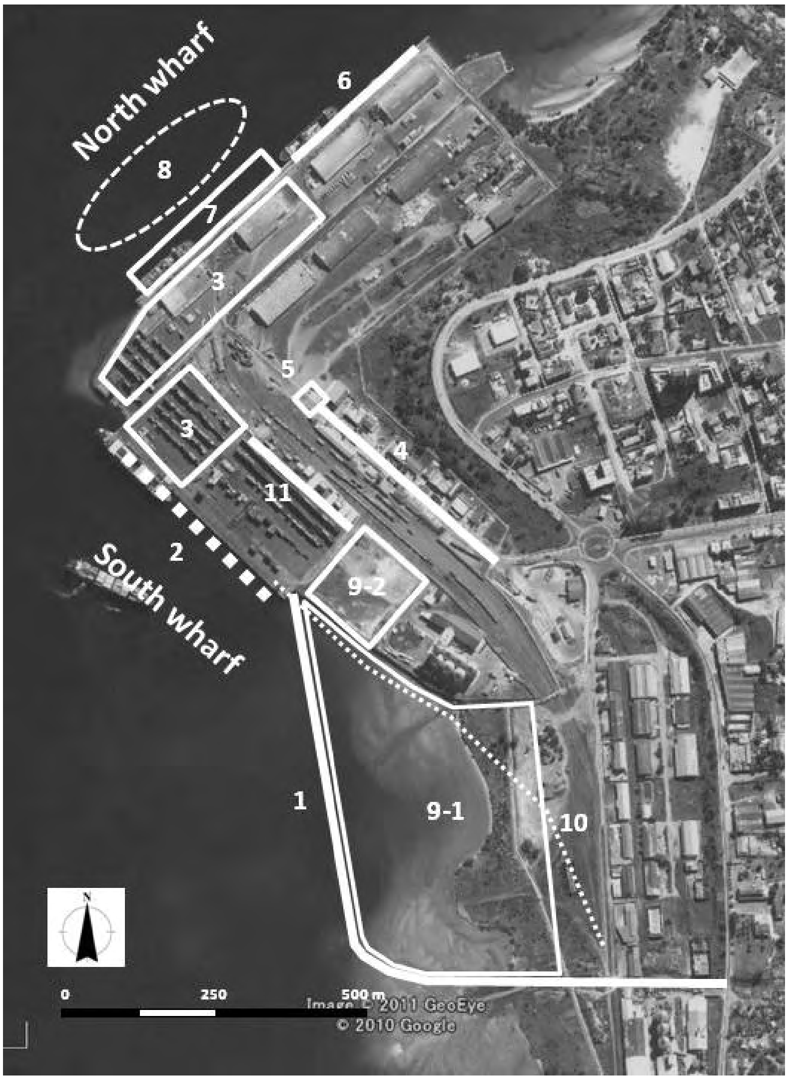
4.13.1 Project description

Table 4.13-1 lists the main project components and associated information. Figure 4.13-1 shows the layout of the main project components. Figure 4.13-2 shows the construction schedule. See other sections of Chapter 4 for more detailed information (e.g. design, cost, and schedule).

Table 4.13-1 Main project components

	Component	Specification	Main construction works
Civil works			
1	Construction of bypass access road	Road: Approx. 1,000 m x 10 m Revetment: Approx. 680 m	Revetment works • Rubble and armor stone deposition Road works • Backfill and soil compaction • Concrete pavement
2	Installation of fenders (South Wharf)	33 fenders	-
3	Construction of new container yard (north & South Wharf)	Approx. 42,000 m^2	• Removal of existing pavement • Demolition of existing structures • Excavation and backfill • Pavement
4	Widening of entrance road	2 m (2 lane to 3 lane)	• Demolition of existing structures • Excavation
5	Widening of entrance gate	-	-
6	Repair of apron (North Wharf)	310 m	• Demolition of existing structures • Excavation • Pavement
7	Construction of new container wharf (North Wharf)	320 m x 40 m	• Demolition of existing structures • Pile driving (steel pipe & sheet) • Installation of concrete blocks • Backfill • Pavement
8	Dredging in front of new container wharf	Approx. 200,000 m^3 (-10→-14 m)	-
9-1	Construction of stockyard (behind bypass access road)	Approx. 67,000 m^2	• Landfill and ground leveling
9-2	Construction of stockyard (South Wharf)	Approx. 17,000 m^2	• Ground leveling
10	Installation of rail track (South Wharf)	Approx. 800 m	-
11	Construction of rail container terminal (South Wharf)	Approx. 6,000 m^2	• Removal of existing pavement • Excavation and backfill • Pavement
Procurement of cargo handling equipment			
1	Rubber Tyred Gantry (RTG) crane	5 cranes	-
2	Reach stacker	4 stackers	-
3	Yard trailer/chassis	12 trailer/chassis	-
4	Mobile crane	1 crane	-

Source: Study Team



Note: The numbers in the figure correspond to the project components in Table 4.13-1.
Source: Study Team, Google

Figure 4.13-1 Layout of the main project components

	Component	2014												2015												2016					
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
1	Construction of bypass access road				■	■	■	■	■	■	■	■	■	■	■	■	■														
2	Installation of fenders							■																							
3	Construction of new container yard				■	■	■	■	■										■	■	■	■	■								
4	Widening of entrance road								■	■																					
5	Widening of gate									■	■	■																			
6	Repair of apron						■	■	■																						
7	Construction of new container wharf					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
8	Dredging in front of new container wharf															■	■	■	■	■	■										
9	Construction of stockyard															■	■	■	■	■	■										
10	Installation of rail track																			■	■										
11	Construction of rail container terminal																					■	■	■	■						

Source: Study Team

Figure 4.13-2 Construction schedule

4.13.2 Project justification

The proposed Project is necessary mainly for the following reasons:

- The future cargo volume, in particular container and bulk cargoes, is forecasted to increase significantly, which is partly due to the various government initiatives that are planned or implemented in the region such as:
  - Establishment of the Nacala Special Economic Zone (SEZ)
  - Promotion of agriculture/forestry projects in the northern region of Mozambique
  - Development of Nacala Corridor
- Volume of export/import container cargo is forecasted to increase from the present volume of around 50,000 TEU to 210,000 TEU by 2020 (see Section 3.5 for more details on cargo demand forecast). Without the proposed Project, the Port will face in the near future major restrictions in container cargo handling as the present container cargo handling capacity is limited to around 100,000 TEU.
- Volume of export/import bulk cargoes (e.g. clinker, fertilizer, wheat, rice, wood chip) is forecasted to increase from the present volume of 0.6 million tons to 2.5 million tons by 2020 (see Section 3.5 for more details on cargo demand forecast). The proposed Project will enhance the efficiency of the bulk cargo handling operation since the South Wharf will be reserved exclusively for bulk cargo handling once the new container wharf becomes operational.
- The existing port facilities are aging and could hinder future cargo handling operations without rehabilitation.

In conclusion, the proposed Project is vital as the Port is expected to play a key role in the future development of the northern region and hinterland countries, which consequently will lead to an increase in employment opportunities and improvement in living standards of the region.

4.13.3 No development option

Without the Project, there will be various negative consequences to port operations, as the Port will experience major difficulties in handling efficiently the growing cargo volume. This could result in major financial losses for the Port and port users, and ultimately could hinder the economic growth of northern Mozambique.

4.13.4 Current environmental status

See Section 2.7.

4.13.5 Analysis of alternatives

Alternatives were considered to identify the most appropriate location of the new container wharf. See Section 4.3 for the analysis result of the new container wharf.

4.13.6 Scoping of environmental impacts

Potential environmental impacts of the Project were identified (i.e. scoping of environmental impacts) through interview surveys, field reconnaissance, field surveys, stakeholder meetings and so on. Considered impact items were based on the requirements of “Japan Bank for International Cooperation Guidelines for Confirmation of Environmental and Social Considerations (April 2002)” The level of potential impact was rated by not considering the alleviating effects of countermeasures. Items that were identified as having potential negative impacts (i.e. items rated as A-, B- or C) are assessed in more detail in the ensuing section, which include planned/recommend countermeasures. The scoping results are presented in Appendix-8.

4.13.7 Assessment of environmental impacts and recommended countermeasures (construction phase)

(1) Social environment

1) Fisheries

Small number of fishermen conducts fishing such as beach seine and draga along the coast adjacent to the Port. Some fishermen also park their fishing boats along the adjacent beaches. However, due to the construction of the new bypass access road and stockyard, the coast and beaches immediately adjacent to the Port (approximately 500 m of coastline) will no longer be available for fishing or boat parking. However, this should not be a major concern as the area of the bypass access road and stockyard is not a major fishing ground nor a boat parking area. There are also alternative fishing and boat parking areas nearby. No concerns were raised during the fishermen consultation meeting (see Appendix-2 for the minutes of the meeting) as well.

Fishermen that operate near the Port may experience temporary reduction in fish catch as marine construction works could degrade the quality of the local marine environment. Following are some examples:

- Degradation of water quality (e.g. increase in water turbidity levels) due to marine construction works such as dredging
- Increase of underwater noise levels due to marine construction works such as pile driving, dredging, rock placement and so on

While it is not possible to accurately predict the extent of these impacts, the construction contractor will be required to implement appropriate pollution control measures to minimize degradation of the marine environment (see Section 4.13.7 (3) 3) for planned water pollution control measures). The Project proponent should also hold regular meetings with the local fishermen to discuss whether the construction works are causing any adverse impacts on their activities.

2) Public health

During peak periods there will be approximately 100 construction workers at the construction site. Influx of these construction workers could result in the spreading of communicable diseases such as HIV/AIDS into the local community. The construction contractor will be required to minimize such risks by for example implementing regular health checks and education programs for the construction workers.

(2) Natural environment

The construction of marine structures (e.g. container wharf, bypass access road, stock yard) and dredging works will result in the permanent loss of approximately 12,000 m^2 of existing benthic habitat, which is comprised mostly of sand-silty habitat. Marine fauna/flora that inhabit the above areas will be lost as a consequence, in particular sessile or slow-moving benthic species such as starfishes, sponges, sea cucumbers, soft corals, sea urchins and so on. While it is not possible to accurately predict how the above losses will affect the local ecosystem, it is likely that impacts will remain within negligible levels due to the following reasons:

- In terms of surface area, the sand-silty habitat that will be lost comprises only a minor fraction of the entire sand-silty habitat area in Nacala Bay.
- No endangered species have been identified to inhabit the construction sites.
- The revetments of the new marine structures should function as a new rocky-type habitat for various marine organisms.

Marine construction works may affect the local ecosystem by causing water pollution. One of the major water pollution sources is dredging as it will resuspend/disperse a significant amount of sediments into the water column, and consequently increase water turbidity levels. High turbidity levels and consequent sedimentation could have a range of impacts on the ecosystem such as:

- Smothering of benthic flora and fauna
- Reduction of photosynthetic efficiency of autotrophic organisms (e.g. seagrass, algae)
- Evasion of marine organisms intolerant to high turbidity levels

Furthermore, since the sediments at the dredging site are likely to be contaminated, the resuspension/dispersal process may also contaminate marine organisms. Therefore, to prevent or minimize such impacts, dredging must be conducted in a manner that will minimize sediment dispersion, such as by installing a silt curtain (see Section 4.13.7.3(3) for planned sediment dispersion minimization measures). The contaminated dredged spoil must also be disposed in ways that will prevent or minimize any adverse impacts on the marine ecosystem (see Section 4.13.7.3(6) for planned disposal method).

(3) Physical environment

1) Air quality

Following are the main potential air pollution sources during the construction phase:

- Fugitive dust emission from construction activities such as land filling and ground leveling
- Fugitive dust and exhaust emissions from travelling construction trucks

Although heavy-construction works such as land filling and ground leveling will generate dust, it should not be a major concern as the construction sites are located relatively far from any sensitive areas (e.g. residential area). Nevertheless, water sprinkling should be conducted whenever there are high levels of dust.

Fugitive dust and exhaust emissions from construction trucks could be more of a problem as many construction trucks will use the access road to transport construction materials, construction waste and so on. During peak periods, the traffic volume of construction trucks along the access road is expected to be approximately 120 per day. The construction contractor will therefore be required to minimize air pollution through measures such as:

- Use of well maintained trucks and implementation of regular vehicle maintenance
- Covering of loading space with sheet cover to minimize dust spills

2) Noise

Following are the main potential noise sources during the construction phase:

- Pile-driving works during the construction of the new container wharf
- Travelling construction trucks

Noise levels of pile drivers vary significantly with the type of pile driver. Table 4.13-2 shows the noise level of two types of pile driver: diesel and hydraulic pile-drivers. Note that the noise level of hydraulic pile-driver is significantly lower compared to diesel pile-driver. Based on standard noise attenuation formula[1], noise emitted from hydraulic pile-driver will attenuate to levels below international noise standards (e.g. WHO guideline value for residential area: 55 dB) within 200 m of the source. Hence there will be no impacts on surrounding sensitive areas (e.g. residential area). On the other hand, noise emitted from diesel pile-driver will remain above noise standards even 2 km from the source, and therefore could become a nuisance to the local residents. Therefore, to minimize noise impacts from pile driving, pile driving is planned to be conducted with hydraulic pile-driver or pile-driver with equivalent noise level.

[1] $L_{Aeq} = L_{Aw} - 8 - 20 \times \log_{10} r$
L_{Aeq}: Equivalent sound level, L_{Aw}: Sound power level of noise source, r: distance from noise source

Table 4.13-2 Noise levels of diesel and hydraulic pile-drivers

Pile driver	Noise level at source (dB)
Diesel pile-driver	138
Hydraulic pile-driver	104

Source: Sarsby R.W. (2000), Environmental geotechnics

Noise from travelling construction trucks could become a nuisance to the local residents as they will use the access road to transport construction materials, construction waste and so on. During peak periods, the traffic volume of construction trucks along the access road is expected to be approximately 120 per day. The construction contractor will therefore be required to minimize noise impacts through measures such as:

- Use of well maintained trucks and implementation of regular vehicle maintenance
- Strict abidance of speed limit and avoidance of unnecessary revving
- Avoidance of night-time travelling whenever possible

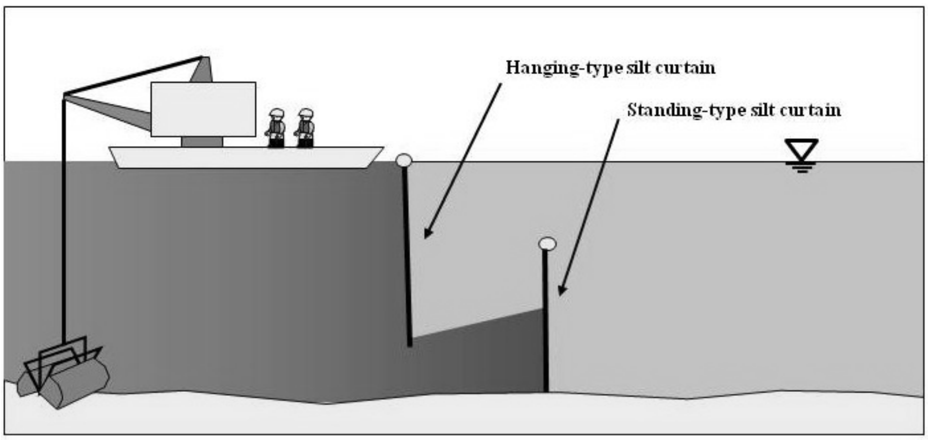
3) Seawater quality

Dredging and the associated works (e.g. transportation of dredge spoil) are the most significant water pollution sources during the construction phase for reasons such as:

- Dredging and the associated works could disperse significant amount of sediments into the water column and consequently raise water turbidity levels.
- Dredging could resuspend/disperse contaminated sediments into the water column.

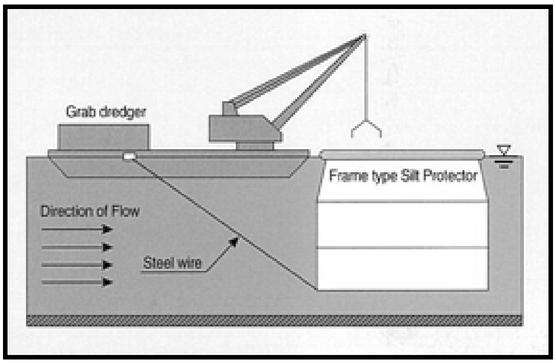
In order to minimize water pollution, the contractor must minimize the area of sediment dispersion. Following are currently planned measures:

- Installation of silt curtains around the dredging site. Figure 4.13-3 shows a schematic image of silt curtain installation. Note that the figure shows two types of silt curtain: hanging type and standing type. The standing type should be used in combination with the hanging type to prevent sediment dispersion from the mid-bottom layers.
- Use of dredger with frame-type silt curtain. Figure 4.13-4 shows a schematic image of frame-type silt curtain.
- Use of enclosed-type grab bucket. This type of grab bucket disperses less sediment compared to normal grab bucket due to its enclosed structure.



Source: Study Team

Figure 4.13-13 Schematic image of silt curtain installation



Source: Taiyo Kogyo Corporation

Figure 4.13-14 Schematic image of frame-type silt curtain

In addition, water quality will be monitored regularly during dredging works. If unacceptable levels are recorded, the methodologies of dredging and countermeasures will be reconsidered (see Section 4.13.9 (2) for monitoring methodology).

4) Groundwater quality

Uncontrolled disposal of contaminated dredged spoil could contaminate the underlying groundwater through leaching and seepage. Contaminated dredged spoil must therefore be disposed in a manner that prevents groundwater contamination (see Section 4.13.7 (3) 6) for planned disposal method).

5) Sediment quality

According to the results of the sediment quality survey, the bottom sediments around the port are contaminated by heavy metals and organic pollutants. These contaminated sediments could contaminate the adjacent areas as marine construction works such as dredging will resuspend/disperse bottom sediments. To minimize the risk of further contamination, various measures should be implemented to minimize sediment dispersion during dredging (see Section 4.13.7 (3) 3) for planned sediment dispersion minimization measures).

If the contaminated sediments are handled and disposed in an appropriate manner, dredging should result in the improvement of the local sediment quality, as it will remove the existing contaminated sediments from the marine environment.

6) Waste

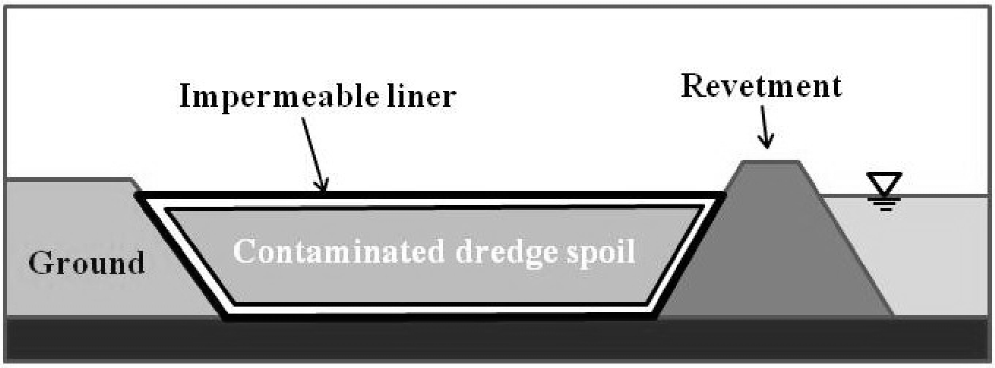
Following are the main types of wastes that will be generated during the construction phase:

- Dredge spoil
- Construction and demolition wastes
- Human waste
- Oily waste

Following are planned/recommended waste management methods for each waste type.

Dredge spoil

Based on the results of the sediment quality survey, the bottom sediments at the dredging site are contaminated. Contaminated dredge spoil must therefore be disposed in a manner that will prevent/minimize contamination of the surrounding environment. The currently planned method is to dispose the contaminated dredge spoil in an impermeable confined disposal facility, such as by installing impermeable liners. Figure 4.13-5 shows a cross-section image of an impermeable confined disposal facility.



Source: Study Team

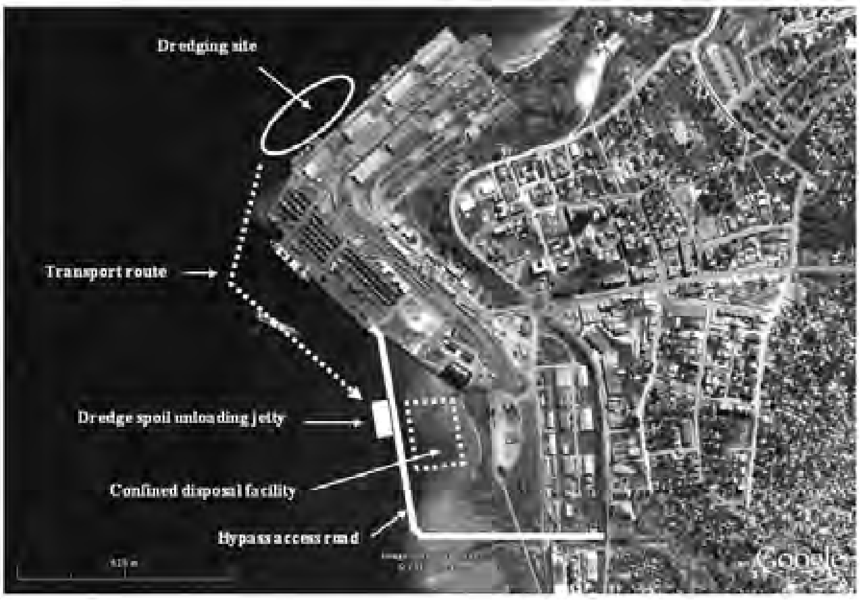
Figure 4.13-15 Cross-section image of impermeable confined disposal facility

The proposed location of the confined disposal facility is the landfill area (i.e. new stockyard) behind the new access road. Following is the proposed handling/transporting procedure of contaminated dredge spoil from the dredging site to the confined disposal facility.

- Unload dredge spoil to barge
- Transport and unload dredge spoil at temporary unloading jetty built next to the new access road
- Transport unloaded dredge spoil to confined disposal facility with dump truck

Note that the above procedures should be conducted in a manner that minimizes spills. Also any excessive water that has accumulated inside the confined disposal facility should be treated and monitored before discharge. Figure 4.13-6 shows the proposed location of the confined disposal facility and other associated information.

Uncontaminated dredge spoil is planned to be used as landfill material of the new stockyard. A detailed sediment quality survey should also be conducted in the ensuing stages (e.g. D/D phase) to identify in detail the spatial extent of contamination at the dredging site (Appendix-9 shows the draft TOR of the sediment quality survey).



Source: Study Team, Google

Figure 4.13-16 Proposed location of the confined disposal facility and other associated information

Construction and demolition wastes

Various types of construction/demolition wastes will be generated during the construction, as it involves significant excavation, demolition and removal works of existing structures. However, since most wastes are non-hazardous, they should be used beneficially or recycled instead of disposed. The disposal method of non-recyclable wastes should be determined after consultation with the local authority. Table 4.13-3 shows the main types of construction/demolition wastes that will be generated, their sources and the planned waste management methods.

Table 4.13-3 Planned waste management methods of the main construction/demolition wastes

Waste type	Main source	Quantity	Waste management method
Soil	Excavated soil from container yard	Approx. 65,000 m^3	Use as landfill material of the new stockyard
Concrete debris	Demolished warehouse, concrete pavement, quaywall	Approx. 25,000 m^3	Use as landfill material of the new stockyard
Metal scrap	Demolished warehouse	-	Recycle
Wood scrap	Concrete formwork	-	Recycle
Rubber tire	Removed rubber fenders	-	Recycle

Source: Study Team

Human waste

Human urine/feces of construction workers could pollute the local environment if discharged in an uncontrolled manner. Therefore temporary toilets will be installed at locations without toilets, such as at the construction site of the bypass access road and workers camp.

Oily waste

Oily wastes such as engine oil and lubricants will be generated from construction-related machines, vessels, vehicles and so on. These oily wastes should be stored in appropriate containers and then collected/treated by local contractors. Oily waste may also be reused for example as lubricants.

7) Accident

There will be a higher risk of maritime accident as various types of work vessels will be present during the marine construction works including: dredging vessels, pile-driving barge, crane barge, dredger barge, anchor boat and so on. The contractor and the Port should therefore implement for example the following safety measures:

- Clear indication of construction zones
- Prior notification to ships regarding the construction works (e.g. schedule, work area)
- Priority should be given to shipping (e.g. stoppage of construction activities during departure/arrival of ships)

The risk of road accidents will also increase as construction trucks will travel through the access road. The contractor should therefore implement for example the following safety measures:

- Notification of truck drivers of high risk areas
- Strict abidance of speed limit

4.13.8 Assessment of environmental impacts and recommended countermeasures (operation phase)

(1) Social environment

Fishing activities inside the bay could become more restricted as there will be more shipping traffic in the future. By 2020, the number of ship call to the Port is expected to reach around 700 per year, which is more than double the present figure (total ship call in 2009 was 299). However, at this moment it is not possible to predict how this will affect the local fishing activities. Nevertheless, the project proponent should hold regular meetings with the local fishermen and seek mutually acceptable solutions if any problems arise.

(2) Natural environment

Uncontrolled discharge of ships' ballast water could introduce invasive species into Nacala Bay, and have devastating effects on the local ecosystem. This risk is enhanced by the increase in ship calls, as well as through the exportation of bulk commodities (e.g. wood chip). The latter is because incoming bulk carriers will be loaded with ballast water filled at the original port.

To prevent spreading of invasive species through ballast water, the International Maritime Organization (IMO) has adopted in 2004 "International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Convention)". The Convention requires ships to manage ballast water through methods such as:

- Exchange of ballast water in offshore water (200 or at least 50 nautical miles from nearest land) which is at least 200 m in depth
- Onboard treatment of ballast water so that the number of viable organism in discharged ballast water is reduced to levels below the set standard.

Although the Convention is not yet effective, the Port should encourage ships, especially bulk carriers, to comply with either of the above requirements so as to minimize the risk of introducing invasive species.

(3) Physical environment

1) Air quality

Following are some air pollution sources that may become a concern in the future:

- Exhaust emission from cargo trucks
- Fugitive dust emission from bulk cargo handling and stockyard

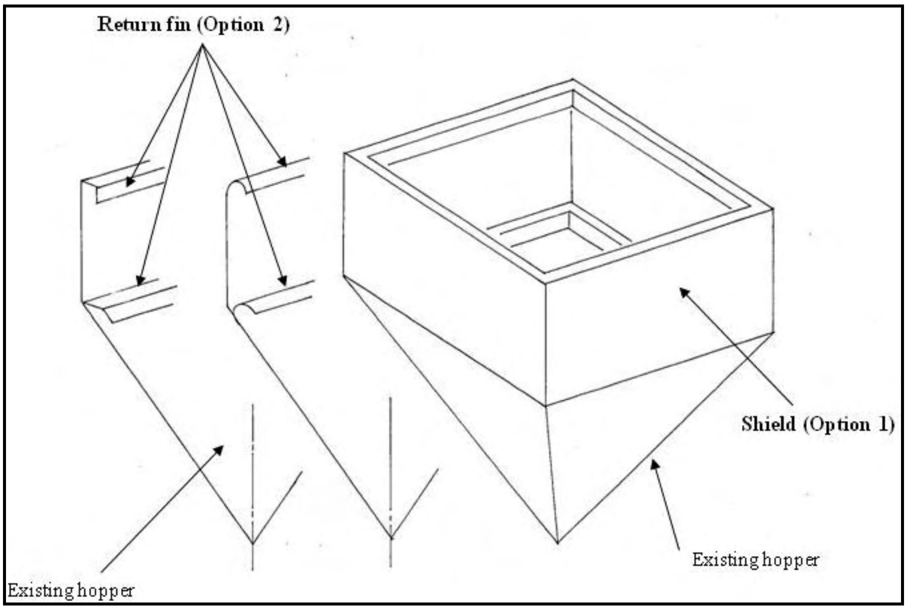
Air pollution may become an issue along the access road as traffic volume of cargo trucks is expected to increase by approximately 4-5 times the present levels by 2020. The Port should therefore encourage truck owners to consider the following measures:

- Implementation of regular maintenance
- Renewal or retrofit of old cargo trucks to less polluting trucks

Fugitive dust emission from bulk cargo handling is an ongoing problem, especially with clinker. The problem could be further exacerbated as volume of clinker import is expected to grow. Following are some options that the Port may employ to reduce dust emission from clinker unloading operation:

Option 1: Installation of shield on top of the existing hopper (see Figure 4.13-7 for conceptual image of the installed shield). The additional height of the shield should reduce dust dispersion to a certain extent. However, the shield cannot be attached on all four sides if the shield obstructs the movement of the grab bucket.

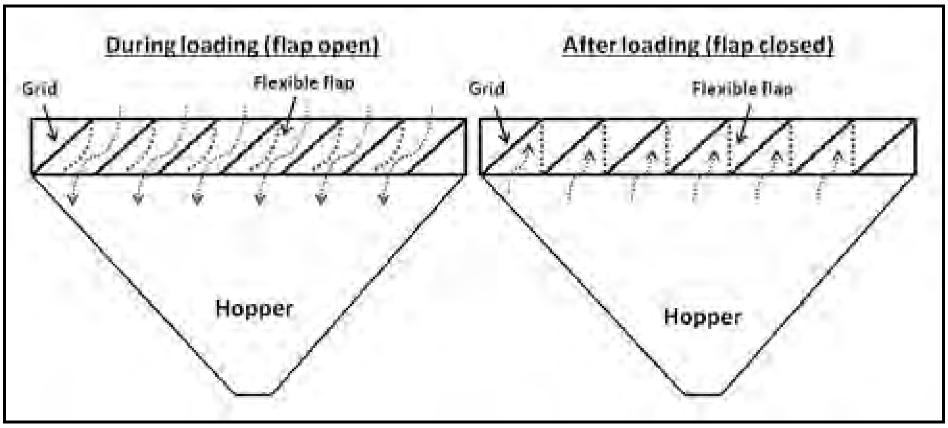
Option 2: Installation of return fin on the mouth of the hopper (see Figure 4.13-7 for conceptual image of the installed return fin). The return fin will block dust escaping from the sides of the hopper. The return fin could also be attached to the shield (option 1).



Source: Study Team

Figure 4.13-19 Conceptual image of dust minimization measures (Options 1 and 2)

Option 3: Installation of a grid with flexible flaps at the mouth of the hopper (see Figure 4.13-8 for a cross-section image of the installed flexible flap). The flap opens when the bulk product (e.g. clinker) is dumped into the hopper and then closes once dumping is finished. This system will significantly minimize dust dispersion because the flap will trap the suspended dust inside the hopper. However, this option will probably be more difficult and costly to install than options 1 and 2.



Source: Study Team

Figure 4.13-20 Conceptual image of installed flexible flap

Option 4: Installation of electrically-powered dust collector. This option is effective but costly and requires power and ancillary equipment. It should be considered if the other options are not effective.

The Port should reduce fugitive dust emission from the new stockyard through for example:

- Installation of dust suppression net
- Tree plantation
- Water spraying

2) Noise

Noise may become a problem along the existing access road as traffic volume of cargo trucks is expected to increase by approximately 4-5 times of present levels by 2020. The Port should therefore, encourage truck owners to consider the following measures:

- Implementation of regular maintenance
- Renewal or retrofit of old cargo trucks to less noisy trucks
- Strict abidance of speed limit and avoidance of unnecessary revving

3) Seawater quality

Following are some water pollution sources that may become a concern after the construction:

- Seepage from the disposal area of contaminated dredge spoil
- Rainwater runoff from the stockyard

Providing that the contaminated dredge spoil is disposed in an appropriate confined disposal facility (see 4.13.7 (3) 6) for details), there should be no seepage of contaminated water into the sea.

Rainwater runoff from the stockyard could also pollute the adjacent waters, especially if harmful bulk products are placed in the stockyard. Therefore, the stockyard should be equipped with a drainage and a simple treatment system (e.g. sedimentation pond) to prevent direct discharge of rainwater runoff.

4) Groundwater quality

Following are some groundwater pollution sources that may become of concern after the construction:

- Seepage from the disposal area of contaminated dredge spoil
- Seepage from the stockyard

Providing that the contaminated dredge spoil is disposed in an appropriate confined disposal facility (see 4.13.7 (3) 6) for details), there should be no seepage of contaminated water into the underlying groundwater.

Seepage from the stockyard should be prevented by paving the area with an impermeable material.

5) Sediment quality

Although the source of the current sediment contamination is uncertain, one possible source is anti-fouling paints of ships as some of the detected contaminants (e.g. TBT, DDT, PCBs) were used as ingredients of anti-fouling paints. However, the risk of further contamination by DDT and PCBs should be low as the use of these substances is now internationally prohibited or restricted. While the use of TBT has been prohibited since the IMO’s “International Convention on the Control of Harmful Anti-fouling Systems on Ships[2]” entered into force in 2008, there is still a moderate risk of TBT contamination as countries that have not ratified the Convention, including Mozambique, may still be using TBT. To minimize the risk of further TBT contamination, the Port should notify and encourage ship owners to voluntarily refrain from using TBT that contains anti-fouling paints.

Spillage of bulk products (e.g. fertilizers, clinker) during unloading/loading operation could also contaminate the local sediment. The Port must therefore improve their unloading/loading operation so to minimize spillage.

6) Accidents

There will be a higher risk of maritime accidents as the number of ship calls to the Port is

[2] Parties to the Convention are required to prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag, as well as ships not entitled to fly their flag but which operate under their authority and all ships that enter a port, shipyard or offshore terminal of a Party.

expected to reach around 700 per year by 2020, which is more than double the present figure (total ship call in 2009 was 299). The incoming/outgoing bulk carriers at the Nacala-a-Velha coal terminal will further raise the risk. The Port should therefore implement for example the following safety measures:

- Reinforcement of current tug boat fleet
- Prohibition of berthing during extreme weather conditions
- Preparation of accident contingency plan including oil spill response plan

The risk of road accidents will increase due to the expected increase in cargo truck traffic and the new intersection of the existing and bypass access roads. The risk of road accident will be particularly high along narrow sections of the access road and at the road intersection. The Port should therefore implement the following safety measures:

- Notification of truck drivers of high risk areas
- Strict abidance of speed limit
- Installation of road mirror or traffic light at the intersection of the new and existing access road

4.13.9 Environmental management plan

An environmental management plan should be prepared to ensure that the Project is implemented with minimal environmental impact. It should at least include information on the proposed countermeasures, an environmental monitoring plan and responsible implementing entities.

(1) Countermeasures

Tables 4.13-4 and 4.13-5 show the planned/recommended countermeasures and responsible implementing entities for each impact expected during the construction and operation phases respectively.

Table 4.13-4 Potential environmental impacts and planned/recommended countermeasures (construction phase)

Category		Potential impact	Countermeasure	Responsible entity
Social environment	Fisheries	Temporary reduction in fish catch as marine construction works (e.g. dredging) could degrade the local water quality.	• Implementation of sediment dispersion minimization measures (see countermeasures of seawater quality).	• Construction contractor
			• Holding of regular meetings with local fishermen to discuss of any adverse impacts.	• Project proponent
	Public health	Spreading of communicable diseases due to influx of construction workers.	• Implementation of regular health checks and education programs.	• Construction contractor
Natural environment	Ecosystem	Degradation of ecosystem due to: • Resuspension/dispersal of bottom sediment (including contaminated sediments) during dredging • Inappropriate disposal of contaminated dredge spoil	<u>Sediment dispersal</u> • Implementation of sediment dispersion minimization measures (see countermeasures of seawater quality). <u>Dredge spoil</u> • Disposal of contaminated dredge spoil in a confined disposal facility.	• Construction contractor

Category		Potential impact	Countermeasure	Responsible entity
Physical environment	Air quality	Deterioration of air quality due to fugitive dust and exhaust emissions from construction trucks.	• Use of well maintained trucks and implementation of regular vehicle maintenance • Covering of loading space with sheet cover to minimize dust spills	• Construction contractor
	Noise	Increase in noise levels due to pile-driving works and construction trucks.	<u>Pile driving</u> • Use of hydraulic pile-driver or pile-driver with equivalent noise level <u>Construction trucks</u> • Use of well maintained trucks and implementation of regular vehicle maintenance • Strict abidance of speed limit and avoidance of unnecessary revving • Avoidance of night-time travelling whenever possible	• Construction contractor
	Seawater quality	Deterioration of seawater quality due to resuspension/dispersion of sediments (including contaminated sediments) through dredging works.	• Installation of silt curtains around the dredging site. • Use of dredger with frame-type silt curtain. • Use of enclosed-type grab bucket. • Implementation of water quality monitoring.	• Construction contractor
	Groundwater quality	Contamination of groundwater due to seepage from disposed contaminated dredge spoil.	• Disposal of contaminated dredge spoil in a confined disposal facility.	• Construction contractor
	Sediment quality	Deterioration of sediment quality due to resuspension/dispersion of contaminated sediments through dredging works.	• Implementation of sediment dispersion minimization measures (see countermeasures of seawater quality).	• Construction contractor
	Waste	Generation of following type of wastes: • Dredge spoil • Construction/demolition wastes • Human waste • Oily waste	<u>Dredge spoil</u> • Disposal of contaminated dredge spoil in a confined disposal facility. • Monitoring of effluent water quality from the confined disposal facility. • Use as landfill material of new stockyard (for non-contaminated dredge spoil) <u>Construction/demolition wastes</u> • Use as landfill material of new stockyard • Recycle <u>Human waste</u> • Installation of temporary toilets at construction sites. <u>Oily waste</u> • Collection/treatment by local contractor. • Reuse (e.g. lubricant).	• Construction contractor

Category		Potential impact	Countermeasure	Responsible entity
	Accident	Increase in the risk of maritime and road accidents.	Maritime accident • Clear indication of construction zones • Prior notification to ships regarding the construction works • Priority should be given to shipping (e.g. stoppage of construction activities during departure/arrival of ships)	• Port and construction contractor
			Road accident • Notification of truck drivers of high risk areas • Strict compliance with speed limit	• Construction contractor

Source: Study Team

Table 4.13-5 Potential environmental impacts and planned/recommended countermeasures (operation phase)

Category		Potential impact	Countermeasure	Responsible entity
Social environment	Fisheries	Restriction of fishing activities due to increase in shipping traffic.	• Holding of regular meetings with local fishermen to discuss of any adverse impacts.	• Project proponent
Natural environment	Ecosystem	Introduction of invasive species through ship ballast water.	• Encourage ships to exchange ballast water in offshore water or conduct onboard treatment of ballast water.	• Port and ship owner
Physical environment	Air quality	Deterioration of air quality due to: • Exhaust emissions of cargo trucks • Fugitive dust emission from bulk cargo handling and stockyard	Exhaust emission • Implementation of regular maintenance • Renewal or retrofit of old cargo trucks to less polluting trucks	• Port and truck owner
			Fugitive dust emission • Use of hopper with dust minimization devices. • Installation of dust suppression net at stockyard. • Tree plantation at stockyard • Water spraying	• Port
	Noise	Increase in noise levels due to increase in cargo trucks.	• Implementation of regular maintenance. • Renewal or retrofit of old cargo trucks to less noisy trucks. • Strict abidance of speed limit and avoidance of unnecessary revving.	• Port and truck owner
	Seawater quality	Deterioration of seawater quality due to: • Seepage from disposed contaminated dredge spoil	Dredge spoil • Disposal of contaminated dredge spoil in a confined disposal facility.	• Construction contractor

Category		Potential impact	Countermeasure	Responsible entity
		• Rainwater runoff from the stockyard	Rainwater runoff • Installation of drainage and treatment system (e.g. sedimentation pond) at the stockyard.	• Port
	Groundwater quality	Contamination of groundwater due to seepage from disposed contaminated dredge spoil and stockyard.	Dredge spoil • Disposal of contaminated dredge spoil in a confined disposal facility.	• Construction contractor
			Stockyard • Pavement of stockyard with impermeable material.	• Port
	Sediment quality	Contamination of sediment through leaching of pollutants (e.g. TBT) from ship anti-fouling paint.	• Encourage ships to refrain the use of harmful anti-fouling paint.	• Port and ship owner
	Accident	Increase in the risk of maritime and road accidents.	Maritime accident • Reinforcement of current tug boat fleet. • Prohibition of berthing during extreme weather conditions. • Preparation of accident contingency plan including oil spill response plan.	• Port
			Road accident • Notification of truck drivers of high risk areas. • Strict abidance of speed limits. • Installation of road mirror or traffic light at the intersection of the new and existing access roads.	• Port and truck owner

Source: Study Team

(2) Environmental monitoring plan

Environmental monitoring should be conducted during the construction and operation phases to confirm any adverse impacts and the effectiveness of the countermeasures. Depending on the monitoring results, the countermeasures should be revised until impacts are reduced to satisfactory levels. Following are the proposed monitoring programs.

1) Construction phase

Monitoring of impact on fishermen

Aim: To confirm whether construction activities are not causing adverse impacts on the local fishermen.
Frequency: 2/year
Method: Holding of meeting with representatives of local fishermen.
Implementing organization: Project proponent

Monitoring of water quality

Aim: To confirm whether dredging activities are not dispersing unacceptable amount of sediment into the surrounding waters.

Frequency: Daily during dredging period
Method: Measurement of turbidity levels with turbidity meter.
Location: Immediately outside the silt curtain. Measurement should be conducted at three depths (i.e. surface, middle and bottom layers)
Threshold level: > 10 NTU (FTU) compared to background level
Implementing organization: Construction contractor

<u>Monitoring of effluent water quality</u>

Aim: To confirm whether effluent from the confined disposal facility (if any) are below threshold level
Frequency: Prior to discharge of effluent
Method: Measurement of suspended solid (SS) concentration
Threshold level: < 10 mg/l
Implementing organization: Construction contractor

2) Operation phase

<u>Monitoring of impact on fishermen</u>

Aim: To confirm whether port operations are not causing adverse impacts on the local fishermen.
Frequency: 1/year
Method: Holding of meeting with representatives of local fishermen.
Implementing organization: Project proponent

4.14. Operational and managerial improvement

4.14.1 Port administration framework in Mozambique

Table 4.14-1 shows the typical ownership and operating structures in container ports in the world. There are six different modes of ownership. The difference among types is the involvement of state and private sector. Type A is 100% state owned and operated, and Type F is 100% privately owned. Type B to E involve the state and private sector collaborating in different ways.

Inefficiency of state owned and operated ports has been repeatedly pointed out over the past 20 years, and the privatization has been a general trend for ownership and operating structures in world's container ports. However, it should be noted that this doesn't imply that a 100% privately owned port is the ideal and ultimate form of port ownership. The role of the public sector is crucial because the efficiency and capacity of ports is one of the decisive factors of the competitiveness of national economy. In fact, Type F remains very exceptional. Normally, collaboration of public and private, namely Type B to E, is preferred as the form of ownership and operation of container ports. Build Operate and Transfer (BOT) agreements, which leave the ownership of the terminal land in public hands, but grant a long-term concession to an operator which finances, builds, equips and then operates the terminal, are the most advanced form of private involvement among the four types of collaboration. However, Drewry assesses that finance is now much harder to obtain, and that it may be therefore that BOT schemes are less prevalent. Though the state sector's share of global throughput has declined as port privatization has been more widely embraced by governments in all parts of the world, the rate of decline is likely to flatten out as the scope for further privatization diminishes. Indeed Drewry data suggests that the contraction in state sector terminal volumes has stabilized in recent years. In 2009 the share of traffic moved by state-owned terminals was 20.6%, compared with 20.4% in 2008.

Table 4.14-1 Typical ownership and operating structures in the international container port

	Mode of Ownership	Land Area	Terminal Infrastructure	Terminal Superstructure	Quayside Operations	Landside Operations	Examples
A	100% state owned & operated	State owned	Owned and constructed by port authority	State owned	Port authority	Port authority	Haifa (Israel), Durban (South Africa)
B	Suitcase stevedores	State owned	Owned and constructed by port authority	State owned	Private stevedores (common-berths)	Port authority	Shuwaikh (Kuwait)
C	Leased terminal	State owned	Owned and constructed by port authority	Privately owned or rented from port authority	Terminal operator	Terminal operator	Oakland Container Terminal (USA). ECT(Rotterdam)
D	Concession agreement	State owned	Owned and constructed by port authority	Privately owned	Terminal operator	Terminal operator	Port 2000, Le Havre (France), Santos Brasil (Brazil)
E	BOT concession	State owned	Construction privately funded	Privately owned	Terminal operator	Terminal operator	Laem Chabang International Terminal (Thailand), JNPT
F	100% privately owned	Privately owned	Privately owned	Privately owned	Terminal operator	Terminal operator	Teesport (UK), Liverpool (UK)

Source: Drewry

The ownership and operating scheme of Nacala Port is rather unique. The Port would fall into Type D basically; however, there are many deviations from the standard scheme. The main points are as follows:

- The concession agreement prescribes that the power of port authority exercised by CFM in the Port shall cease basically as of the date when CDN's operation begins, and the power shall be conferred upon CDN. This implies that CDN is not a mere operator, but is the port authority.
- CDN is furnished with the right of development and operation in the port area which covers not only whole Nacala Bay but also Fernao Veloso Bay. In the concession area, the right is exclusive, and in the rest of the area in the Port, CDN can enjoy a right of preference. The concession agreement contains the BOT scheme.
- CFM holds 49% share of CDN (but the largest share as a single entity).

Thus, the concessionaire (CDN) is furnished with mighty power, namely, the power as a port authority, and exclusive right or a right of preference for the development and operation for the very large area far beyond the existing footprint of the Port. In return, the public sector (CFM) holds the largest share of CDN.

This scheme seems to be a mixture or compromise of radical privatization and conservative state port policy. This is a very unique and ambitious scheme; however, the result has not been successful so far. There has been no major investment from CDN. Operational efficiency and productivity have been always very low. Port infrastructure remains deteriorated. The quantity and capacity of equipment have been insufficient. And the Port is not competitive at all.

Furthermore, there is a concern that the mighty and exclusive power of the concessionaire could hinder the growth of the Port in the future. It is generally fair competition among operators in a port that leads to higher cargo volumes and this is substantiated by many examples around the world. . For instance, Dar es Salaam had been suffering from insufficient investment from the concessionaire, but the Government succeeded in revising the concession and removing the exclusive right of container operation in the port through extensive negotiations with the concessionaire.

Accordingly, the Study Team would like to recommend that:

- Considering the vital importance of Mozambican ports in the development of the country's economy, the role of the Government (MTC and CFM) shall be intensified basically. It should be noted that the intensification of the state involvement is not retrogressive as mentioned in the former part of this sub-section.
- In this context, the Government should:
    - Establish a law on ports which prescribes basic principals on administration, management, development and planning of ports.
    - Establish the comprehensive port policy aiming at intensifying competitiveness of Mozambican ports.
- Based on the principals and a procedure prescribed by the law on port including consultation with stakeholders, legally binding plan for Nacala Port development shall be established, which regulates use of land and basin aiming at their rational and effective utilization.
- In accordance with the principals prescribed by the law on port and the comprehensive port policy, the revised scheme of ownership and operation of Nacala Port shall be prepared aiming at promoting competition among private operators and securing the public interest.
- In accordance with the principals prescribed by the law on port and the comprehensive port policy, and paying due attention on the debt sustainability, the public investment in port development projects, which are urgently required for the development of the country's economy, shall be secured.

Besides essential issues described above, minor modification of the concession agreement will be necessary because the current agreement doesn't presume the investment in facilities inside concession area by the public sector. The required modification would include:

- Right of the public sector to the implement a development project within the perimeter of concession area.
- Consent of the concessionaire to the implementation of development project by the public sector within the perimeter of concession area.
- Cooperation of the concessionaire in the implementation of development project by the public sector.
- Renunciation of the right of the concessionaire to claim compensation against losses arising in the course of the implementation of development project by the public sector.

- Transfer of the asset created by development project by the public sector.
- Right and obligation of the concessionaire in operating the asset created by development project by the public sector.

In addition, the financial scheme will also have to be modified. This will be discussed in the following sub-section.

4.14.2 Financial scheme of the operation in Nacala Port

This sub-section proposes the concession fee scheme and cash flow control of the project to be feasible for both management of PMB and TOC.

(1) Scheme of concession fee

In accordance with the current concession agreement between GOM including CFM and CDN, CDN has an obligation to pay the concession fee of the Port as mentioned in the sub-section of 2.5 (5), US$ 1.5 million per annum as a fixed portion and 12.5% of gross annual return as a variable portion, in the present period. The concession fees are applied to US$ 2.0 million per annum as fixed and 15.0% of gross annual return as variable from 2015 to 2019. The year of 2019 is the expiry year of the current concession period.

Under the Urgent Rehabilitation Project, the Study Team calculates an additional concession fee. The fixed fee is US$ 8.6 million per annum and the variable fee is 15% (2015~2019), 20% (2020~2024) and 25% (2025~2051) of gross annual return. Regarding the additional concession fixed fee, the payment starts from 2016 after one year’s grace period.

Therefore, the concession fixed fee both of the current and the additional is paid until the end of the concession period in 2019. Total concession fixed fee of the current and the additional is US$ 10.6 million per annum.

After expiry of the current concession agreement, TOC and GOM including PMB will enter a new concession agreement of the Port. In the new agreement, TOC pays concession fixed and variable fees as follows:

- Fixed fee: US$ 10.6 million per annum from 2020, and
- Variable fee:
    - 20% of gross annual returns during years one to five of the new agreement,
    - 25% of gross annual returns from year six to the end of the new concession period.

The current and the new (next phase) concession fees are summarized in the table below:

Table 4.14-2 Summary of concession fees of the Port

Status of Concession	Portion	Year				
		2010 ~ 2014	2015	2016 ~ 2019	2020 ~ 2024	2025 ~ 2051
Current	Fixed	US$ 1.5 million	US$ 2.0 million		---	---
	Varible	12.50%	15.00%		---	---
Next Phase	Fixed	---	*Grace period*	US$ 8.6 million	US$ 10.6 million	US$ 10.6 million
	Varible	---	15.00%		20.00%	25.00%
Total	Fixed	US$ 1.5 million	US$ 2.0 million	US$ 10.6 million	US$ 10.6 million	US$ 10.6 million
	Varible	12.50%	15.00%		20.00%	25.00%

Source: Study Team

(2) Cash flow control

1) Need of reserve account

The financial statement of CDN in 2009 stated that CDN has an obligation as accounts payable from 2006 to 2009 for concession fixed and variable fees, the amount of which has accumulated to MT 282 million.

In September 2010, Insitec Group sold their interests in CDN to Vale Mozambique. Vale Mozambique has a plan to rehabilitate the railway and construct a new port terminal for the coal mining project in Tete Province. The plan will decrease the financial burden of railway development and maintenance for CDN, so it is expected to enable them to focus on railway operations for container and bulk cargo.

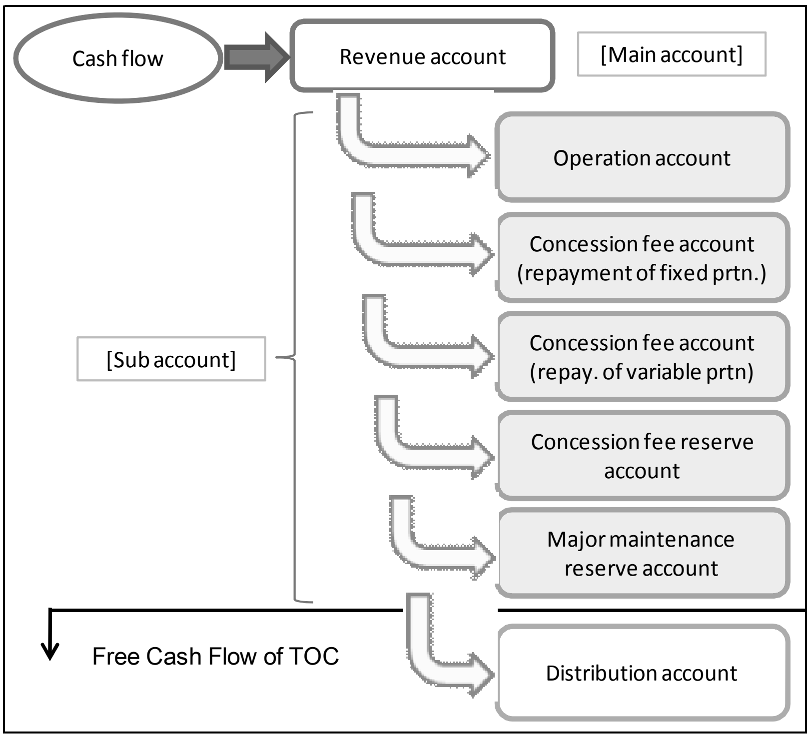
CDN-port has earned profits every year since operation started but CDN-rail has been operating, managing and maintaining the railway at a large deficit. CDN-port has transferred the profits to CDN-rail to cover deficits in the railway sector, so CDN-port can hardly afford to develop and repair the facilities and the Port equipment.

PMB (CFM) has to monitor TOC's (CDN's) administration from the standpoint of a conceding authority of the project to ensure sustainable development of the port activity despite being the largest shareholder of CDN, until the end of the current concession period.

Taking this current situation into account, it is most important to collect concession fees from TOC to avoid being late on loan repayments to the loan syndication. To guarantee the collection of concession fees, it is said that opening reserve accounts is an effective measure to control cash flow of a project. The account is used to cover a cash flow shortage. The new concession agreement, therefore, should stipulate that reserve accounts be opened for the payment of concession fees and maintenance expenditure.

2) Cash flow waterfall of the project

Figure 4.14-1 shows a sample of the TOC cash flow through accounts of the project which is called a cash flow waterfall.



Source: Project Finance – a risk-control business -, edited by the Study Team

Figure 4.14-1 Cash flow waterfall and project account

A main account and several sub-accounts within the main account are opened at the same time. These accounts are used for each purpose and TOC cash flow of the project is allocated in order of stipulated priority in the new concession agreement.

The main account is the revenue account to which TOC earnings are firstly credited.

Several sub-accounts are opened for purposes of operation expenditures/tax payment, concession fixed fee, concession variable fee, reserve of concession fees and maintenance expenditure. Amount required is credited to each sub-account for next payment and reserved from the main account.

In the case of a cash flow shortage, cash is credited to a senior sub-account but not to a subordinate one. Hence, expenditure to continue the operation of the Port is set at the highest priority within the several sub-accounts.

Details of accounts and their functions are shown in the below table in order of priority:

Table 4.14-3 Account details and function

Main account	
Revenue account	TOC earnings are firstly credited to revenue account. This account is the most significant and the source of cash flow for several sub-accounts. The surplus of cash flow is controlled at this account.
Sub-account	
Operation account	Operation costs such as personnel, lighting/fuel, tax and administration for present and next month is credited to this account and paid.
Concession fee account (for fixed and variable portion)	Amount of concession fixed and variable fees for the coming date of payment is credited to this account and paid to PMB. In case of semi-annual payments, one-sixth of the fee amount is reserved per month till the coming date of payment. It is set aside as an appropriation for the concession fess in advance. There can be separate accounts for the fixed and variable.
Concession fee reserve account	This reserve account is to avoid an overdue payment due to a short-term cash shortage. The reserved amount is generally equivalent to one payment.
Major maintenance reserve account	1% of civil work cost and 2% of equipment procurement cost is reserved in this account to repair, rehabilitate and maintain the facilities and equipment.
Distribution account	This amount is at the bottom of the sub-accounts. Dividend is paid from this account.

Source: Project Finance – a risk-control business -, edited by the Study Team

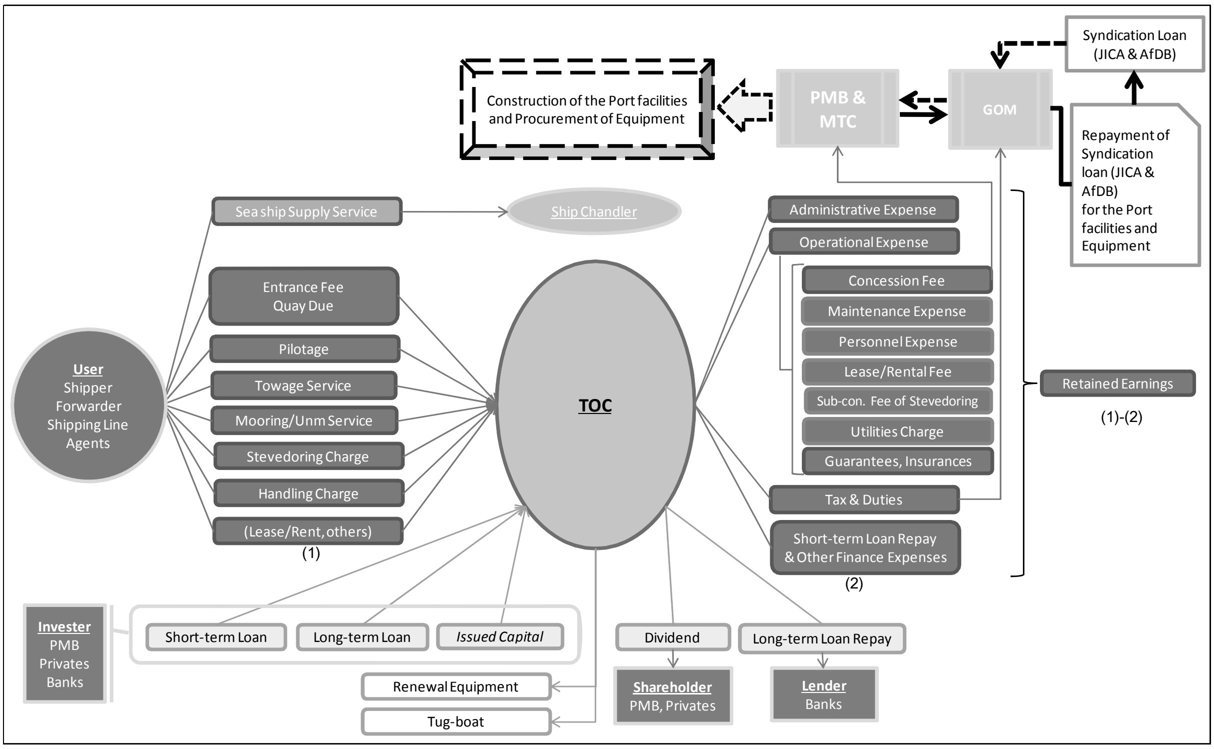
3) Port tariffs and dues

CDN has rights and obligations to establish a policy on port tariffs and dues. The setting and adjustment of such port tariffs and dues are stipulated in the current concession agreement as follows:

- CDN shall be free to set and revise the tariffs.
- The tariffs shall be sufficient to cover the long-term costs.
- The tariffs may include reductions intended to increase traffic.
- CDN may adjust tariffs as part of a promotional offer

In the financial analysis of sub-section 4.12, container handling charge is set at 80% of the current level, taking into consideration competition from nearby ports in near future. Appropriate profit both of TOC, PMB and the flexibility of revising the tariff stipulated the current concession agreement. The average cost per TEU at the Port is US$ 243.

The flow of revenue and expense of each entity at the Port related to the project is illustrated below.



Source: Study Team

Figure 4.14-2 Flow of revenue and expense

4.14.3 Technical improvement of port operation

To cope with increasing container cargoes in the Port where area is limited, the only option is to improve the productivity of the operation. In this context, technical improvement of port operation is crucial in addition to the implementation of port development projects.

(1) Terminal gate operation

First of all the separation of gates by cargo type and the increase of number of lanes are important as discussed in the previous chapter.

At the container terminal, the gate operation shall be fully computerized. The system must be connected with the terminal operation system and the customs clearance system. Damage check is one of the important tasks at a container gate because the gate is the dividing point of responsibility of a terminal and a consignee. TV camera system should be installed to streamline inspection works. A maximum waiting time of 30 minutes in the queue at the terminal gate shall be a benchmark for the productivity improvement of gate operation. Current long queue at X-ray scanning is expected to disappear when the unnecessary inspection of empty containers is discontinued and replaced by a sampling inspection based on a risk management system. It is also necessary to set the criteria for cargoes which need weighing at weigh bridges.

(2) Container terminal operation

The responsibilities of CDN staff at the site of the container terminal are planning, administration of each container, supervising of stevedoring company. Therefore, CDN is required to accumulate comprehensive knowledge of the port operation. Above all, continuous capacity building is required for CDN to reduce the time of ships’ staying at the Port and the dwell time of cargoes.

1) Terminal operating system

An integrated terminal operating system which covers planning, monitoring of all movements of containers, controlling gate operation, and issuing documents is required to conduct efficient container terminal operation. The terminal operating system needs to be improved to cope with increasing cargoes and new facilities. The system needs to be able to respond to the changing conditions; workers will also need to obtain the skills to use the system effectively.

2) Quay side operation

The cause of low productivity of quay side operation is the insufficient number of reachstackers and inefficient movement of reachstackers. A sufficient number of reachstackers will be provided by the Urgent Rehabilitation Project. The operational efficiency of reachstackers shall be improved as discussed in Chapter 2.5.1 (4).

3) Stacking yard operation

A 5 high RTG system will be introduced in the container stacking yard by the Urgent Rehabilitation Project. The land use efficiency is very high as there is no need to prepare the space between each container. Instead, it takes a lot of time to take out the inlying containers if its operation is improper. Therefore, a sophisticated terminal operation system including yard planning system and skilled RTG operators are required.

(3) Port security

Enhancing port security, in a way, runs counter to efficient logistics and efficient port operation. But to conduct security measures properly gives a port a reputation for reliability and eventually increases a port’s competitiveness. The port facility security measures of the Port are mainly supported by manpower; security guard. To ensure the port security, continuous capacity building is required for CDN. And education and training are also needed for the security guards.

4.14.4 Maintenance and repair of port facilities

Maintenance and repair of the facilities are described below and they are tabulated in Table 4.14-4 and Table 4.14-5 with frequency of the activities and persons in charge.

1) South Wharf

The stripped concrete of the wharf structure should be maintained by applying repair methods proposed in the sub-section of 4.1.2 for maintaining the facility for an even longer period.

It is understood that piles of the wharf are of only concrete without rebars and they are vulnerable against bending forces. Accordingly, changes of piles, i.e. surface cracks or deformation of piles, should be regularly monitored. 20 piles in a block, that is 60 piles in total, should be visually inspected for identifying changes to concrete surfaces.

The inspection of piles should be conducted every two months with following procedures:

- Initially grinding concrete surfaces of specified piles for drawing fixed lines
- Drawing straight lines on the ground surfaces of specified piles
- Measuring the lines to identify deformation of the surfaces
- Locations of piles and locations of lines on a pile: being illustrated in figures in Appendix-10.

For confirming function of the rear walls, visual inspection should be conducted in the range of the whole rear walls to identify development of the existing and new stripped concrete. Considering the present situations of the rear walls, stripped concrete is expected to develop due to expansion of rusted rebars. Condition of the members should be monitored and they should be properly repaired if necessary.

For confirming stability of the anchor walls, joints between the container yard and the slab deck at six locations should be monitored every month for confirming existence or nonexistence of openings between them. They will be indices for checking the stability. In addition to the monitoring locations, elevations at twelve locations around six anchor walls should be surveyed every month for monitoring changes of ground elevations due to shifting of the anchor walls. The monitoring locations are shown in figures in Appendix-10.

For monitoring stability of the deck structure, surveys of elevations and coordinates of fixed points are proposed. They should be set at 4 points in a block and a total of 12 fixed points in 3 blocks should be surveyed as shown in figures in Appendix-10.

Port master and civil engineer should be responsible for the task. The procedure is indispensable for securing the safe handling operation on the wharf.

In case that any specific changes are found, detailed inspection should be made and suspension of handling operation will be required for confirmation of the degree and causes.

2) Facilities to be provided in Part 1 for URP

Roads and pavements in the port areas should be visually inspected to find out any damages to be repaired every two months. Civil engineer should be responsible for this task. Civil engineer should be mainly responsible for the activities and operation manager should assist the engineer for inspection of the container yard.

The fender system newly installed at the South Wharf should be well maintained and chains supporting rubber fenders will be replaced every five years. If rubber fenders are seriously damaged, they should be replaced immediately for protecting the wharf structure. Port master and civil engineer should be responsible for these tasks. Rubber fenders fixed at the oil terminal for well maintaining anti-impact-load plates should be inspected every month by the above two officers.

The gate building should be visually inspected every six months and the building repainted when required under the supervision of a civil engineer. Necessary measures should be taken under the supervision of the responsible officers based on inspection results.

3) Facilities to be provided in Part 2 for URP

The landfill area should be monitored every six months under the responsibility of a civil engineer.

Rails and pavement newly laid should be inspected every day by a civil engineer and an inspector newly appointed. Bulk yards should be monitored every two months by a civil engineer. Basically the facility will be free from maintenance and some measures will be taken when required.

Pavements and railway system in the port area should be inspected, the same as mentioned for Part 1. The container yard should be duly inspected as mentioned above.

Pavements and fenders in the new container terminal should be maintained as above. Cathodic protection system applied to the wharf will be effective for 30 years; however, impacts by docking ships may occasionally damage the system. Visual inspection by a diver in the presence of a civil engineer should be made every six months to confirm that all cathodes are properly fixed and the cathodic protection system is working properly.

Maintenance dredging in the dredged basin in front of the new container terminal will not be required; however, sounding surveys at three-year intervals are recommended from a view point of maritime safety.

4) Cargo handling equipment

RTGs, reach stackers and yard chassis will be introduced for improvement of handling efficiency. Workshop Manager should be responsible for maintenance of all the equipment. Inspection of machinery should be made by operators daily, weekly, monthly according to the forms that specify the inspection items. Machinery should be repainted every month.

In addition to the regular inspection by operators, overhaul, replacement of spare parts, etc. should be duly made according to manufacturers' recommendations.

Table 4.14-4 Schedule of maintenance and repair (1/2)

		Facilities to be maintained	Maintenance items	Details	Frquency of check or repair	Persons in charge
0		Monitoring situations of concrete of South Wharf	Repair of concrete members	Stripped concerete surfaces to be repaired	By the year 2013	Port Master and Civil Engineer, CDN
			Inspection of concrete surfaces of members	4 piles at a line, 5 lines in a block, 3 blocks; 60 piles to be visually inspected in total	Once every 2 months	Port Master and Civil Engineer, CDN
			Inspection of the whole rear walls	Visual inspection of the whole rear walls for identifying the existing and new stripped	Once a month	Civil Engineer,CDN
			Survey of joints between the container yard and the slab deck and survey ground elevation around anchor walls	Existence of cracks to be cheked at six fixed pints allong the joints between the two facilites and 12 locations around anchor walls to be	Twice a month plus other occasions for surveys	Port Master and Civil Engineer, CDN
			Survey of elevations and coordinates of the concrete slab	4 fixed points at a block, 3 blocks; elevations and coordinates at the 12 fixed points to be	Once every 2 months	Port Master and Civil Engineer, CDN
A	A-1	Road pavements of by-pass road	Maintenance and repair of concrete and shoulders of the road	Visual inspection along the whole line	Once every 2 months	Civil Engineer, CDN
	A-2	Fenders along South Wharf	Maitenance of Fenders at Oil Berth	Derusting from anti-impact-load plates and repaint	Once a month for derusting and repaint once a year	Port Master
			Maitenance of fenders at South Wharf	Replacement of chains	Once every 5 years	Port Master
	A-3	Pavements and runways for RTGs	Maintenance and repair of concrete pavemet	Visual inspection in the newly paved runways	Once every 2 months	Civil Engineer and Operation Manager,CDN
	A-4	Entrance road	Maintenance and repair of asphalt concrete pavemet	Visual inspection of the expanded road	Once every 3 months	Civil Engineer
	A-5	Gate	Maintenance of the gate building	Visual inspection and repaint	Once every 6 months	Civil Engineer
	A-6	Pavement in port	Maintenance and repair of pavemet	Visual inspection of the repaired road	Once every 2 months	Civil Engineer
	A-7	Coping concrete, pavements, fenders, etc. in Oil Terminal	Maintenance and repair of coping and pavemet	Visual inspection in the whole area	Once every 2 months	Port Master and Civil Engineer, CDN
			Maintenance and repair of fenders	Derusting from anti-impact-load plates and repaint.	Once a month for derusting and repaint	Port Master and Civil Engineer, CDN

Source: Study Team

Table 4.14-5 Schedule of maintenance and repair (2/2)

		Facilities to be maintained	Maintenance items	Details	Frquency of check or repair	Persons in charge
B	B-1	Landfill and Ground levelling	Survey of ground elevations and recovering the required elevations	Visual inspection in the whole area	Once every 6 months	Civil Engineer
	B-2	Rails and pavements	Inspection of rails and pavement conditions	Visual inspection in the whole area	Every day	Civil Engineer and a railway inspector
	B-3	Ground levelling of bulk yard	Monitoring of the elevations	Visual inspection in the whole area	When required	
	B-4	In-port road pavements	Maintenance and repair of pavemet	Visual inspection of the repaired road	Once every 2 months	Civil Engineer
	B-5	Rail container terminal	Monitoring of rails and pavement conditions	Visual inspection in the whole area	Every day	Civil Engineer and a railway inspector
	B-6	Container yard	Maintenance and repair of pavemet	Visual inspection of the repaired road	Once every 2 months	Civil Engineer
	B-7	Provision of New Container Terminal (NCT)	Maintenance and repair of pavemet	Visual inspection of the repaired road	Once every 2 months	Civil Engineer
			Maitenance of fenders	Derusting from anti-impact-load plates and repaint.	Once a month for derusting and repaint	Port Master and Civil Engineer, CDN
			Maintenance of cathodes	Visual inspection of fixed cathodes	Once every 6 months	Civil Engineer, CDN and a diver recruited temporaily
	B-8	Dredging the basin of NCT	Maintenance of the dredged basin	Sounding surveys in the basin	Once every 3 years	Port Master and Civil Engineer, CDN
C	C-1	RTGSs	Maintenance of RTGs	Visual inspection, overhaul, replacement of spare parts, repaint, etc.	Visual inspection: daily, weekly,	Workshop Manager, CDN
					Visual inspection and repaint: every month	
					Overhaul, replacement of parts: according to manufacturers'	
	C-2	Reach stackers	Maintenance of reach stackers	Visual inspection, overhaul, replacement of spare parts, repaint, etc.	Visual inspection: daily, weekly,	
					Visual inspection and repaint: every month	
					Overhaul, replacement of parts: according to manufacturers'	
	C-3	Yard chassis	Maintenance of chassis	Visual inspection, overhaul, replacement of spare parts, repaint, etc.	Visual inspection: daily, weekly,	
					Visual inspection and repaint: every month	
					Overhaul, replacement of parts: according to manufacturers'	

Source: Study Team

4.15. Operation and Effect Indicators

(1) Definition of the indicators

In this section, Operation and Effect Indicators which enable project monitoring and evaluation on the basis of consistent indicators used from the ex-ante to ex-post stages are proposed. Their target values are also proposed here.

The definition of Operation and Effect Indicators by JBIC are as follows:

- Operation Indicator: An indicator to measure, quantitatively, the operational status of a project.
- Effect Indicator: An indicator to measure, quantitatively, the effects generated by a project.

Both of them are basically equivalent to outcome indicators among the performance indicators used by the World Bank.

The following is general criteria for setting appropriate indicators:

- Validity: The set indicators shall be able to measure the achievement of the project purpose.
- Reliability: The same results shall be obtained, regardless of how many times the indicators are measured and regardless of who makes the measurements.
- Ease of access: The set indicators shall be easy to access. And the number of indicators, and cost and time required to measure the indicators shall not be excessive.

After the initiation of the project, the executing agency is requested to measure and record the actual performance of the Operation and Effect Indicators for the mid-term review, ex-post evaluation and ex-post monitoring. The record of the actual performance is used to evaluate the effectiveness of the project.

(2) Operation Indicator

Freight volume is generally adopted as an Operation Indicator for port projects as indicated in “The Reference of Operation and Effect Indicators” by JBIC. For the Urgent Rehabilitation Project in Nacala Port, the freight volume is also valid, reliable and easy to access as an Operation Indicator. Considering characteristics of the project, the Study Team proposes two types of freight volume as Operation Indicators:

- Annual container throughput of the dedicated container berth in the North Wharf: This indicator measures the operational status of the newly constructed container berth, which is the main component of the project.
- Annual total cargo throughput of the berths located at the eastern shore of Nacala Bay: This indicator measures the operational status of all components of the project.

It is necessary to clarify the definition of the indicators for securing the reliability. The definition of each indicator shall be as follows:

(Annual container throughput of the dedicated container berths in the North Wharf)

- All types of shipping containers including empty containers, transshipment and domestic containers handled at the dedicated container berth in the North Wharf shall be counted.
- Non-containerized cargo shall not be included even though it is handled at the container berth in the North Wharf, because separation of container cargo flow from other cargo flows is one of the important objectives of the project. RORO cargoes except containers transported by RORO vessels shall also not be included for the simplification of calculation, though the container berth would be a suitable location for RORO handling until relocation of dry bulk handling from the South Wharf to a dedicated new dry bulk terminal.

- The unit of the indicator shall be TEUs. The port doesn't handle 45-foot containers at present; however the Port is expected to handle them in the future with the promotion of light industry in Nacala SEZ. Theoretically a 45-foot container should be counted as 2.25TEU. But the conversion factor for the indicator shall follow the definition in the port statistics provided by CFM, whether 2.0 or 2.25, which is to be decided when a 45-foot containers arrives at the Port.

(Annual total cargo throughput of the berths located at the eastern shore of Nacala Bay)

- The cargo volume to be handled in the mineral terminal in Nacala-a-Velha shall not be included.
- The unit of the indicator shall be metric tons.
- The weight of empty containers and tare weight of containerized cargoes shall be included following the definition of cargo throughput in the port statistics provided by CFM.
- It is possible that RORO liner vessels start calling at the Port. In such a case, basically, it is preferable that the weight of chases is not to be included. However, this shall also follow the definition of the port statistics for the simplification of calculation and the removal of evaluators' subjectivity.

The baseline data and the target value of the Operation Indicators are shown in Table 4.15-1. The target value is calculated based on the demand forecast (the base case). In the calculation of target value for total cargo volume, the weight of empty containers and tare weight of containerized cargoes are added to the value in the demand forecast. Though the formation of grain hub function is foreseen in the demand forecast, its cargo generation is eliminated from the calculation of target value since the Urgent Rehabilitation Project is indifferent to grain hub. The values for intermediate years can be obtained by linear interpolation.

Table 4.15-1 Baseline data and target value of the Operation Indicators

	Baseline Data (2009)	Target Value	
		2020	2030
Annual container throughput of the dedicated container berths in the North Wharf	52,620 TEUs *	210,000 TEUs	490,000 TEUs
Annual total cargo throughput of the berths located at the eastern shore of Nacala Bay	1,270,000 tons	5,000,000 tons	9,000,000 tons

Note: * Throughput of container berth in the South Wharf
Source: Study Team

(3) Effect Indicator

The purpose of the Urgent Rehabilitation Project is:

- To secure sustainability of port operation;
- To improve efficiency of port operation; and
- To consolidate foundation for the increase of port capacity in the next decade,

with the aim of achieving the super-goals of:

- Trade and transport facilitation for LLCs and landlocked region in Mozambique; and
- Industrial development of northern Mozambique.

Considering the project purpose, the Operation Indicator listed in Table 4.15-1 can also be the principal Effect Indicator of the project. Sustainability and efficiency affect the cargo throughput directly. The increase of port capacity can be measured by long term growth tendency of cargo throughput. It is commonly understood that cargo throughput can be Effect Indicator as well as Operation Indicator for port projects as described in "Evaluation Handbook for ODA Loan Projects" by JBIC.

Besides the principal Effect Indicator, several auxiliary indicators are proposed as listed in Table 4.15-2, together with their target values. It is important that the effects of the project be assessed by employing these indicators comprehensively taking the characteristics of each indicator into consideration. Though the auxiliary indicators may describe some part of effects better than principal indicators, these indicators tend to be affected by external factors more.

Table 4.15-2 Baseline data and target value of the Effect Indicators

	Remark	Baseline Data (2009)	Target Value	
			2020	2030
Principal Indicators				
Annual container throughput of the dedicated container berths in the North Wharf	The indicator is affected by the regional and world's economy. The data can be provided by CDN.	52,620 TEUs	210,000 TEUs	490,000 TEUs
Annual total cargo throughput of the berths located at the eastern shore of Nacala Bay	The indicator is affected by the regional and world's economy. The data can be obtained from CFM statistics.	1,270,000 tons	5,000,000 tons	9,000,000 tons
Auxiliary Indicators				
Annual total transit container volume to/from Malawi handled in the Port	The indicator is affected by Malawian economy and performance of the Nacala Corridor. The data can be obtained from CFM statistics.	6,178 TEUs	57,000 TEUs	104,000 TEUs
Ratio of Annual total transit container throughput to/from Malawi handled in the Port to that handled in Beira	The indicator is affected by the performance of Beira Port. The data can be obtained from CFM statistics.	0.24	1.8	1.8
Annual average cargo handling volume per vessel staying time	The indicator is affected by configuration of cargo type. The data can be obtained from CFM statistics.	50.3 ton/hr	More than baseline data	More than baseline data
Annual average container handling volume per vessel staying time	The data can be obtained from CFM statistics.	6.7 TEU/hr	More than baseline data	More than baseline data
Annual average cargo handling volume per vessel-quay operation hour	The indicator is affected by configuration of cargo type. The data can be obtained from CFM statistics.	76.3 ton/hr	More than baseline data	More than baseline data
Annual average container handling volume per vessel-quay operation hour	The data can be obtained from CFM statistics.	8.2 TEU/hr	More than baseline data	More than baseline data

Source: Study Team

Dwell time is often adopted as an Effect Indicator for port projects; however this is not suitable as an Effect Indicator for the Urgent Rehabilitation Project for the following reasons:

- Although the current import dwell time of 10 days is not admirable at all, this is rather short considering inefficient cargo handling in the Port. The reason is that cargo volume is too small. Accordingly, it can be foreseen that the dwell time becomes longer with the increase of cargo volume for the short run. This makes it difficult to set a target value.
- The average dwell time of 25 to 30 days for transit cargoes is extremely long, and it should be shortened. However, this is mainly caused by insufficient capacity of the railway system. Therefore, the validity of the dwell time as an Effect Indicator for the port project is doubtful.
- Dwell time has not been recorded systematically by CFM or CDN, and no statistical data is available. The only available information is the result of hearing survey to CDN. Thus, the data is not easy to access.

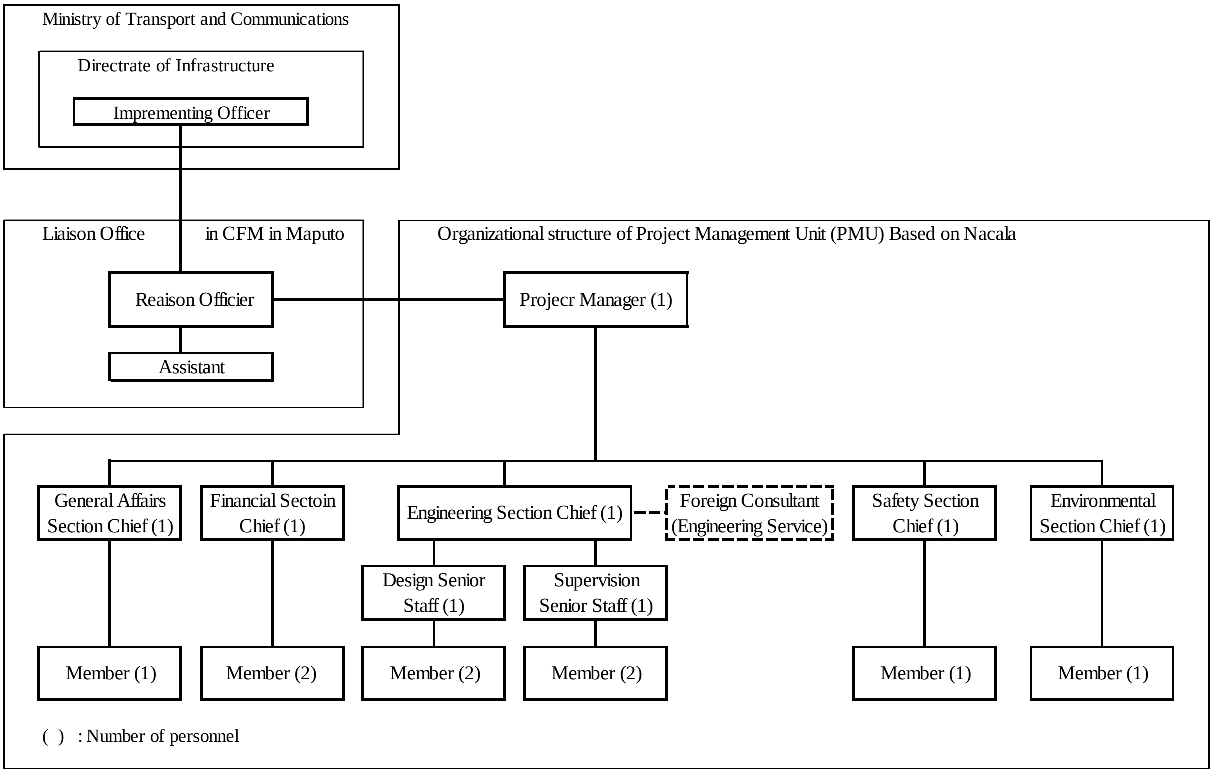
4.16. Institutional framework for the project implementation

4.16.1 Necessity of the establishment of PMU

During the implementation stage of the project, the collective work among the relevant agencies is vital. The MTC and the CFM should establish a task force for the budget arrangement, implementation of EIA, establishment of a project management unit (PMU), etc.

The PMU is a government organization established for the purpose of smooth and swift implementation of the project and, therefore, it is given the legal power by the implementing agency of the project to conclude the contract and to disburse. The PMU has the responsibility not only to supervise and monitor the progress of the project, but also to ensure the safety of the construction and to monitor the impact on the social and natural environment over the period of project implementation. To this end, the PMU should be based at Nacala. The PMU should keep in close touch with CFM and MTC, and should have a liaison office in Maputo.

The organizational structure of the PMU is shown in Figure 4.16-1: the number in the figure indicated in the parentheses shows the number of personnel of respective sections.



Source: Study Team

Figure 4.16-1 Organizational structure of PMU

4.16.2 Roles and functions of PMU

The Project Management Unit is a sort of autonomous body as far as the implementation of the project is concerned. Once the budget is authorized by the higher authority, the PMU implements itself the project with full responsibilities. Manager of PMU is authorized to conclude the contract and to execute all the expenditure in accordance with the implementing plan of the project. Once construction starts, it is foreseen that the traffic within the Port will increase. For the strict implementation of safety and security of the construction site, the PMU must have a Safety Section.

Thus, the PMU consists of four Sections: General Affairs, Financial, Engineering (senior staff for design and another senior staff for the supervision of construction), Safety Section and Environmental Monitoring. A foreign consultant is assisting the Engineering Section in the supervision of the contractors as the part of the engineering services on a contract basis.

Apart from the PMU organization the MTC also must have an Implementing officer in the Directorate of Infrastructure.

4.16.3 Number of personnel of PMU

The total number of the personnel of the PMU is expected to be 17 people (See Table 4.16-1).

Table 4.16-1 Number of personnel of PMU

Nacala Based PMU Staff

Class	Number
Manager	1
Section Chief	5
Senior Staff	2
Staff member	9
Total	17

Source: Study Team

4.16.4 Tasks of respective sections

The tasks of the Project Manager and chief of each section are as follows:

(1) Project Manager

Project Manager is responsible for all the technical and financial matters of the PMU to complete the Project in accordance with the implementing plan. To this end he has such power as to carry out contract procedure including negotiation and conclusion of contracts.

(2) Advisor

An advisor is assigned to assist the Project Manager especially in the field of engineering matters. The advisor should have knowledge and experience in the project management of port facility construction. In case qualified personnel are not available locally, a foreign consultant will be recruited from abroad.

(3) General Affairs Section

This section carries out those internal matters of the PMU such as payroll, vehicle, housekeeping, office supply, and all the matters that do not fall under the responsibilities of other sections.

(4) Financial Section

This section is responsible for contractual matters including negotiation, legal matters related with the contract and the payment for the contracts

(5) Engineering Section

The section is responsible for the execution of the Project components as prescribed in the contracts with contractors and consultants. The staff members of this section supervise and monitor the works done by the contractors. The section is also responsible for the settlement of all issues, problems and conflicts that may occur with government agencies, private entities or local people in the course of the implementation of the Projects.

Since the project consists of many components to be implemented under separate contracts, the Section has two groups lead by two senior members: Senior staff for designing and another senior staff for the construction supervision.

(6) Safety Section

The section is responsible for the safety of all the activities related to the Project. The section is also responsible for the traffic control to prevent accidents and conflict between the cargo trucks and work vehicles in the Port.

(7) Environment Monitoring Section

This section is responsible to ensure that all the activities related to the Project comply with the conditions prescribed by EIA Certificate and the environmental control plan of the Project.

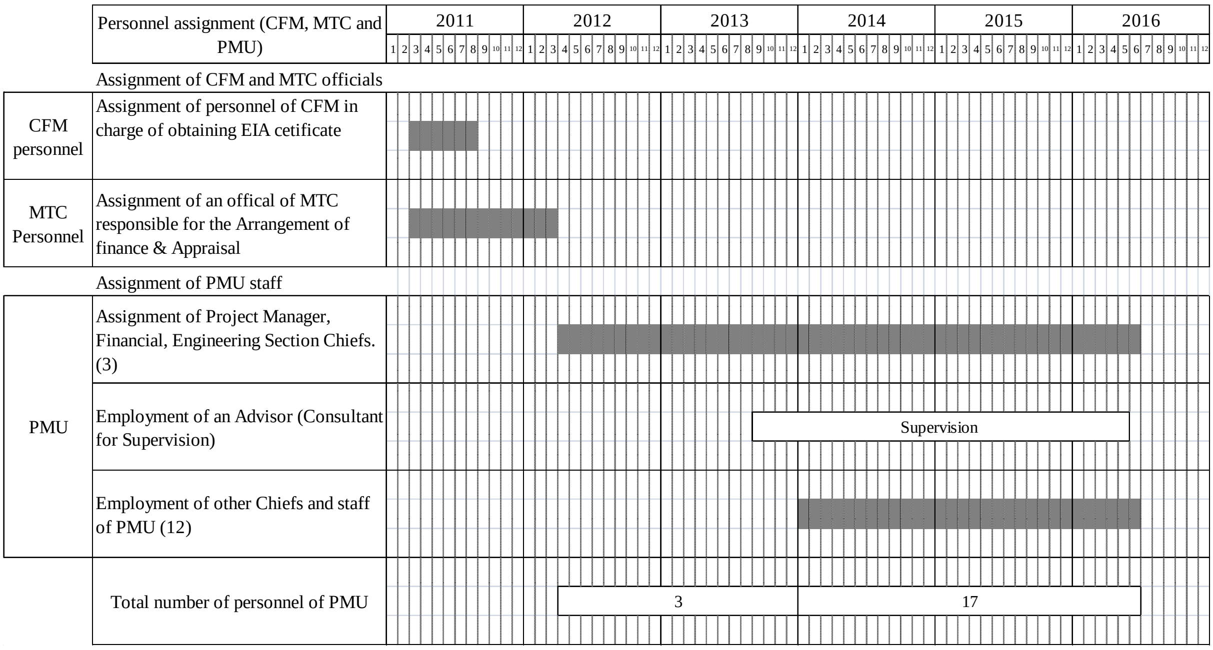
(8) Liaison Office in Maputo

Liaison Office of PMU is set up within CFM. The office is responsible for coordination between MTC/CFM and the Main Office of PMU in Nacala.

4.16.5 Assignment period

It is the responsibility of MTC and CFM to get EIA approval and negotiate with financing institutions and the Mozambique government to ensure funding for the project. Thus, prior to the establishment of PMU, CFM and MTC have to set up task forces for these matters. As soon as an agreement on financing has been reached, the PMU should be established. During the stage of the selection of the consultant before the actual construction starts, the PMU may be run by key members, namely, project manager, chiefs of the Financial and the Engineering Sections. When actual construction starts, the MPU has to have a full staff.

The durations of the personnel assignments are shown in Figure 4.16-2.



Source: Study Team

Figure 4.16-2 Period of employment of the staff of PMU

CHAPTER 5

5. Conclusions and recommendations

5.1. Conclusions

5.1.1 Necessity of the Urgent Rehabilitation of the container wharf of Nacala Port

With the growth of the economic activities in the Northern Provinces of Mozambique and the SEZ in the vicinity of the Port, the cargo volume of the Port has been growing. In particular, the growth of the container cargo volume is remarkable. The Study exhibited that the Port has a great potential to attract transit cargoes to and from Malawi and Zambia if the railway and highway access are improved. Thus, the Port is contributing to economic activities as the gateway of both Northern provinces and the landlocked countries. The main cargoes loaded from the Port are containers and dry bulk cargoes, namely, clinker, grain and fertilizer. Though the volumes are comparatively small, bagged cargoes are handled, e.g., export of sugar and import of rice.

The Port has been operated by CDN under the concession contract since 2005. By the contract, CDN is responsible for the repair, maintenance, rehabilitation and reconstruction of the port infrastructures. However, due to the negligence of repair and maintenance, the wharves are in very poor condition. The South Wharf and the western part of the North Wharf are pier type structure. All the reinforced concrete piles of the pier type wharf are seriously damaged, and need repair or rather reconstruction.

In addition to the port infrastructure, there are various factors that prevent the port from achieving efficient operation. Some of those are:

(1) Congestion at the port entrance road
(2) Mixed use of the South Wharf by containers and dry bulk
(3) The facility layout of the Port was designed as the railway terminal and it is not suitable for transport by trucks.
(4) The number of units of container handling equipment

It is very likely that the port will be overflowed by increasing cargoes unless proper action is taken. It is necessary to modernize and expand Nacala Port through the provision of required port facilities as well as the provision of efficient and economical cargo-handling services based on an adequate management and operation system.

5.1.2 Medium and Long-term Development Plan (target year: 2030)

(1) Zoning of port area

The port area should have separate areas to handle different types of cargoes. The South Wharf should be used for dry bulk such as grain and break bulk including vehicles, while the North Wharf should be renovated to a full container terminal. The oil terminal, which is currently situated at the north end of the North Wharf, should be relocated to a new dedicated oil terminal. The expansion of the Port should be toward the north where the configuration of the sea bed is suitable for deep water wharves. The newly developed wharf to the north of existing footprint should be used for dry bulk handling.

(2) Expansion of the container terminal

In the target year of the Master Plan, 2030, the volume of container cargoes is expected to reach 440,000 TEUs including international local and transit containers, transshipment containers and domestic (cabotage) containers. The Port has to have two fully equipped container berths that can accommodate Panamax size container carriers.

The railway service will play an important role in the container transportation to and from Malawi and Zambia. The Port also has a rail container terminal for the smooth connection between the container terminal and railway.

(3) Renovation of the South Wharf to dry bulk and break bulk terminal

The existing South Wharf is seriously damaged and, therefore, container cargoes that require heavy equipment shall be removed. The South Wharf shall be renovated for the exclusive use of bulk cargoes (dry bulk and break bulk). The backup area for the bulk terminal should be expanded by reclaiming the southern part of the Port. The bypass access road and railway should be constructed for the exclusive use of bulk cargoes to prevent congestion at the main gate.

In the Long-term Plan, a new grain terminal should be constructed to cope with the increase of cargo volume. It is recommended the new grain terminal should be constructed to the south of the existing South Wharf.

(4) New construction of dry bulk berths at the north of the Port

For the increasing volume of dry bulk other than grain, two dry bulk berths should be newly constructed to the north of the Port.

(5) Construction of a new oil terminal

A fully equipped oil and gas terminal should be constructed.

5.1.3 Short-term Development Plan

The Short-term Development Plan is intended to upgrade the container cargo handling productivity. To this end, the following project components are included.

(1) Container handling equipment

Due to the lack of the units of container reach stackers and trailers, the container handling productivity remains quite low. The Short-term Development Plan includes procurement of four (4) reach stackers, twelve (12) yard chassis, and two (2) RTGs. In addition one unit of mobile crane is also procured for the unloading and loading of heavy cargoes and for the unloading and loading of containers on gearless ships.

(2) Installation of fenders at the South Wharf

After the completion of the new container terminal at the North Wharf, the South Wharf will exclusively be used for bulk cargoes. The pier structure of the South Wharf is damaged and needs repair or rather reconstruction. However, until alternative facilities for dry bulk cargoes are constructed and start operation, the existing wharf should be used with minor repair and careful operation without heavy load. The rubber fenders designed for Panamax size ship should be installed at the existing wharf in order to reduce the impact force during berthing.

(3) Zoning of the port area

With the implementation of the Short-term Development Project, the Port will be divided into three zones: dry bulk, container and general cargo/petroleum zones. To this end, the following components will be implemented.

- Bypass access roads
  By-pass access road will be constructed for dry bulk cargoes and general cargo so that each zone has a respective access road.
- Expansion of the backup area of the South Wharf.
- Additional entrance road for general cargoes.
- Pavement of apron of the North Wharf
  Besides the damaged pier structure of the North Wharf, the pavement of apron is deteriorated and heavily damaged in the middle section and cannot be used for loading/ unloading. Therefore, by repairing the pavement of apron, the northern part of the North Wharf shall be used for the unloading and loading general cargoes.

(4) Construction of a new container berth and container yard

A new container berth should be constructed at the western part of the North Wharf. The damaged berth that has the water depth of -7.5 m shall be demolished and renovated to a 320m long and – 14m deep berth with a 40 m wide apron. A new container yard shall be also constructed by demolishing warehouses No. 0, 1 and 2. In the container yard, RTG shall be installed to increase the storage capacity of the container yard.

(5) Widening of port entrance road and construction of gates

The port entrance road is widened and a total of 6 gates shall be constructed. The gates will have a communication system so that all the clearance procedures should be done at the gate (one stop shop).

(6) Ground leveling and road system in the North Wharf

The land area of the North Wharf is currently used for the stock yard of scrap. It is expected that export of scrap will cease as the steel mill in SEZ starts operation, and the land area should be leveled for multi-purpose use.

This work includes the demolishing warehouse A and B as well as the reconstruction of the port road.

(7) Introduction of grain unloader

Toward 2020, the capacity of the South Wharf may need enhancement. It is recommended to introduce unloaders for grain.

5.1.4 Urgent Rehabilitation Project

Of the components listed for the Short-term Development Plan, the following components are given priority to be included in the Urgent Rehabilitation Project.

(1) Container handling equipment
(2) Installation of fenders at the South Wharf
(3) Zoning of the port area
- Bypass access roads
- Expansion of the backup area of the South Wharf
- Additional entrance road for general cargoes
- Pavement of apron of the North Wharf

(4) Construction of a new container berth and container yard
(5) Widening of port entrance road and construction of gates

5.2. Recommendations

5.2.1 Improvement of port administration

(1) Capacity building for the port administration

It is recommended to enhance the administrative capacity of the government. It was proved by the Study that Nacala Port as well as other major ports in Mozambique has great potential to serve for not only the immediate hinterland in the country but also for the adjacent landlocked countries and landlocked regions. While each major port is making efforts to attract local and international transit cargoes, the government should take proactive measures to formulate a transport network and to encourage competition among major ports in the country.

One of the possible ways to promote capacity building is to have in-house experts in MTC elaborate a strategic development plan for the port system through the cooperative work with staff of CFM. Most of the international funding agencies, including JICA, provide expert dispatch programs.

(2) Legislation for the port development plans

It will take many years to realize the Long-term Development Plan of the Port. Thus, the land and the water areas of the project sites should be reserved until the development work actually starts. It often happens that when actual development work starts the projects site is already used for other purposes. Therefore, it is recommended to authorize the development plan and to legislate against the land use for other purposes than port related businesses.

To this end, firstly MTC should establish legal procedure for the authorization of the port development plan. Secondly, MTC should draw a port development master plan taking into consideration the Long-term Development Plan proposed in this report and authorize the master plan through the established legal procedure. In the course of the authorization of the master plan, the plan should be refined through the consultation with the agencies concerned and with the stakeholders. Once the plan is authorized and given a legal base, the use of the proposed port space, i.e., land and water areas, should be properly controlled by laws.

5.2.2 Promotion of the port related business

(1) Integration of SEZ and the Port

One of the advantages of the Port is that a SEZ has been established in the close proximity to the Port. By utilizing the advantage of the physical proximity of SEZ and the Port, SEZ should share some part of the functions of the Port. As a logistics center, vanning (stuffing) and devanning (taking goods out of containers) can be done at the freight station in IFZ of SEZ, which is a designated bonded area where imported goods can be brought in without undergoing custom procedures.

The Port is situated in the urban area of Nacala. In accordance with the increase of port cargoes, the traffic along the access road will increase. The existing road system leading to the Port is not sufficient to cope with the future traffic related to the Port. Therefore, the Port Expressway connecting the Port, the IFZs and the Corridor shall be constructed as discussed in section 3.9. In order to reserve the land for future infrastructure development and, to secure the consistency of land use in the immediate outside area of the Port, this area should also be controlled against unrestrained development. The area should be designated as Port Related Zone, where priority of land use is given to port related businesses.

(2) Strategic invitation of grain terminal

Of the dry bulk cargoes, grain is the principal commodity of the Port. Taking advantage of the large depth of the bay, the Study identified the potential of the Port as a grain transshipment terminal. While the Port has the potential to serve as a grain terminal, it cannot be realized automatically. To realize this potential, the Government and CDN should make efforts to invite a private company to run the logistics business for grain.

(3) Enhancement of the inter-modal connection between rail and the Port

The Port was originally designed as a transit terminal between train and ship. Therefore, rail trucks extend on the aprons of the wharves. Nowadays, direct transfer between rail and ship is no longer effective due to containerization and increase of ships' size. Therefore, rail terminal, which currently occupies a fairly large land area dividing the Port into two parts should be modernized.

Accordingly, the rail terminal including shunting area should be newly constructed outside of the existing port area. The multimodal terminal in the Port should be specially designed for the convenience of transfer of marine cargoes to/from trains.

(4) Cold chain for the export of agricultural products

Various projects are on-going for the development of the agricultural sector. While some agricultural products are transported in bulk, some others, such as fruits, are transported in reefer cars. At present, fruits are transported by reefer containers. As the export volume increases, reefer ships may be employed. In such occasion, the Port should contribute to the development of a "cold chain" by providing cold storage in the Port.

5.2.3 Modernization of the Port

(1) Establishment of strict delineation of container terminal

Container terminal should be enclosed and exclusively used for container handling only. For the maximum use of the limited land area, no passage or storage of other cargoes, vanning or devanning or no long staying empty containers should be allowed. The entrance and exit of containers at the gate should be strictly controlled and recorded. All movements of containers within the container terminal should be centralized so that the location of any container can be identified at any time: this is very important information for consignors.

(2) Removal of all the conflict of the traffic flow

By strict zoning, all the conflicts of traffic flow in the port area should be removed. To this end, gates and access roads should be separately designated by type of cargoes. The port road system in the North Wharf should be remodeled.

(3) Upgrading of ship traffic control

With the coal terminal, which is scheduled to start operation in 2014, strict and careful control is required for the sea safety in Nacala Bay. The responsibility of the harbor master will be greater and new regulation of ship maneuvering is required.

(4) Enhancement of port security

The Port has the potential to export copper ore from Zambia. Stricter security is required for those high value commodities. It is the responsibility of the Port to ensure security.

(5) Promotion of container transshipment

The Port is situated at a strategic location where several liner service routes overlap: one from the north originated from West Asia via Middle East while the other originated from Southeast Asia via Durban. At the Port container transship operation is performed between the two services. If the Port provides better service than in other ports, the port can expand its transshipment business.

(6) Reduction of burden of customs inspection

At present, customs office inspects all the cargo trucks coming in and going out of the Port by X-ray scanning system regardless of loaded or empty. This causes traffic congestion at the entrance of the Port. Inspection is compulsory for export containers and X-ray scanning system is used for the inspection of sealed containers. On the other hand, the import containers can be inspected by opening the containers.

As the volume of cargo increases, it is practically impossible to scan all the trucks. For the smooth and effective traffic flow, it is vital to stop unnecessary scanning such as empty trucks, bulk and general cargoes. Those containers generated in the factories in IFZ can be inspected before the sealing of containers at the factories.

5.2.4 Design of a new container terminal

(1) Toxic substance in the sediments

It was found that the sediments in front of the western part of the North Wharf contain toxic substance, in particular PCB. This area will be dredged up to – 14m after the completion of the new wharf. If the dredged material contains toxic substance, it should be placed in an enclosed basin that prevents seepage. Thus, the larger the volume of contaminated sediment, the higher cost is required for the construction of the enclosed basin. Therefore, in the course of detail design, sampling of sediment should be done not only on the surface sea bed but also in the sub-layers of the sea bed for the purpose of identifying the extent of the contaminated area and depth. It is also recommended to carry out chemical analysis of the toxic substance. With these additional information and data, the volume of the contaminated sediments and the method of placement of dredged material will be determined and the cost for the dredging will be estimated more precisely.

(2) Further confirmation of soil conditions during the detail design of the new wharf

During the Study, the boring was done with large intervals for the purpose of identifying the soil conditions over the whole wharf zone. The result showed that the soil condition at the western part of the North Wharf is quite complicated and varies considerably along the face line of the wharf.

Thus, it is recommended to carry our additional boring prior to the detail design of the wharf for the purpose of reconfirmation of the soil conditions where the new pier will be constructed. The boring should be done in smaller intervals, e.g., every 50 meters in the direction parallel to the face line of the wharf and every 30 m in the direction perpendicular to the face line. The soil sample should undergo both physical and mechanical tests.

(3) Monitoring for regular maintenance of the infrastructure

Monitoring, which is scheduled inspection of the port structures, and repairs should be performed for not only the new wharf that is proposed in the Study but also other existing facilities in accordance with the method proposed in this report. For the existing facilities, the monitoring should be started as soon as possible, while, for the new and rehabilitated facilities through the Urgent Rehabilitation Project, the monitoring should start immediately after the completion of the structure.

5.2.5 Preservation of function of the South Wharf

(1) Maintenance and minor repair of the South Wharf

The existing South Wharf has to be maintained to handle bulk cargoes. Therefore, CDN should keep inspecting regularly the progress of the damage of the pier structure.

(2) Control of berthing speed

Even though rubber fenders will be installed as a component of the Urgent Rehabilitation Project, the berthing at the South Wharf should be carefully controlled by the harbour master so that the ship should approach the parallel to the face line of the wharf and that the berthing speed should be no larger than 0.1 m /sec.

(3) Maintenance of rubber fenders

CDN should conduct periodical inspection of the fenders. Any damage should be repaired or fenders should be replaced as soon as possible.

(4) Regular maintenance programs

The inspection of the damage of the pile heads and the rubber fenders and the repair of them are performed as a regular program. The cost for the regular inspection and anticipated repairs should be budgeted as regular maintenance work.

5.2.6 Monitoring of financial status of CDN (TOC)

CFM (PMB) has to monitor CDN's (TOC's) financial account, in particular cash flow, from the standpoint of a supervisory authority of the project for the purpose of ensuring sustainability of the port development and sound operation. It is recommended that TOC should open reserve accounts, which is an effective measure to monitor and control the cash flow of TOC. The reserve in the account should be exclusively used to cover a cash flow shortage to avoid going overdue on the loan repayment of the project. Amendment of the concession agreement, therefore, is required to stipulate to open reserve accounts for the payment of concession fees and maintenance expenditure.

The following financial accounts are often used for the monitoring of the cash flow:

(Main account)

- Revenue account: TOC revenue is firstly credited to this account which is the most significant and the source of cash flow for several sub-accounts.

(Sub-account)

- Operation account: Operation costs for present and next month is credited to this account.
- Concession fee account: Amount of concession fixed and variable fees for the coming date of payment is credited to this account and paid to PMB.
- Concession fee reserve account: This reserve account is to avoid an overdue payment due to a short-term cash shortage.
- Major maintenance reserve account: 1% of civil work cost and 2% of equipment procurement cost is reserved in this account.
- Distribution account: This amount is at the bottom of the sub-accounts.

5.2.7 Important issues for the construction works of Urgent Rehabilitation Project

(1) Urgent Rehabilitation Project Part-1

1) Bypass access road

Since the road will be constructed on the coast, the revetment works will be needed before the road construction works. Estimated total volume of rubble and armor stone for the revetment is around 64,000 m^3; it will be executed by using a barge with a crane. Estimated total volume of backfill for the road works is around 52,000 m3. Backfilling work will be executed from the landside to the South Wharf.

2) Pavement of apron at the northeast side of the North Wharf

The northeast side of the North Wharf is used for oil terminals; therefore, the use of fire is strictly prohibited in this area. Accordingly, machines or works such as concrete breaking, which may cause fire or explosion, are not permitted for use in this area while oil or gas tanker is berthed at the wharf. Therefore, it is necessary to relocate the oil handling function to the southwest side of the North Wharf temporarily for the duration of the construction. This scope of works includes the demolition of the existing structures/pavement, excavation, concrete pavement, coping concrete, installation of fenders, etc. All works should be finished within 2 months as soon as possible to mitigate the hindrance to the operation of the oil terminal.

(2) Urgent Rehabilitation Project Part-2

1) Reconstruction of the North Wharf

The southwest side of the existing berth in the North Wharf will be demolished and a new berth will be constructed by the steel pipe sheet pile method. Furthermore, a new container yard will be constructed behind the new berth.

2) Dredging (-14 m)

Dredging works will be carried out upto the elevation of -14m in the area in front of the new container berth, by a grab dredger with enclosed-type of bucket. As the bottom sediments to be dredged are contaminated, it is necessary to study appropriate countermeasures according to the environmental regulations to prevent diffusion of the pollution into seawater. Dredged material will be transported by barge to the landfill yard enclosed by the bypass road. The consultant for engineering study and detailed design and the construction contractor should have past experiences in dredging and disposal of contaminated sediment. Especially, the past experiences to dredge PCB contaminated soil and equipment details of enclosed-type of grab bucket are to be demonstrated at the stage of preliminary qualification for the consultant and the contractor.

(3) Mitigation measures for the hindrance to the port operations

1) Temporary construction road

Prior to the construction, a temporary construction road and a gate will be constructed between the existing road located on the east side of the entrance road of the Port and the east side of the CDN office in the Port. All the trucks and vehicles related to the construction should not pass through the gate of the Port or the entrance road, so that regular port operations will not be affected. The construction works shall be done in a safety manner, such as traffic control of heavy vehicles.

2) Construction at sea

Before construction, the transportation routes of the barges on the sea near the Port need to be determined through discussions between the contractor and the related persons in the Port. The working area needs to be marked by buoys, and a safety patrol boat needs to be arranged to prevent accidents.

3) Construction in the Port

Before construction, a meeting needs to be held between the contractor and related persons in the Port to discuss mitigation methods to avoid the hindrance to the regular port operations. Suitable actions, such as partial execution, specifying the execution areas and employment of a safety guard will be required. The Contractor shall take appropriate care and coordinate with CDN’s operation and oil unloading works during the period of the construction at the Port.

5.2.8 Environmental issues

According to the sediment quality survey conducted by the Study Team, high levels of harmful substances such as PCBs, TBT and DDT were detected in the bottom sediments around the Port. Therefore, in the ensuing stages (e.g. D/D phase) a detailed sediment quality survey should be conducted at the proposed dredging site to identify the extent of contamination in the surface as well as subsurface levels. The draft TOR of the sediment quality survey is attached as Appendix-9.

Dredging of contaminated areas should be conducted in a manner that minimizes sediment dispersion. Options to minimize sediment dispersion include the use of silt curtain and enclosed-type grab bucket (see Section 4.13.7 (3) 3) for more details).

Contaminated dredge spoil should be disposed in a manner that will prevent contamination of the surrounding environment. One option is to dispose it in an impermeable confined disposal facility (see Section 4.13.7 (3) 6) for more details). As a condition of preliminary qualification, the construction contractor should be required to have sufficient experience and expertise (e.g. use of enclosed-type grab bucket) in dredging and disposal of contaminated sediments (e.g. PCBs).

Dust emission from bulk cargo handling, in particular clinker, should be minimized by improving the handling equipment and procedures (see Section 4.13.8 (3) 1) for more details).

The Port and relevant stakeholders should discuss measures to minimize environmental risks associated with ballast water discharge and harmful anti-fouling paint (see Sections 4.13.8 (2) 1) and 4.13.8 (3) 5) for more details).

MTC should inform MICOA about the project and proceed with the EIA procedure as soon as possible (see Section 2.8 for details on the EIA procedure). The EIA should be approved by MICOA before the appraisal of international development partners.

The EIA should also be in compliance with JICA's environmental guideline "JICA Guidelines for Environmental and Social Considerations (April 2010)". MTC should in particular make sure that the EIA covers the check items of the "Environmental Checklist" which is part of the above guideline. A draft version of the "Environmental Checklist" is attached as Appendix-11.

APPENDIX

Appendix-1

Minutes of the 1st Stakeholders Meeting of the Nacala Port Development Project

Date: July 2nd, 2010

Local: Complexo Napala – Nacala

Starting time: 9:15 am

End time: 11:00 am

Participants: Attached list

In July 2nd, 2010, it was held the ceremony to, officially, launch the Nacala Port's Development Project in which there was an intervention of the local authorities, government, some members of the SADC committee, as well as of elements of the key institutions involved in the implementation of the project, namely, the National Director for the MTC Infra-structures, the CDN's CEO, GAZEDA, and the Team Leader of the JICA.

Speech 1: The National Director for the MTC Infra-structure - Made the introduction making the presentation of the spokespeople, and passed the word to the CDN's CEO.

Speech 2: CDN's CEO - Praised the initiative and mentioned that the development of the Nacala's Port & Corridor will benefit all the northern region of Mozambique, as well as Tete Province (coal mines), including the neighboring countries, specifically Malawi and Zambia. He mentioned that, in a short term, Tanzania will also make use of the infra-structures mainly due to the exploitation of coal in the northern region of this country.

- Dr. Couto emphasized the importance of integrating the railway systems from Mozambique to Malawi and Zambia ("…this is the only project that integrates Port & Railway Systems in the region…").

- CDN has the obligation to include the transport services of goods & passengers in the northern region of Mozambique.

- Probably due to this development project there will be a 3rd factory of cement in Nacala (the biggest concentration of cement factories in the country)

- Nacala Bay/Namalala Bay has the advantage of having deep waters (38 m deep) that even the bad whether does not interfere in its operations, big ships can navigate with ease, …

- 70% of the cargo is containers

- Need to relocate the oil terminal to avoid contamination and avoid unpleasant incidents, make a new pipeline as the actual location around Nacala City is dangerous

- This study will recommend the construction of a hub for containers. The only hub in the southern region is located in Durban – SA. There are conversations with the government about this issue.

- As part of this project, it is in course the transformation of the air forces airport into an international airport.

- The plan of the oil refinery is not for a near future due to financial issues.

- Presentation of statistics slide show regarding various areas that are enclosed in the Nacala Port & Corridor area.

- Why is Nacala a pole of development of the Northern region? Because it has a deep waters port, an operational city with all necessary infra-structures, it is located in the Mozambique Channel that is the route of 80% of the oil and ore in the region, and fruits in a near future.

Speech 3: JICA – Team Leader – He made a brief presentation of the project starting by the Objectives of the Study, the Implementing Agency of the study, the actual Situation of Nacala Port and Corridor, the Existing Facilities of Nacala Port, the Scheme of the Technical Cooperation of the Japanese Government, the Hierarchy of the Development Policy/Plans, the Areas of Origin and Destination of Nacala Port Cargoes, the Key issues of the Study, the Environment and Social Considerations, and the Schedule of the study.

Speech 4: GAZEDA – Dr. Nhombe – Mentioned the approval by the government for the creation of the Special Economic Zone in Nacala, in September 2007, as the beginning of the transformation of this area into one of the most important poles of economic development in Mozambique.

-This Special Economic Zone has the particularity to influence with its potentials and established benefits, the Nacala Corridor that covers the provinces of Nampula, Niassa, Cabo Delgado, and Zambézia. The influence of this zone goes beyond the the Mozambican border covering neighbor countries like Malawi, Zambia, Tanzania, DRC, boosting the process of regional integration that is being held by SADC.

- There is no doubt that the rehabilitation & expansion of Nacala Port will improve CDN’s services.

- Nacala Port & Corridor is a strong ally in the process to fight poverty in Mozambique.

- Promised that the population of the Special Economic Zone in Nacala, the local & foreign entrepreneurs, all public & private institutions will transform Nacala in an industrial park of reference in the southern region of Africa.

Speech 5: Representative of the Government in Nacala – Said that this project is seen with great expectations, and there is no doubt that it will improve Nacala’s life in all senses, as well as the surrounding regions.

Speech 6: President of the City Council – Praised the initiative of rehabilitation & expansion of Nacala Port, and mentioned the fact that this adds value to the economy of the region, and of Nacala above all. He also introduced some key people and decision makers of the local community.

Comments of the Participants

Name:Armindo Chauque

Occupation: Nampula's Environment Director

- The meeting was productive because we could understand the challenges that are expected in the social and environments aspects. I hope that the scheduled meetings will be fulfilled, and take into account some aspects regarding the natural environment after the beginning of the process of rehabilitation & expansion of Nacala Port. We also hope to be invited to discuss with you the study of the environmental impact that this project will bring.
- We also hope that the JICA considers the study of the environmental impact for the rehabilitation of the railway that connects Nacala and Moatize.

Name: Mário Camilo

Occupation: Nacala's Labour Director

- The presentation of the study was excellent taking into consideration that there was a concern of introducing the important guests, and the parts involved in the project.
- It is an ambitious project, and from what was presented there is confidence that Special Economic Zone in Nacala will be with no doubt an economic potential in the region.
- We thank those who had the idea of announcing this project through this study.

Name: Sansão Horácio

Occupation: Director of the Nacala's Fiscal Area

- The presentation of the study was excellent.
- Appreciated the fact of some presentation being done in Portuguese & English.
- Hope this project will come true.
- As it was identified a deep waters place in Namalala, it should be projected the development of tourism in one of Nacala's beaches, taking into account the pollution of the water due to the projects of port and the oil refinery.

Name: Champion Machauqueque Amade

Occupation: Councillor for Urbanization at Nacala's City Council

- The rehabilitation of Nacala port is extremely important in order to warranty the berthing of big vessels and create jobs.

- This will be the right answer from the government after the definition of Nacala as a Special Economic Zone for the fast development of the areas of Nacala-Porto and Nacala-a-Velha.
- But it is important that the rehabilitation begins so that the so waited dream of the participants in this event and others comes true.

Name: -

Occupation: Department of Environment Management

- The meeting was productive. The projects that were presented will bring good results in case it is fulfilled. But it is important to consider the environmental aspects as the port is located in an area that has a valuable and sensitive ecologic system.

Name: Gilberto Andrade

Occupation: SDV' Ami – Chief Administrator

- The initiative of meeting was positive.
- Along the elaboration of the project it should be important to give especial attention, among other things, to the container handling machinery and bulk cargo.
- Should be used good equipment, and its maintenance services should be regular and professional.

Name: Latifo Buananti

Occupation: Fisherman's Organization

- It is a god signal for Nacala's development.

List of participants

	Name	Position / Institution
1	Lovemore Bingandadi	SADC / Corridors Advisor
2	Paul Kulemeka	Chief executive officer, Road Authority, Malawi
3	Harumi Maruyama	JICA Mozambique Office
4	Ussemane Julai	CDN P
5	Albertina Loni	GAZEDA
6	Maria Olivia Bravo	CDN – Official of Communication
7	Delson Hamido	TN Manager
8	José Joaquim Daúdo	C.F.M North Delegation
9	Califa Assotema	
10	Mendes Tomo	S.D.H.E. Director
11	Marcelino Mawheira	CIMPOR Director
12	Eulalia Ouchin	Agrifuturo Coordenator
13	Selemane Palode	Municipal Counsel President
14	Mike Donald	Logistics Allowance
15	Ermelinda Mapose	Pedagogic University Administration Director Assistant
16	Vasco D. Matos	Municipal Counsel
17	Macopa	CDN
18	M. Riaz	CDN
19	Mario Cambo	Labour Director of Nacala
20	Gilberto Andrade	Administration and HR of SDV AMI
21	Paulo Leonardo	Heath Director
22	Rafael Abilio Monteiro	SDEZT Director
23	Nelo Lazaro	Diary Mozambique Journalist
24	Vasco Gama	Journalist
25	João Mabombo	BAD
26	Armindo Chauque	Environment Director
27	Victor Lopes	Environment Management Technical
28	??????????????	Transport and Communication-Nampula
29	Jose Francisco Mamone	Transport and Communication – Nampula
30	Januario Sumaila	The Head of General Office of DPPCN
31	Raimundo Machel	Town Councilor of Transport at Municipal
32	Buana Ali	Town Councilor of Economic at Municipal
33	Eucrecia S. Cossa	Town Councilor of Social at Municipal
34	Justino Soja	Town Councilor of Municipal
35	?????????????????	ANE
36	Aderito Mail	ANE
37	Star Horacio	ATO- Fiscal Area
38	Jose Alexandre Fain	M.S.C (Mediterranean Shipping Company)
39	Pramoz	Bakhresa Millin Manager
40	Antonio Pilale	District Governor- Administrator
41	Abdul A Osman	ATRON
42	Joao Mabombo	BAD
43	Ibraimo	MANICA
44	Daniel Sitoe	Maritime Administration

	Name	Position / Institution
45	Batista	DPTC-Nampul
46	Chale Ossufo	Nacala Municipal President
47	Daniel Chapo	Nacala-a-Velha Administrator
48	Daniel Gimo	Nacala Permanent Secretary
49	Joao Sualehe	Shipping-agent MOZSTAR
50	Champion Amade	Municipal Councilor
51	Elias Mwape	Road Development Agency
52	Agostinho Langa	CDN- Porto
53	Branquinho Nhombe	ZEEM Delegat
54	Celestino de Sousa	DIPREME
55	Fernando Couto	CDN-CEO
56	Fila Logeno	DIDPREME
57	Vicente Martins	TVM Journalist
58	Ancha Buana	Community Authority
59	Samuel Catutula	MOCARGO
60	Andre Coto	CDN
61	Jahamo Calima	IPEX/UCODIN
62	Julio Paulino	Journalist

Minutes of the 2nd Stakeholders Meeting of the Nacala Port Development Project

Date: December 16th, 2010

Local: Complexo Napala – Nacala

Starting time: 10:00 am

End time: 13:00 pm

Participants: See attached list

1. Objective and agenda of the meeting

The objective of the meeting was to inform and obtain opinions of the stakeholders about the proposed short-term development plan of Nacala Port, its potential environmental impacts and mitigation measures. Dr. Kobune, the leader of the Study Team, first made a presentation on the short-term development plan, which centered on explanations on the main project components. Mr. Sato, the environmental expert of the Study Team, then presented the potential environmental impacts and mitigation measures. The main impacts explained were regarding impacts of dredging, access road construction, bulk cargo handling and ballast water discharge. After the presentation, a Q&A session was held, which is summarized below.

2. Summary of the Q&A session

	Name/organization	Question/opinion	Answer
1	Mr. Antonio Frederico CDN	There were mistakes in the translation of some technical terms (e.g. ballast water) and should be corrected in the future.	The mistakes will be corrected in the future.
2	Mr. Daniel Sitoe Maritime Administration	What measures are available to reduce the risk of transporting invasive species through ballast water?	IMO adopted in 2004, “International Convention for the Control and Management of Ships Ballast Water & Sediments”, which requires ships to control/treat ballast water prior to discharge. However, due to lack of effective treatment technologies, the convention is not yet in effect. Although not 100% effective, currently the most common measure is to exchange ballast water in open ocean, which is for the time being probably the most realistic option for Nacala Port. Other options include treatment of ballast water on ships or at port, but these measures are still not widely employed. Bulk carriers that will export bulk commodities from Nacala (e.g. coal) are particularly of high concern as they will come to Nacala Bay full of ballast water.
3	Mr. Mario	What measures are available to minimize dust dispersion from clinker operation?	One possible option is to raise the height of the receiving part of the hopper, which should reduce dispersion during unloading operation.

4	Mr. Salate	During dredging, how will the silt curtain be installed?	The Study Team is still considering the best option on how to install silt curtain.
5	Mr. Antonio Frederico CDN	Has the Study Team considered the effect of land-based pollution sources (e.g. factories, workshops) when analyzing the cause of pollution around the port?	The Study Team acknowledges the fact that land-based pollution sources may be one of the causes of pollution around the port. However, we have not analyzed the extent of how much land-based pollution sources are contributing to pollution, and a separate study will be required to fully understand it.

3. Closing remarks

The meeting was closed by speeches from representative of CDN and MTC.

4. Opinion sheet

The Study Team distributed an opinion sheet so that the participants could write any comments/opinions about the meeting. Following are the submitted comments/opinions.

Name/organization	Comments/opinions
Nuno Paulino—BP	The performance was good, especially in the chapter of environmental impact. However, I remained in some doubt, because the amounts involved were not advanced, if the project is already approved or not. What impact will direct this project in the current fuel terminal.
Alves dos Santos Salato—AENA	My opinion about the meeting today is high excellent. The explanation was noticeable and shows without doubt that the fate of the project prior public consultation and the result of the sample view of the Mozambican people. I think that also involves bay of Nacala Nacala-a-Velha, so this had to expand the building but on the other side of the bay. They should also involve associations to do the Environmental Impact Study, as AENA whose main purpose and mission is "Healthy Environment for all ". This may help to check the sources of pollution.
Ibraimo Essimela Amade—Associação dos pescadores de Naherenque	It was grateful for the meeting. Thanks.
Daude Califa—Associação dos Pescadores de Naherenque	For me it was good.
Califa Buanauli—Associação dos Pescadores de Naherenque	For this meeting, I liked very much to have a strategic objective for the development of the city of Nacala and the country.
Calibo Califa Buanauli—Associação dos Pescadores de Naherenque	Already spoken of the sentinel network that will relieve the marine resources that are outside the network? What is the treatment that will give existing resources within the network of feeling.
Manuel Ussene—Conselho Comunitário de Pescas	As a responsible fishing port of Nacala, I was very happy for what will happen in the coming years. Thanks.
Rade Nifane—Associação dos Pescadores de Naherenque	My opinion about the meeting today went well.

Note: The translation may not be accurate as some of the hand writing was not readable.

5. Participant list

No.	Name	Organization
1	Califa Buandi	ASSOPENA
2	Calibo Califa	ASSOPENA
3	Duanda calefa	ASSOPENA
4	Ibraimo Essimela	ASSOPENA
5	Manuel Ussene	PCCP
6	Carlos Alberto Joel	IDPPE -Nacala
7	Rade Nifaine	ASSOPENA
8	Tagir Rasse	UP –NPL -NAl
9	Crimildo Madeira	CDN
10	Nahulue	
11	Michael Smewing	SDV AMI
12	Brice freyes	SDV AMI
13	Paulo	Caia
14	António F. Candido	CDN
15	Dionísio Mendes	Alfandegas de Nacala
16	Gilberto Salomone	KUDUMBA
17	Rosário Chicose	MOCARGO
18	Marcelino Madeira	CIMPOR
19	Ibraimo Assumade	MANICA -S.S
20	Nuno Paulino	BP -Moçambique
21	Daniel Sitoe	ADEMAR -Nacala
22	Afonso Brito	DIAMOND SHIPPINGS
23	Helder Langa	NECTAR MOZ LIN
24	João Sualche	MOZSTAR Lda
25	Alves dos Santos Salato	AENA
26	Raime R. Pachinuala	Terminais do Norte
27	Abudo Sele Faquihe	CDN
28	Salim Talaquichande	GAZEDA
29	Benedita Angelina Nuro	GAZEDA
30	Marc Guyonnaud	CMACGM
31	Orlando Alfredo Manhique	M. dos Transportes e Comunicações

Minutes of the 3rd Stakeholders Meeting of the Nacala Port Development Project

Date: April 12th, 2011

Local: Naherengue Complexo Turístico – Nacala

Starting time: 10:00 am

End time: 13:00 pm

Participants: See attached list

1. Introduction

The meeting started with opening remarks from the national director of MTC, the mayor of Nacala Municipality and the administrator of Nacala District. Mr. Langa of CFM acted as the facilitator of the meeting.

2. Presentation by the Study Team

Dr. Kobune, the team leader, first presented the contents of the proposed long/medium-term, short-term and urgent development plans of Nacala Port.

Mr. Sato, the environmental expert, presented the main environmental impacts of the Urgent Rehabilitation Project of Nacala Port, and recommended countermeasures. His presentation focused mainly on the following points:

- Impacts of dredging
- Disposal method of contaminated dredged spoil
- Impacts of bypass access road and stockyard construction
- Risk of ballast water discharge inside the bay
- Impacts of antifouling paint systems

3. Discussion

(1) Mr. Chale Ossufo, the mayor of Nacala Municipality expressed his support towards the proposed development plans of Nacala Port. However, he expressed his objection regarding the location of the proposed oil terminal, as a new sewage treatment plant is planned in the vicinity. He also added that in the future around 40,000 people are expected to inhabit the area behind the proposed oil terminal, and the accidental risks will be too high for the residents.

In response to the location of the oil terminal, Dr. Kobune commented that its location was determined by referring to the master plan of Nacala Bay, as well as the municipality's land use plan.

The mayor commented that the future stockyard zone will not constitute a problem towards the local fishermen, as the project is of capital importance and the expectation of the development is beyond fisheries. He also highlighted the risk of ballast water discharge and the need for the urgent ratification of the relevant IMO Convention by Mozambique. The mayor also raised concern on the life span of the confined disposal facility and how long it will contain the contaminated sediments.

The question was answered by the Study Team as follows:

Mr. Sato explained that the confined disposal facility will be enclosed by an impermeable liner, which is designed to last permanently. However, it will be important to employ a construction company that is experienced in constructing confined disposal facilities.

Dr. Kobune also commented that a detailed sediment quality survey will be implemented prior to the detail design, to identify in detail the extent of contamination in the dredging area. The final design of the confined disposal facility will be determined in accordance to the survey results.

(2) A representative of CMA CGM (port operator) expressed concern over the possible lack of capacity of the new container terminal, since the Urgent Rehabilitation Project proposes just one new container berth. He emphasized the fact that the port is already becoming congested due to the increase in both bulk and container cargoes.

Dr. Kobune acknowledged his opinion and stated that indeed the new container terminal will not be sufficient unless the port drastically improves its cargo handling efficiency. To improve the cargo handling efficiency, the Urgent Rehabilitation Project will procure new cargo handling equipment such as reach stacker, RTG, yard trailer/chassis, etc. It is expected that the installation of these new equipment will double or triple the capacity of the container berth.

4. Opinion sheet

The Study Team distributed an opinion sheet so that the participants could write any comments/opinions about the meeting. Following are the submitted comments/opinions.

Name	Institution/Opinion
Bernardinho Nhombe	GAZEDA The meeting was very good despite the late start. The invitation came to us in time, so I wish to thank CDN.
Ibraimo Mussa	MANICA FREIGHT SERVICES My suggestion is to include in the study of environment, the dynamic of ocean. Because as you know we are facing climate changes and the water level will increase and it is necessary to think about it.
Fernando R. Adamuges	MOZAMBIQUE PORT LDA - NACALA It was a very interesting meeting for the improvement of Nacala. It will also contribute to the country’s economy including the land-locked countries. We expect the urgent plan to be in place.
Ancha Buana Alide	THE QUEEN OF NACALA I hope the plan is realized as it will help all the people in Nacala Porto. We are interested in the development of Nacala.
Milala Abdala	This is a great project! The project is well come!
Antonio Pilale	GOVERNMENT OF NACALA The meeting allowed the people from Nacala to obtain information about the development plans of the port and also provide opportunities to express their opinions. It was good to have the mayor of Nacala Municipality at the meeting.
Jose Alexandre da Rocha	MEDITERRANIAN SHIPPING COMPANY The meeting was instructive and fulfilling. Thank you!
Inocencio Horacio	CDN – PORTO DE NACALA The meeting was productive even though it started late.
Danilo A. Laice	PETROMOC The meeting was productive. There was room for debate and the issues were concerned to Nacala Port Development.
Challe Ossufo	MUNICIPALITY OF NACALA PORTO I was impressed of the importance of the productive meeting that will bring incomes to the country in general and the District in particular. At the next meetings, more local participants should be invited.
Franco Anselmo	CFM - NORTE The meeting was productive. For the next consulting meetings more

	people should be invited, even the ones from Malawi and Zambia, because I believe they could bring more inputs.

Note: The translation may not be accurate as some of the hand writing was not readable.

Participant list

	Name	Institution
1	Chale Ossufa	Municipality of Nacala, President
2	Antonio Pilale	District of Nacala, Administrator
3	Ana Dimande	MTC
4	Emánuel Impissa	GOV. NACALA -A- VELHA
5	Branquinho Nhombe	GAZEDA
6	Salim Talaquichande	GAZEDA
7	José A. Bonilla	ODEBRECHT
8	Tomás Armando Nhane	DPPF
9	António Clemente	CINAC
10	Anibal Manave	CFM
11	José Joaquim Daúde	CFM-NORTE
12	Cristino de Oliveira	CFM-NORTE
13	Franco Catutula	CFM
14	Agostinho Langa	CDN
15	Loni Shott	CDN
16	Inocênio Horácio	CDN
17	Pilale Abdala	ADMAR
18	Virgínia Chaúque	ALFÂNDEGA
19	Agostinho Sunzuane	BAKHRESA
20	Akash Pinay	BAKHRESA
21	Manuel Ussene	CCP-NAHERENQUE
22	Marc Guyonnaud	CMA CGM
23	John Hoeben	CMA CGM
24	Cornélio João Baptista	IMA
25	Hercídio António	KUDUMBA
26	Timone Barnaba Calanse	MAERSK LINE
27	Ibraimo Nazimo Mussa	MANICA
28	Zainadine João Dauane	MIGRAÇÃO
29	Fernando Adamugy	MOZPORT
30	José Alexandre da Rocha Faia	MSC (MOZ) Lda
31	Helder Langa	NECTAR MOZAMBIQUE
32	Danilo Laice	PETROMOC
33	Hetar A. Amisse	RADIO WATANA
34	Ancha Buana	RAINHA
35	Michael Smewing	SDV-AMI
36	Raime Raimundo Pachinuapa	TERMINAIS DO NORTE
37	Denílson Hamide	TERMINAIS DO NORTE
38	Floriberto Fernandes	TVM
39	Luis trichade Gamariel	UTI MOÇ. Lda
40	Koji Kobune	Leader, Study Team
41	Masafumi Ito	Member, Study Team
42	Takeshi Sato	Member, Study Team
43	Paulo André Tovela	E.S.C.N, Interpreter

Appendix-2

Minutes of meeting with local fishermen in the Nacala area

Date/time: December 14th, 2010   14:00-15:00
Place: Outdoor meeting place in Naherengue
Participants: JICA Study Team (Mr. Kobune, Mr. Sato)
See attached list for participants from local fishermen

Summary of meeting:

After an introductory speech from Mr. Carlos Alberto Joel of IDPPE, Mr. Sato of JICA study team made a brief presentation on the proposed Short-term Development Plan of Nacala Port, and the potential impacts that may have on the local fisheries and planned countermeasures. The following table shows the potential impacts and proposed countermeasures explained during the meeting.

	Potential impact	Proposed mitigation measures
1	Possible reduction of fish catch in areas near the port due to marine construction works such as dredging. Dredging may cause deterioration of surrounding water quality (e.g. increase water turbidity) and cause fishes to temporally escape to other areas.	Silt curtains will be installed to minimize dispersion of sediments.
2	Dredging could disperse the polluted sediments around the port, and hence contaminate marine life near the port.	Silt curtains will be installed to minimize dispersion of sediments and hence risk of marine life contamination. The dredged sediment will be disposed into a confined disposal facility.
3	Some beach areas used for fishing activities (e.g. beach seine) will be lost due to construction of the new access road.	The access road will be carefully aligned to minimize loss of beach area.

After the presentation the following questions were raised by the participants:

Q1: The local fishermen don't have a fixed boat parking area, and instead park their boats wherever suitable on the day. How will the port development affect boat parking?
A1: The port development, in particular the access road, will reclaim some portion of the beach near the port. Those fishermen that park in the proposed access road area, which is not many, will have to park at a nearby beach.

Q2: I park my boat at a sandbar near the cement factory. Will port development affect boat parking in that area.
A2: The port development will not affect the sandbar near the cement factory, as the Short-term development plan does not expand towards north.

Q3: Since dredging will generate turbid water, does that mean there will be no fish near the port?
A3: We plan to install silt curtain around the dredging area. That should contain turbid water within proximity of the port, hence fish outside the silt curtain should not be affected too much. In any case, fishing is prohibited near the port. Also please complain to the port, if unacceptable amount of turbid water is dispersing from the dredging area.

The meeting was closed by a closing remark from a representative of the local fishermen, expressing his appreciation for informing the fishermen in advance of the port development.

Participant list:

Lista de participantes

	Nome	Bairro	Contato
1	Calila Califa	Muzuane alta	– ASSOPENA
2	Ibraimo C. Amade	Cas. Nauaia	– ASSOPENA
3	Kade N. I. Saide	NAUAIA	ASSOPENA
4	Hlimo	Muzuane Baixa	ASSOPENA
5	Califa [illegible]	Muzuane alta	– ASSOPENA
6	Manuel Zissene	Naherengue CCP	
7	Maria [illegible]	Técnico do IDPPE	Nacala
8	Chame [illegible]	Motorista do IDPPE	Nacala
9	Acácio [illegible]	Nauaia Secretário	
10	Dauda Califa	Muzuane	ASSOPENA
11	Assuate Sefo	Muzuane	ASSOPENA
12	Omar Amisso	Nauaia	ASSOPENA
13	Ibraimo Amisse	Muzuane	ASSOPENA
14	[illegible]	Chefe do Posto A. Matire	
15	Carlos [illegible]	IDPPE – Nacala Marave	
16	Cassimo Abudo	Muzuane	ASSOPENA
17	Virginia de Abiba Nauaia	Muzuane	ASSOPENA
18	Fátima Faquilo	Muzuane	ASSOPENA
19	Carlos Chaua	Secretário do R. Muzuane	
20	Rema Amade	Nauaia	ASSOPENA
21	Rande Fatima	Muzuane	ASSOPENA
22			
23			
24			
25			

Appendix 3 Results of water and sediment quality surveys

(1) Water quality

To understand the water quality status around the Port and Nacala Bay, the Study Team conducted a water quality survey on July 16-17th, 2010. The field works and laboratory analysis were sub-contracted to PARETO, a consultant based in Réunion.

1) Methodology

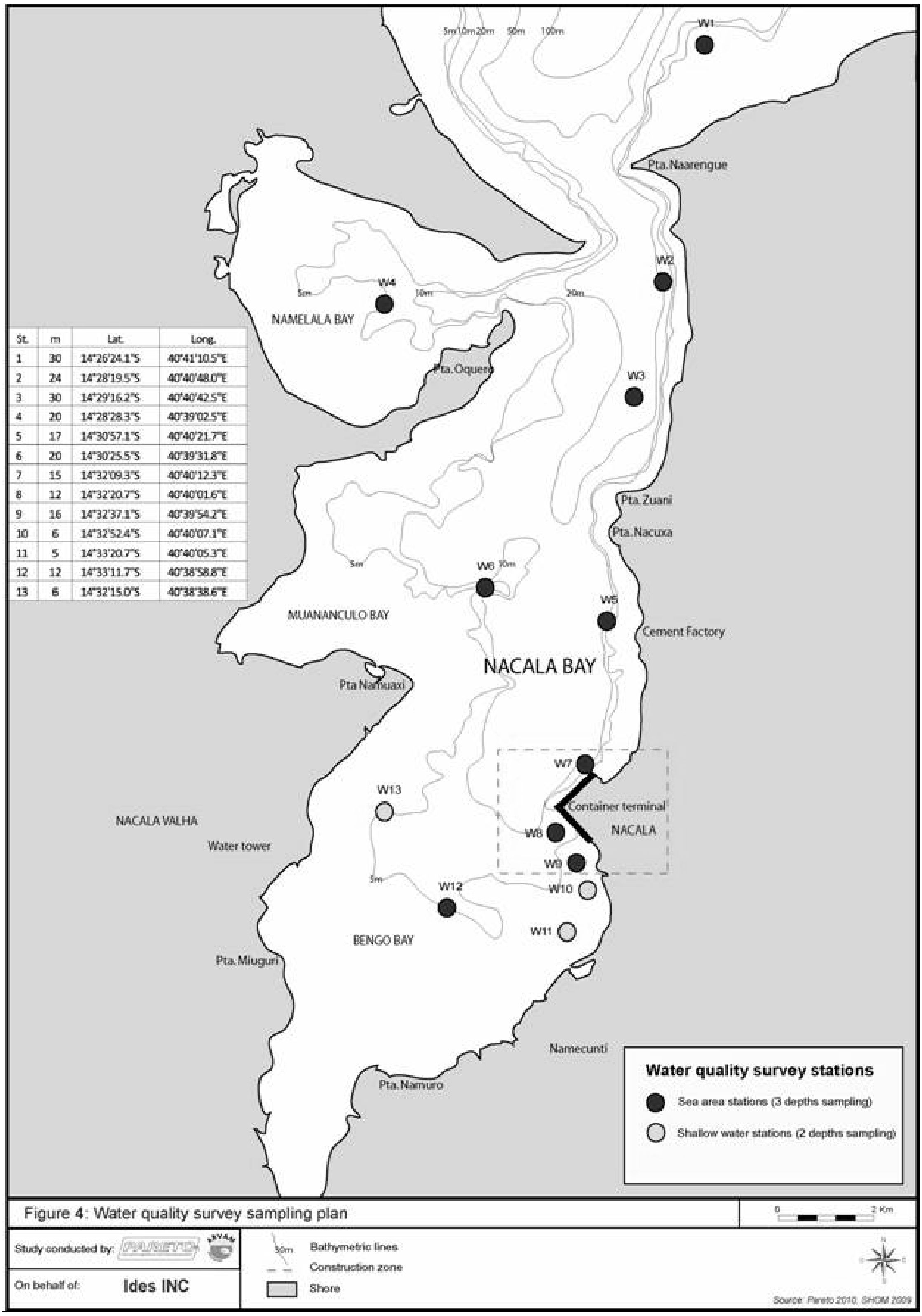
Table 1 shows the surveyed water quality parameters and employed methodologies. Water temperature, pH, salinity, dissolved oxygen (DO) and transparency were measured *in situ*, by using specialized equipments. The other parameters were analyzed at certified laboratories.

Figure 1 shows the location of the surveyed sites (total of 13 sites). Water quality was measured at the surface, middle and bottom layers. However, in shallow areas (St. 10, 11 and 13), measurements were conducted only with the surface and bottom layers.

Table 1 Surveyed water quality parameters and employed methodologies

Parameter	Unit	Measurement/sampling method	Analysis method	Quantification limit
Water temp.	°C	*In situ* (YSI 600 QS multi-parameter probe)	-	-
pH	-	*In situ* (YSI 600 QS multi-parameter probe)	-	-
Salinity	PSU	*In situ* (YSI 600 QS multi-parameter probe)	-	-
Dissolved Oxygen (DO)	mg/l	*In situ* (YSI 600 QS multi-parameter probe)	-	-
Transparency	m	*In situ* (Secchi disk)	-	-
Turbidity	FNU	Niskin bottle	NF 27027	0.01 FNU
Total Suspended Solids (TSS)	mg/l	Niskin bottle	NF UN 872	0.02 mg/L
Total Nitrogen (T-N)	mg/l	Niskin bottle	NF EN ISO 25663	0.2 mg/L
Total Phosphorus (T-P)	mg/l	Niskin bottle	NF EN ISO 6878	0.02 mg/L P
Total Hydrocarbon (THC)	mg/l	Niskin bottle	NFT 90-202	1 mg/L
E. coli	CFU/100 ml	Niskin bottle	IDEXX method	0.01 CFU/100 ml

Note: T-N, T-P and THC were analyzed at Laboratory of Rouen, a COFRAC accredited (French accreditation) laboratory. Turbidity, TSS and *E.coli* were analyzed at PARETO's laboratory.
Source: Study Team



St.	m	Lat.	Long.
1	30	14°26'24.1"S	40°41'10.5"E
2	24	14°28'19.5"S	40°40'48.0"E
3	30	14°29'16.2"S	40°40'42.5"E
4	20	14°28'28.3"S	40°39'02.5"E
5	17	14°30'57.1"S	40°40'21.7"E
6	20	14°30'25.5"S	40°39'31.8"E
7	15	14°32'09.3"S	40°40'12.3"E
8	12	14°32'20.7"S	40°40'01.6"E
9	16	14°32'37.1"S	40°39'54.2"E
10	6	14°32'52.4"S	40°40'07.1"E
11	5	14°33'20.7"S	40°40'05.3"E
12	12	14°33'11.7"S	40°38'58.8"E
13	6	14°32'15.0"S	40°38'38.6"E

Source: Study Team

Figure 1　Location of the water quality survey sites

2) Results

General water quality parameters

Table 2 shows the results of general water quality parameters. Following are the main findings.

- Water temperature ranged between 25-26 °C, and tended to be higher at shallow waters (St.10, 11 and 13). Although water temperature was generally slightly higher at the surface layer, the temperature difference between the layers was small (less than 0.5 °C).
- Salinity ranged between 34-35 PSU, and tended to be slightly higher at the surface layer, probably due to evaporation. An exception was St. 9, where the surface layer salinity was lower than the mid- and bottom layers by almost 1 PSU. This may be due to the freshwater input from the runoffs south of the Port.
- Except St.13, pH ranged approximately from 7.3-8.2. ph at St.13 was below 7 (6.78-6.90), which is low compared to typical marine waters.
- DO concentration ranged approximately from 5.7-6.1 mg/l. There were no sites or layers with signs of oxygen depletion.
- As expected, turbidity tended to be high in the inner bay and shallow areas (St. 10-12). However, there were no strong correlations between turbidity and TSS values.

Table 2   Results of general water quality parameters

St.	Depth (m)	Trans. (m)	Layer	Temp. (C°)	Salinity	pH	DO-sat. (%)	DO-conc. (mg/l)	TSS (mg/l)	Turbidity (FNU)
1	30.0	15.0	S	26.07	34.87	7.86	90.60	6.03	7.33	0.26
			M	26.04	34.80	7.78	92.50	6.11	4.71	0.25
			B	26.30	34.64	7.62	91.30	6.05	6.86	0.23
2	24.0	11.0	S	25.78	34.97	8.20	87.90	5.87	2.76	0.31
			M	25.77	34.97	8.20	87.20	5.85	9.83	0.25
			B	25.67	34.98	8.20	87.20	5.81	2.68	0.24
3	30.0	10.5	S	25.98	34.98	8.16	91.60	6.13	9.69	0.12
			M	25.79	34.95	8.14	86.10	5.79	0.93	0.22
			B	25.73	34.93	8.14	86.20	5.78	2.36	0.27
4	20.0	10.0	S	26.23	35.06	7.68	89.80	5.80	4.14	0.39
			M	25.87	34.86	7.56	85.90	5.68	1.04	0.38
			B	25.92	34.82	7.52	91.00	5.89	3.07	0.47
5	17.0	12.0	S	26.01	34.97	8.15	89.80	5.99	1.31	0.32
			M	25.92	34.95	8.12	87.90	5.84	9.20	0.24
			B	25.89	34.94	8.12	87.60	5.84	1.93	0.23
6	20.0	13.5	S	26.50	35.01	7.91	88.50	5.86	8.85	0.26
			M	26.09	34.83	7.80	86.80	5.75	3.93	0.27
			B	26.10	34.77	7.74	86.70	5.72	3.86	0.28
7	15.0	10.0	S	26.38	35.00	8.03	88.50	5.92	8.64	0.23
			M	26.02	34.87	7.97	88.10	5.85	1.07	0.10
			B	26.06	34.84	7.94	88.10	5.85	2.73	0.30
8	12.0	>12.0	S	26.14	34.92	7.88	92.10	6.08	2.57	0.23
			M	26.11	34.89	7.86	89.30	5.94	9.50	0.22
			B	26.12	34.79	7.82	89.10	5.94	6.07	0.30
9	16.0	8.5	S	26.45	34.02	7.81	88.70	5.87	13.28	0.39
			M	26.18	34.93	7.86	89.70	5.94	1.40	0.32
			B	26.04	34.82	7.79	89.60	6.00	7.64	0.31
10	6.0	>6.0	S	26.99	34.89	7.47	90.80	5.92	2.79	0.60
			M	-	-	-	-	-	-	-
			B	26.70	34.68	7.28	88.80	5.83	7.43	0.33
11	5.0	3.0	S	26.77	34.88	7.74	91.70	6.04	4.21	1.40
			M	-	-	-	-	-	-	-
			B	26.65	34.57	7.58	89.10	5.87	7.36	0.37
12	12.0	7.0	S	26.06	34.92	7.51	89.60	5.85	6.32	0.32
			M	26.00	34.82	7.44	89.70	5.87	9.07	0.65
			B	26.11	34.72	7.38	86.90	5.71	2.35	0.94
13	6.0	>6.0	S	26.93	34.78	6.90	90.00	5.98	3.79	0.25
			M	-	-	-	-	-	-	-
			B	26.95	34.40	6.78	88.50	5.86	4.29	0.56

S: surface layer, M: middle layer, B: bottom layer
Source: Study Team

Other water quality parameters

Table 3 shows the analysis results of T-N, T-P, THC and *E. coli*. Following are the main findings.

- T-N and T-P were measured as an indicator of nutrient enrichment. T-N concentration was highly variable between sites and layers, and was particularly high at the bottom layer of St. 6 (0.96 mg/l). T-P concentration ranged between <0.02-0.04 mg/l and was less variable between sites and layers compared to T-N. According to the Japanese water quality standard, water quality will be unsuitable for benthic organisms when T-N and T-P concentration constantly exceed 1 mg/l and 0.09 mg/l, respectively.
- THC was measured as an indicator of oil pollution. While oil films were often observed near the shore south of the Port, total hydrocarbon concentration was either below or near the quantification limit (0.2 mg/l), except the middle layer of St. 6.
- The highest numbers of *E. coli* was recorded at the surface layer of St. 10, which is located near a small runoff. However, the numbers were still low (246 CFU/100 ml) enough that it satisfied the European water quality standard (Directive 2006/7/EC) for ‘excellent quality’, which is 250 CFU/100 ml.

Table 3 Results of other water quality parameters

St.	Depth (m)	Layer	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	Total Hydrocarbon (mg/l)	*E. coli* (CFU/100ml)
1	30.0	S	0.25	<0.02	<0.20	10
		M	0.24	<0.02	<0.20	<10
		B	0.41	<0.02	<0.20	74
2	24.0	S	0.31	0.03	<0.20	<10
		M	0.58	0.04	<0.20	<10
		B	0.26	0.03	<0.20	<10
3	30.0	S	<0.20	0.04	<0.20	<10
		M	<0.20	0.04	<0.20	<10
		B	0.26	0.03	<0.20	10
4	20.0	S	0.29	0.02	<0.20	20
		M	0.26	<0.02	<0.20	31
		B	0.30	0.03	0.28	74
5	17.0	S	0.27	0.03	<0.20	<10
		M	0.53	0.03	<0.20	<10
		B	<0.20	0.04	<0.20	<10
6	20.0	S	0.38	0.02	<0.20	20
		M	0.44	0.03	0.59	<10
		B	0.96	<0.02	<0.20	20
7	15.0	S	<0.20	0.03	<0.20	20
		M	<0.20	0.04	<0.20	10
		B	<0.20	0.03	<0.20	<10
8	12.0	S	<0.20	0.03	<0.20	20
		M	0.29	0.03	<0.20	<10
		B	<0.20	0.03	<0.20	20
9	16.0	S	<0.20	0.03	<0.20	10
		M	0.31	0.03	<0.20	<10
		B	0.33	0.03	<0.20	20
10	6.0	S	0.49	0.03	<0.20	246
		M	-	-	-	-
		B	0.33	0.02	<0.20	85
11	5.0	S	0.31	0.03	<0.20	<10
		M	-	-	-	-
		B	0.23	0.02	<0.20	20
12	12.0	S	0.24	0.02	<0.20	20
		M	0.44	0.02	<0.20	<10
		B	<0.20	0.02	<0.20	31
13	6.0	S	0.22	0.02	<0.20	10
		M	-	-	-	-
		B	0.28	0.02	<0.20	31

S: surface layer, M: middle layer, B: bottom layer
Source: Study Team

(2) Sediment quality

To understand the sediment quality status around the Port, the Study Team conducted a sediment quality survey on July 14th, 2010. The field works and laboratory analysis were sub-contracted to PARETO, a consultant based in Réunion.

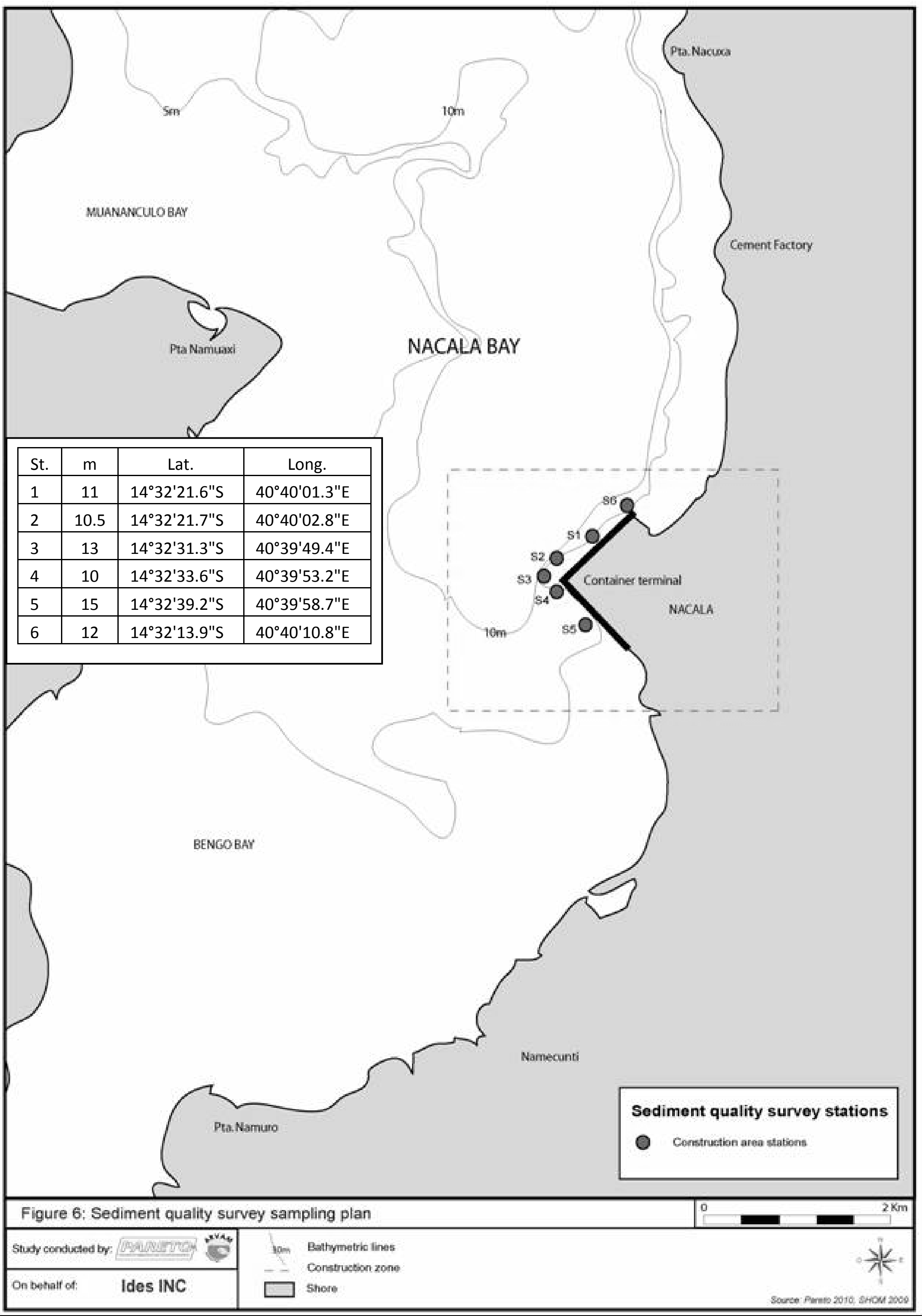
1) Methodology

Sediment samples were collected from the surface layer at 6 sites around the Port as shown in Figure 2. Samples were collected by squba divers by scooping the sediment with plastic bottles. Several samples were collected from each site, which were mixed and then preserved in an one litre (1 L) container. Samples were then sent to Laboratory of Rouen (COFRAC accredited (French accreditation) laboratory) for analysis. Table 4 shows the surveyed sediment quality parameters and employed methodologies.

Table 4 Surveyed sediment quality parameters and methodologies

Parameter	Analysis method	Quantification limit
Specific gravity	Measure apparent	-
Moisture content	NF ISO 11465	-
Particle size distribution	NF ISO 13320-1	2 μm-2 mm
Total Nitrogen (T-N)	NF ISO 11261	500 mg/kg
Total Phosphorus (T-P)	NF EN ISO 6878 mod.	100 mg/kg
Total Sulphur (T-S)	ISO 13358 mod.	10 mg/kg
Heavy metals		
Arsenic (As)	NF EN ISO 11969 mod.	0.1 mg/kg
Cadmium (Cd)	NF EN ISO 5961	0.1 mg/kg
Chromium (Cr)	NF EN ISO 11885	2 mg/kg
Copper (Cu)	NF EN ISO 11885	3 mg/kg
Lead (Pb)	FD T 90-112	1 mg/kg
Mercury (Hg)	NF EN ISO 17852	0.02 mg/kg
Nickel (Ni)	NF EN ISO 11885	2 mg/kg
Zinc (Zn)	NF EN ISO 11885	5 mg/kg
Organics		
DDT	XP X 33-012	1.0 μg/kg
Total PCBs	XP X 33-012	1.0 μg/kg
Total PAHs	XP T 90-250 mod.	2.0 μg/kg
TBT	XP X 33-012	1.0 μg Sn/kg

Source: Study Team



St.	m	Lat.	Long.
1	11	14°32'21.6"S	40°40'01.3"E
2	10.5	14°32'21.7"S	40°40'02.8"E
3	13	14°32'31.3"S	40°39'49.4"E
4	10	14°32'33.6"S	40°39'53.2"E
5	15	14°32'39.2"S	40°39'58.7"E
6	12	14°32'13.9"S	40°40'10.8"E

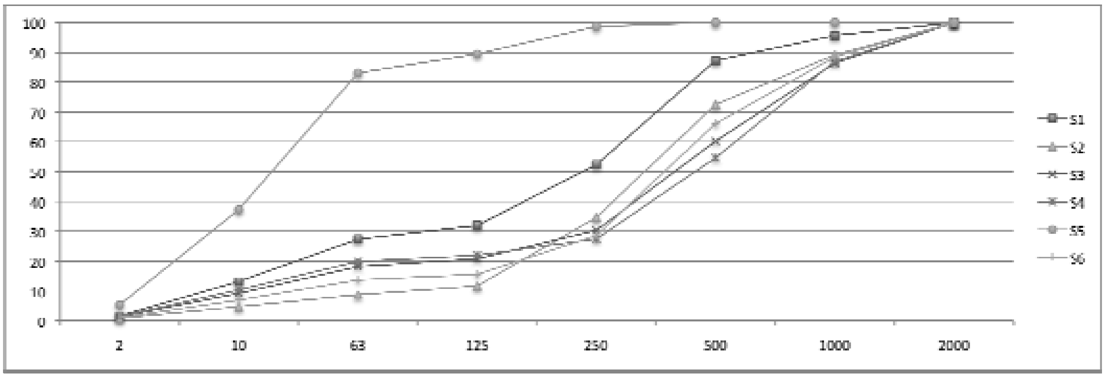
Source: Study Team

Figure 2 Location of the sediment quality survey sites

2) Results

Physical properties

Figure 3 shows the particle size distribution of the sampled sediments. Note that the sediment of St. 5 was predominantly composed of silt (over 80%), whereas sediment of the other sites were mostly composed of fine sand. Table 5 shows the specific gravity and moisture content of the samples.



Source: Study Team

Figure 3 Results of particle size distribution analysis

Table 5 Results of specific gravity and moisture content analysis

	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6
Specific gravity	1.78	1.86	1.91	1.89	1.36	1.85
Moisture content	31.3%	25.8%	23.3%	23.4%	55.0%	25.8%

Source: Study Team

T-N, T-P and T-S

T-N, T-P and T-S were measured as an indicator of nutrient enrichment. Table 6 shows the concentrations of T-N, T-P and T-S at the 6 sites. T-N, T-P and T-S concentration were all highest at St. 5, which was also the site with the highest silt content. The concentrations of St. 5 are for example comparable to inner area of Tokyo Bay, which is generally considered as polluted area. Possible sources may include runoffs from the south side of the Port and spillage from bulk commodity (e.g. wheat) handling.

Table 6 Analysis results of T-N, T-P and T-S

	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6
T-N (mg/kg)	836.6	<500.0	823.3	621.6	1945.0	531.6
T-P (mg/kg)	735.0	230.0	311.0	295.0	920.0	365.0
T-S (mg/kg)	110.0	167.0	404.0	350.0	1310.0	383.0

Source: Study Team

Heavy metals

Table 7 shows the concentration of heavy metals at the 6 sites. St. 1, 5 and 6 were contaminated by high levels of one or more heavy metals (chromium, lead or nickel). Lead concentration was high at St. 1 (125 mg/kg dw) and 6 (85 mg/kg dw). Possible sources may include ship paint (lead has been used a stabilizer, pigment and biocide in antifouling paint), leakage of leaded gasoline from the oil-handling berth and so on. Chromium and nickel concentrations were high only at St. 5. Possible sources may include clinker spillage (clinker may contain chromium and nickel depending on the raw material, by-product and fuel used in the manufacturing process), runoffs from the south side of the Port and so on.

Table 7　Analysis results of heavy metals

Unit: mg/kg dw

	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	Screening level*	SQG-high*
Arsenic	9.7	9.4	5.9	3.2	4.7	4.0	20	70
Cadmium	0.1	<0,1	<0,1	<0,1	0.2	<0,1	1.5	10
Chromium	79.0	21.0	39.0	40.0	**116.0**	32.0	80	370
Copper	47.0	7.0	9.0	11.0	33.0	14.0	65	270
Lead	**125.0**	18.0	25.0	26.0	41.0	**85.0**	50	220
Mercury	0.04	0.09	0.02	0.02	0.09	0.02	0.15	1
Nickel	12.0	6.0	12.0	10.0	**40.0**	8.0	21	52
Zinc	118.0	17.0	31.0	35.0	139.0	44.0	200	410

*: The values of the screening level and SQG-high are referred from National Assessment Guidelines for Dredging, Australian Government. Sediment is considered to be uncontaminated if no analytes exceed screening level. Sediment is considered to be significantly contaminated if one or more analyte is above the 'Screening level', and very significantly contaminated if one or more analyte is above the 'SQG-high' level.

Note: The bold figures indicate that the concentration is above 'Screening level'.

Source: Study Team

<u>Organics</u>

Table 8 shows the concentration of harmful organic compounds at the 6 sites. All the sites were contaminated by high levels of one or more harmful organic compound. Contamination was most significant at St. 1, in particular for DDT, PCBs and TBT. Although the source of these pollutants are uncertain, one possible source maybe be ships, as all these substances were or are still used as ingredients of ship antifouling paint. If this is the case, St. 1 may have the highest concentration because the adjacent berth is the oldest in the Port, therefore more time for accumulating these pollutants compared to the other sites.

Table 8　Analysis results of harmful organic compounds

	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	Screening level*	SQG-high *
Total PAHs (µg/kg dw)	<10	<10	<10	<10	<10	<10	10,000	45,000
DDT (µg/kg dw)	**2057.6 (205.76)**	**90.3 (9.03)**	**41.4 (4.14)**	**12.8** (1.28)	**43.0 (4.30)**	**27.3 (2.73)**	1.6	46
Total PCBs (µg/kg dw)	**89.1** (8.91)	<7.0	<7.0	<7.0	<7.0	**25.1** (2.51)	23	-
TBT (µg Sn/kg dw)	**193.0 (19.30)**	6.7	5.4	5.6	**25.6** (2.56)	**54.0** (5.40)	9	70

*: The values of the screening level and SQG-high are referred from National Assessment Guidelines for Dredging, Australian Government. Sediment is considered to be uncontaminated if no analytes exceed screening level. Sediment is considered to be significantly contaminated if one or more analyte is above the 'Screening level', and very significantly contaminated if one or more analyte is above the 'SQG-high' level.

Note 1: The bold figures indicate that the concentration is above 'Screening level' or 'SQG-high' level.

Note 2: The National Assessment Guidelines for Dredging requires to normalize the dry weight concentration to 1% total organic carbon (TOC). However, since TOC was not measured, the above values are when TOC content is assumed to be 1%. The values in parenthesis are when TOC content is 10%, which will be the most underestimating value.

Source: Study Team

3) Countermeasures

Since the sediments around the Port is significantly contaminated by heavy metals and harmful organic compounds, it is highly recommended to implement pollution prevention measures during dredging activities, so to prevent any adverse impacts on marine life and humans. Following are some recommendations:

- A detailed sediment quality survey should be conducted once the dredging location is decided. The purpose is to understand in more detail the level and spatial extent of contamination at the dredging site.
- Ocean disposal of contaminated dredged material should be avoided to prevent further contamination of the ocean.
- Appropriate methods (e.g. installation of silt curtain) should be used to prevent/minimize sediment dispersion during dredging.
- An appropriate disposal method and location should be determined (e.g. disposal into confined disposal facilities) to prevent/minimize contamination of the surrounding environment.

Appendix-4

Natural condition Survey Results

Ap.2.1 Soil Investigation

Soil investigation had been conducted at 12 locations of the project site. 5 points were for land boring and 7 points were for marine boring. Figure Ap4.1 shows the borehole points.

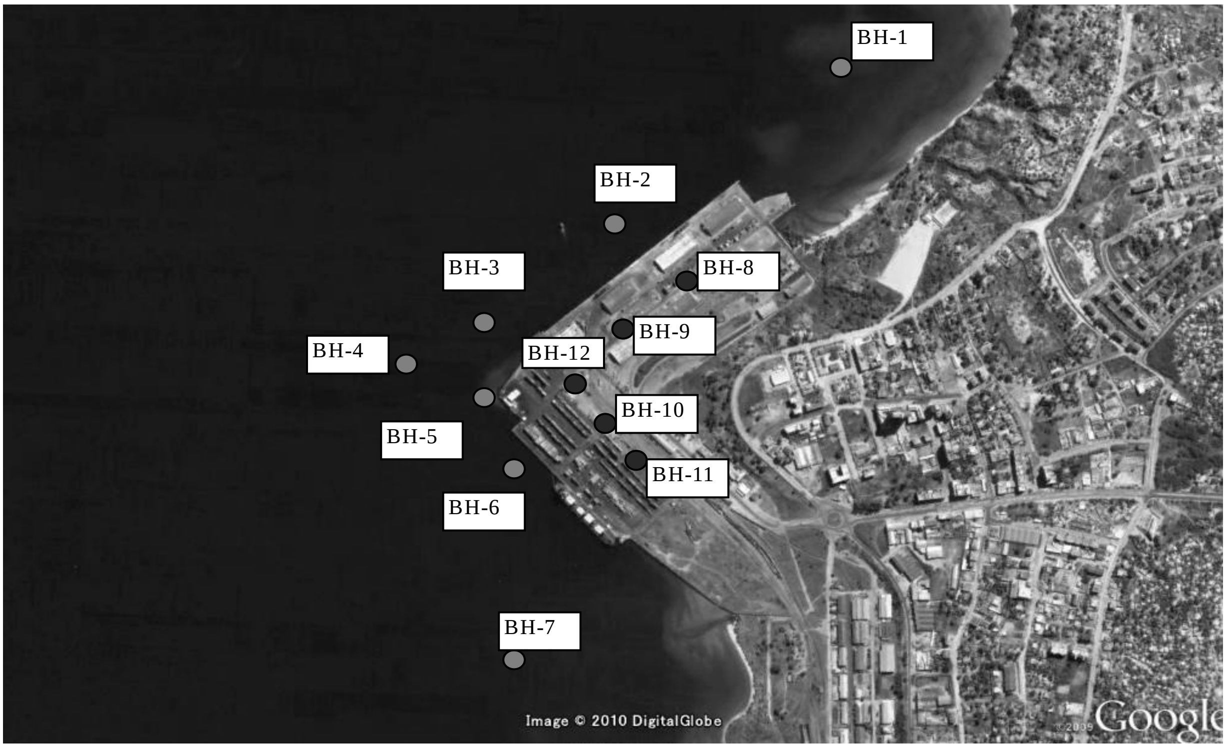
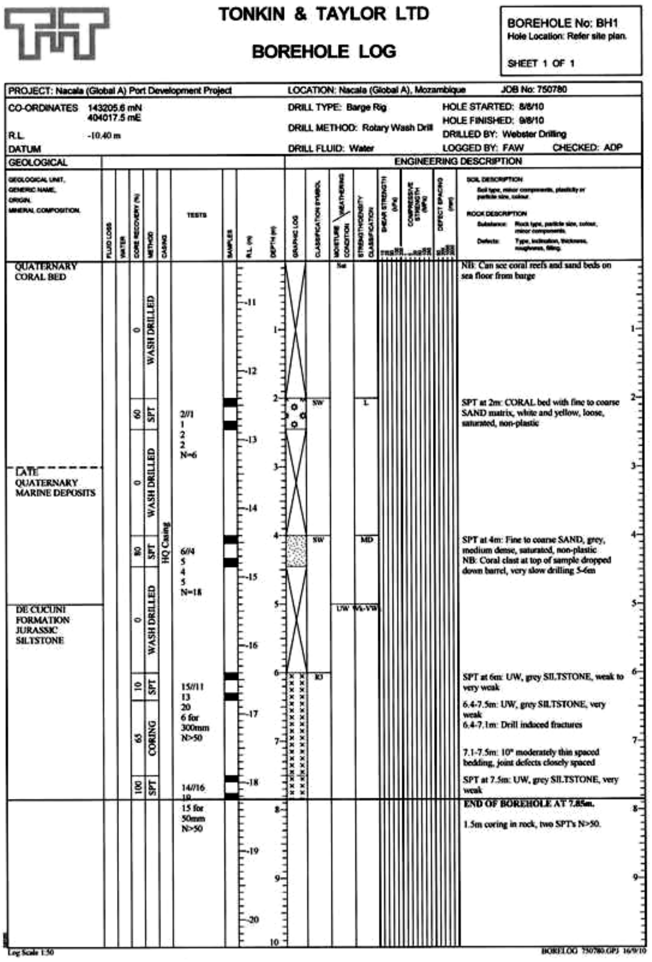
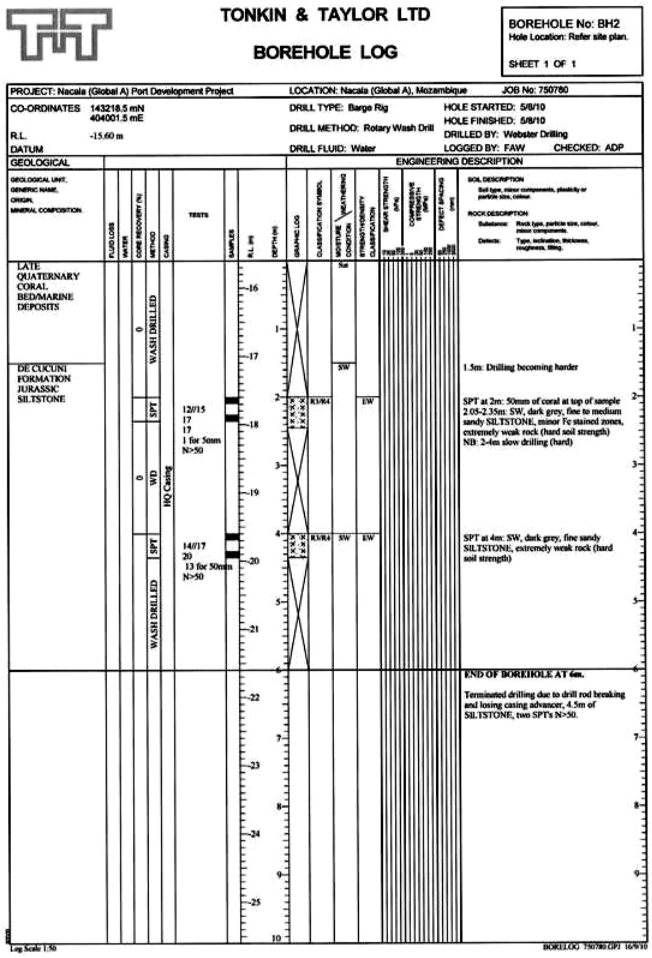


Figure Ap4.1 Borehole Positions
(Marine Boring; BH-1 to BH-7, Land Boring; BH-8 to BH-12)

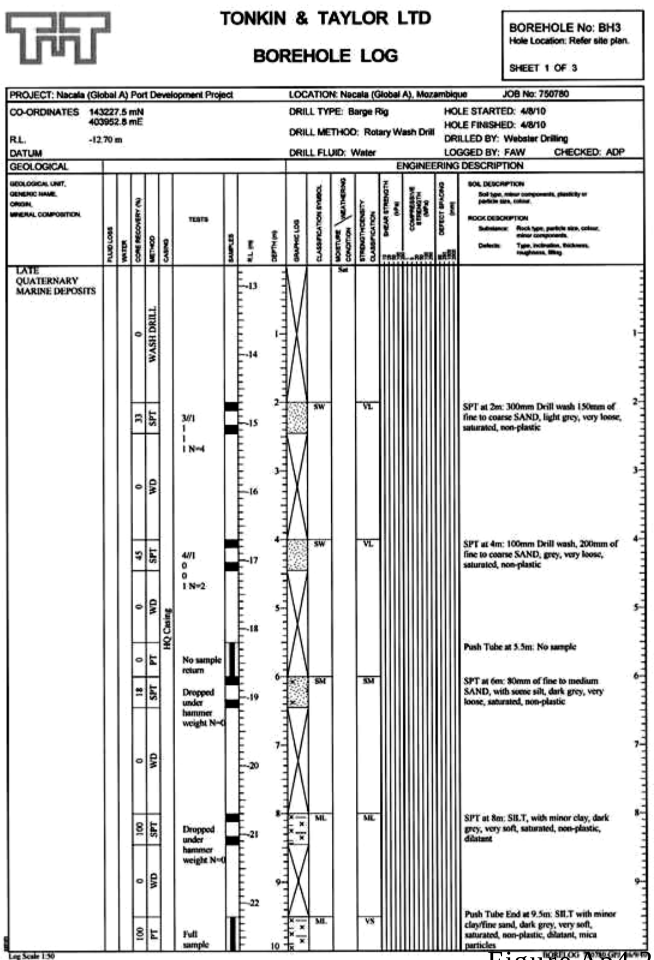
Borehole logs are shown in Figure Ap4.2. Results of particles size analysis are shown in Figure Ap4.3.



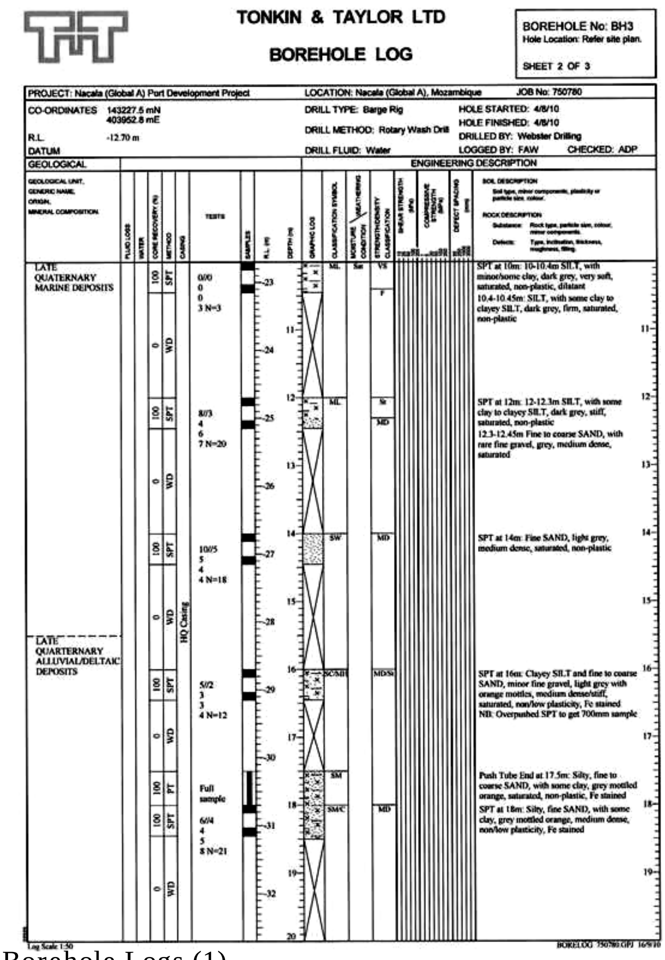
BH-1,1/1



BH-2,1/1

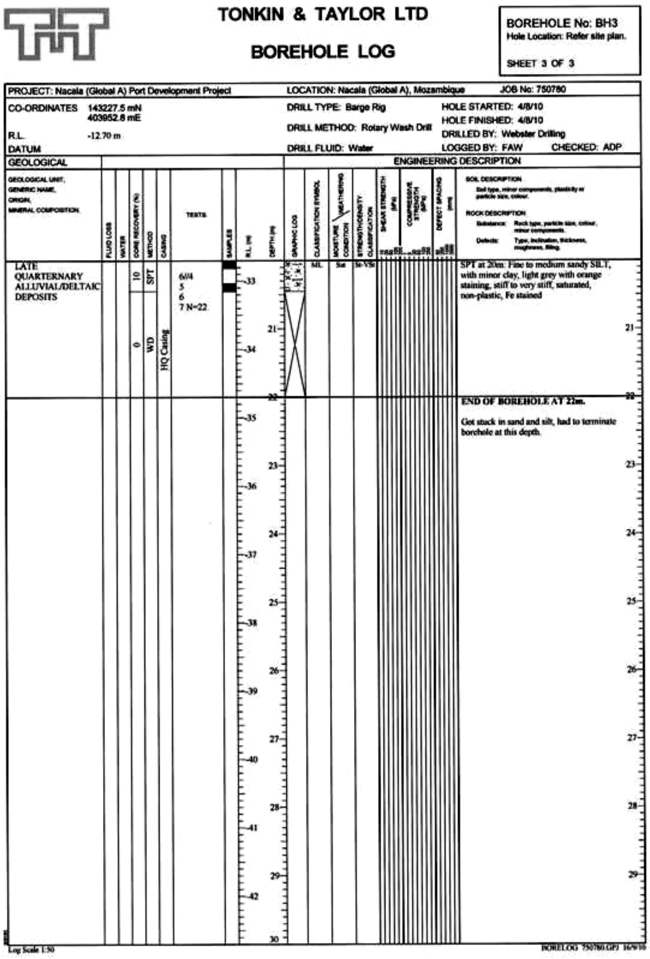


BH-3,1/3

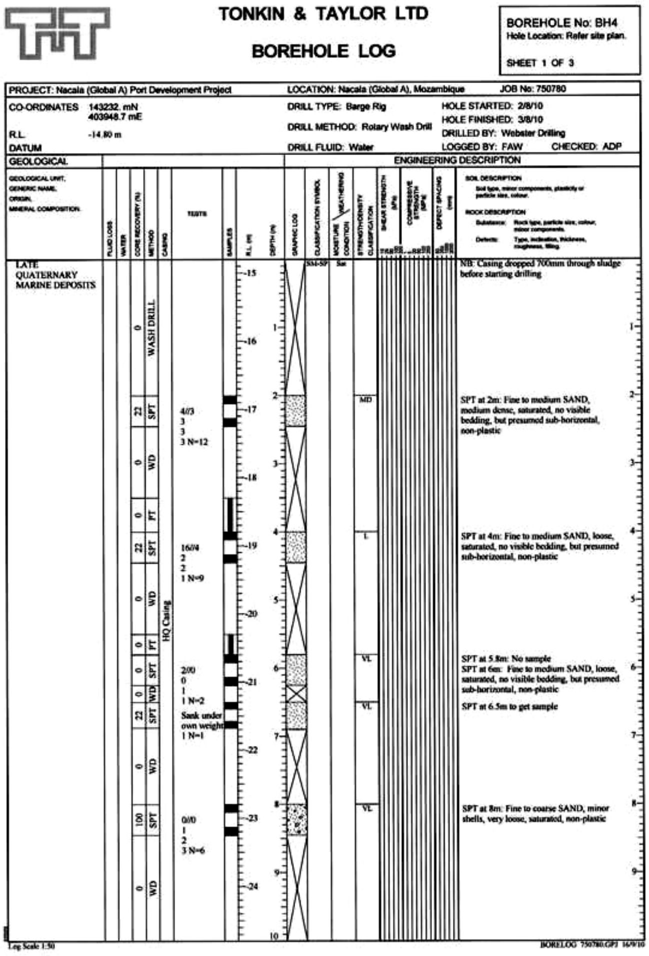


BH-3,2/3

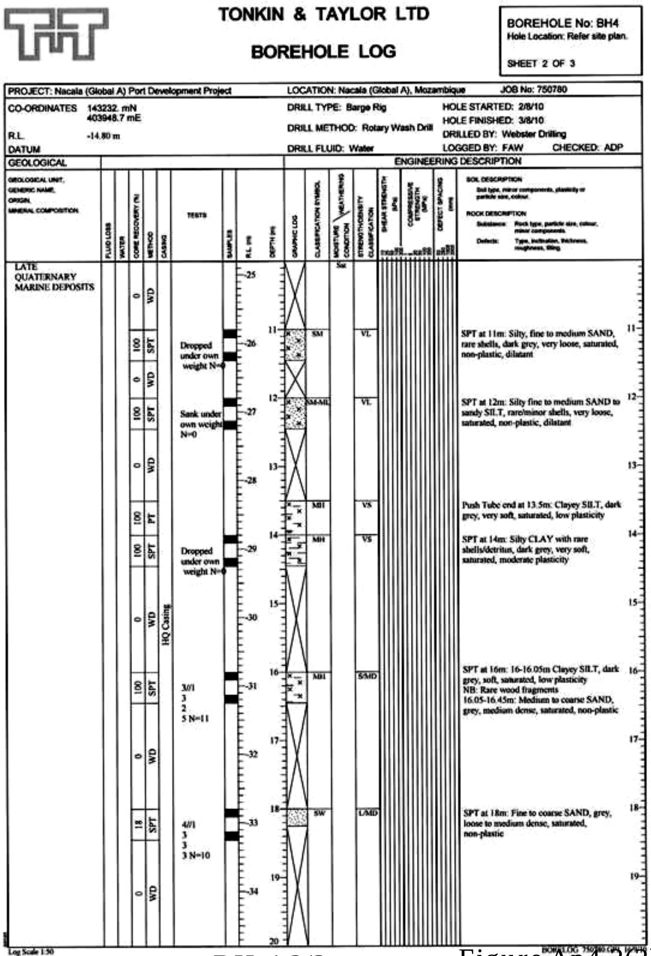
Figure Ap4.2(1) Borehole Logs (1)



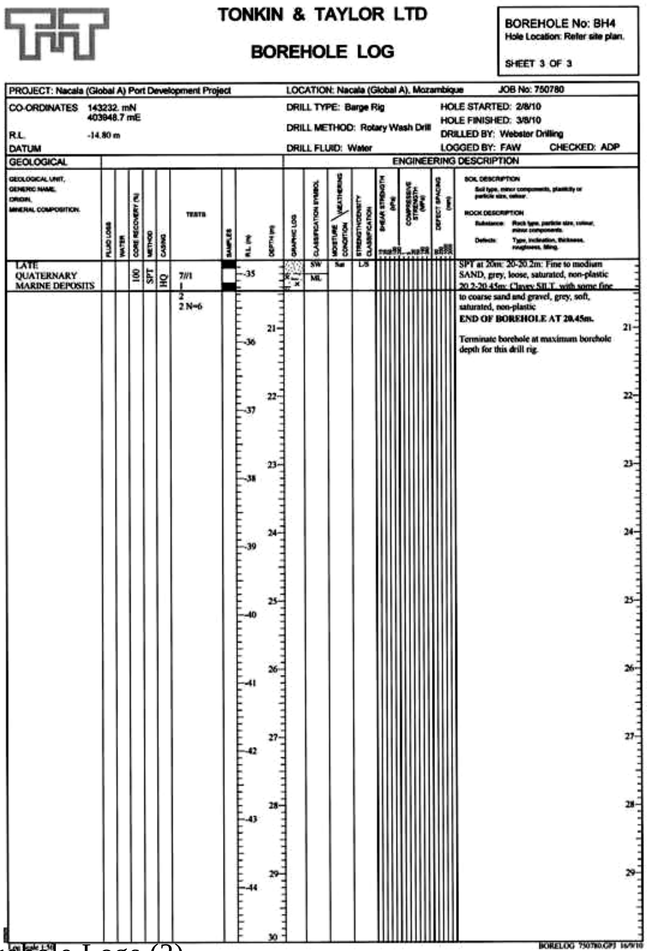
BH-3,3/3



BH-4,1/3

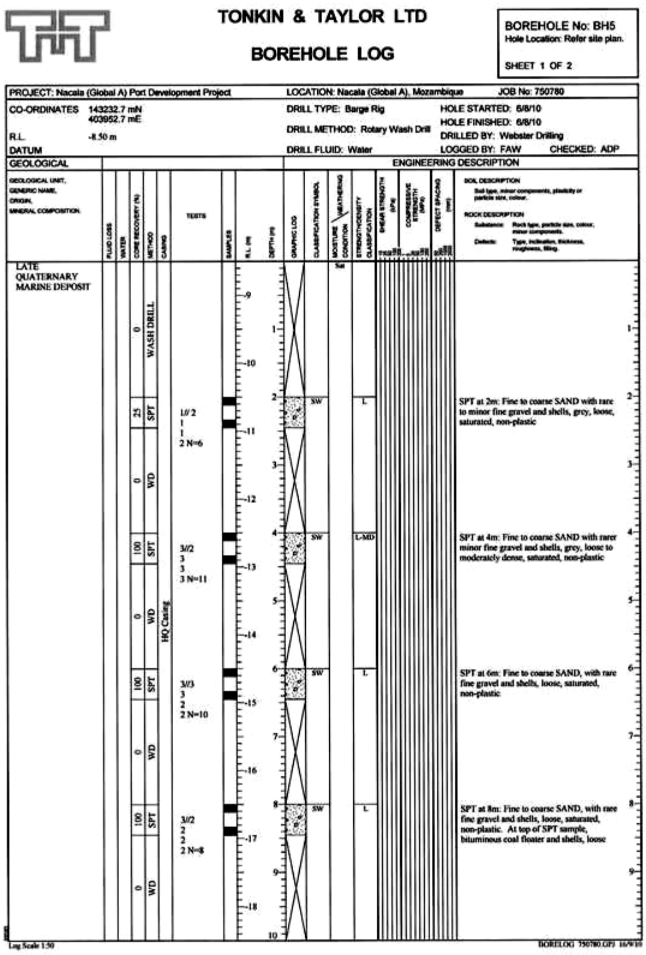


BH-4,2/3

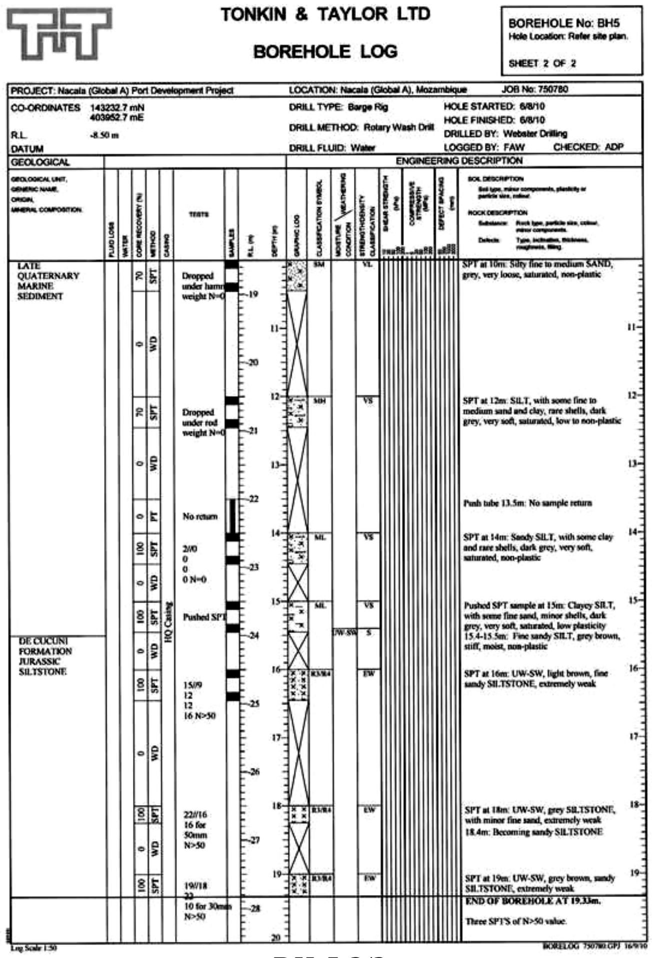


BH-4,3/3

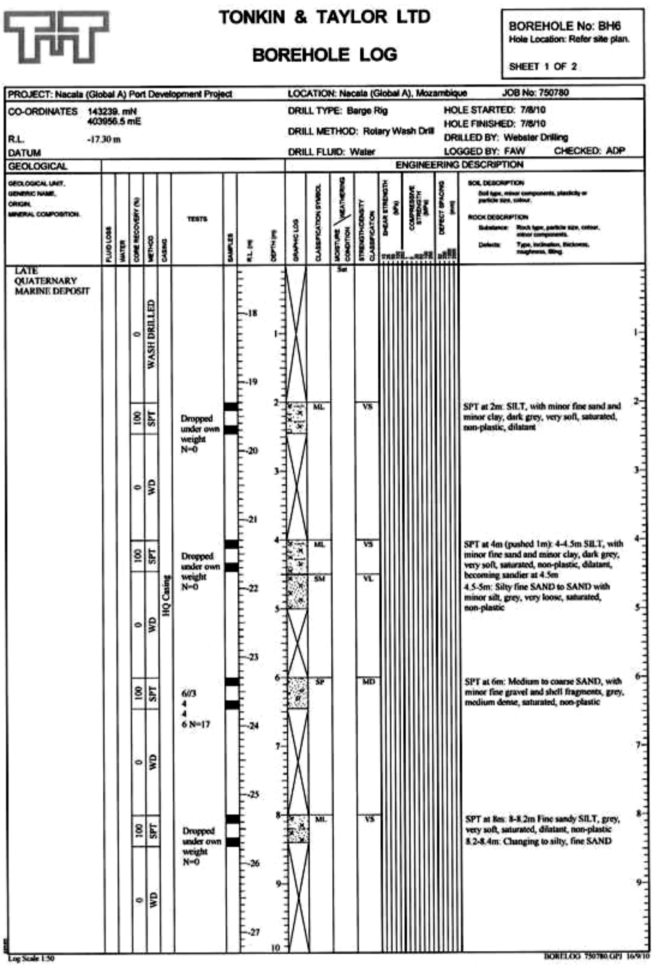
Figure Ap4.2(2) Borehole Logs (2)



BH-5,1/2



BH-5,2/2



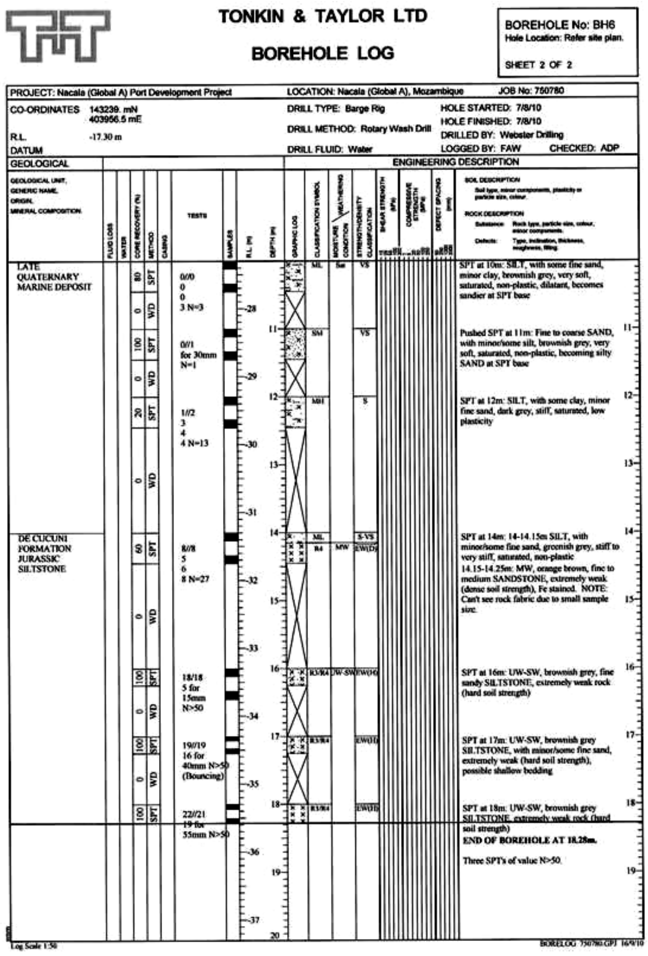
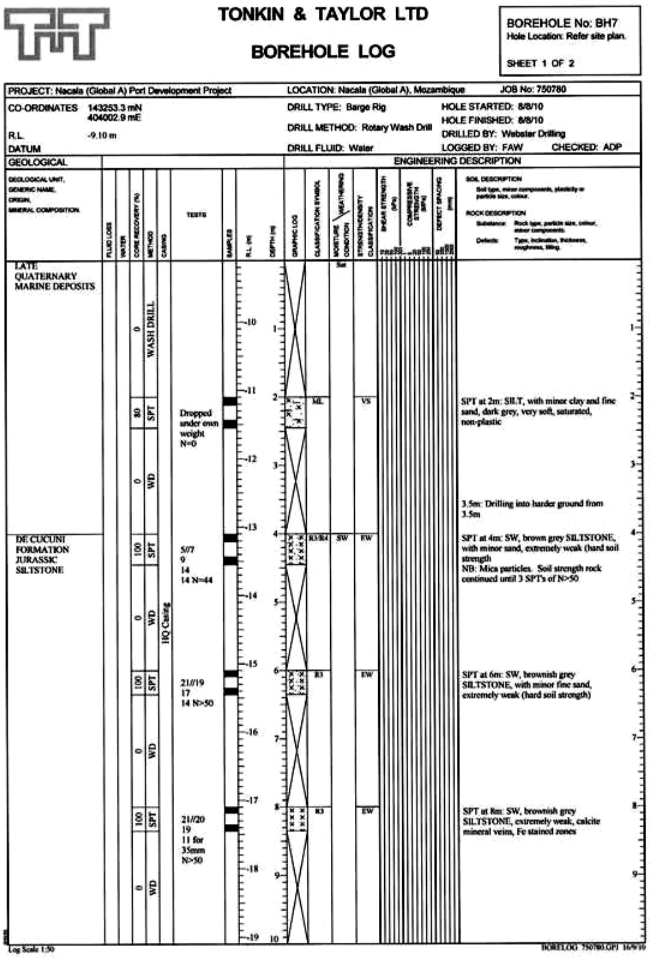


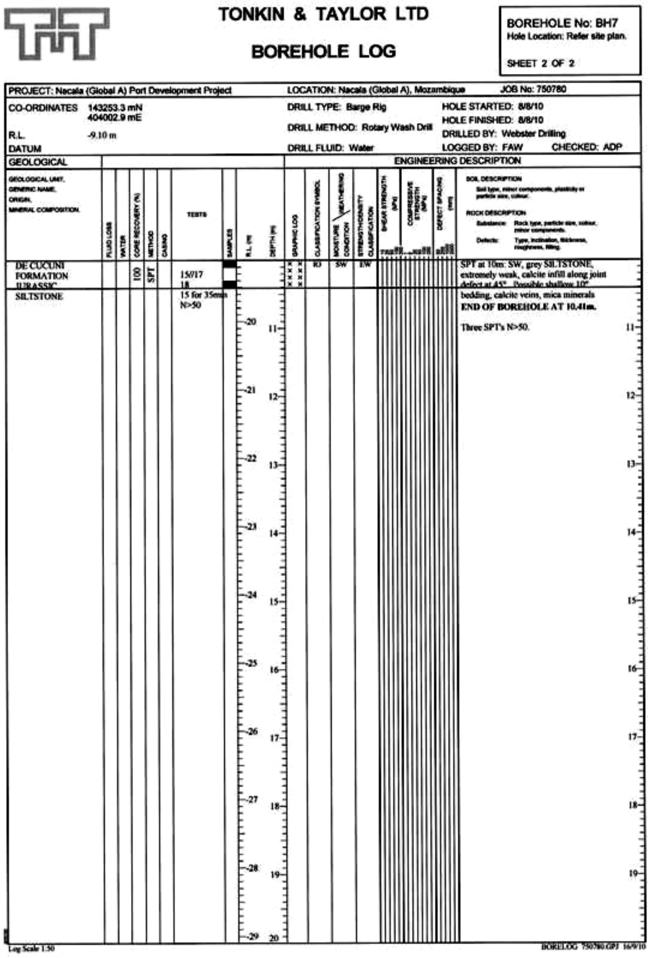
Figure Ap4.2(3) Borehole Logs (3)

BH-6,1/2

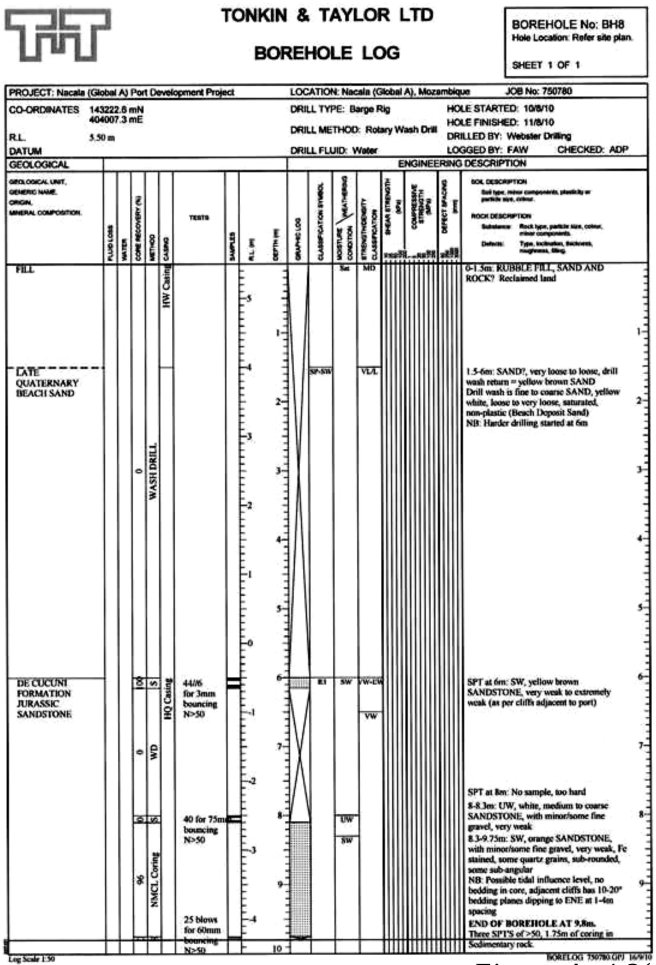
BH-6,2/2

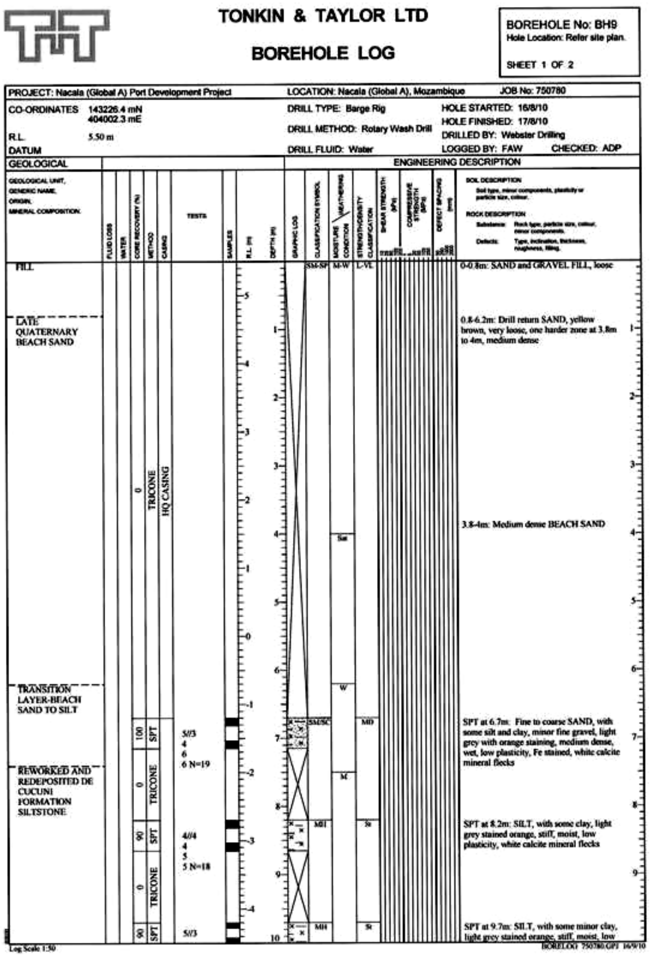


BH-7,1/2



BH-7,2/2

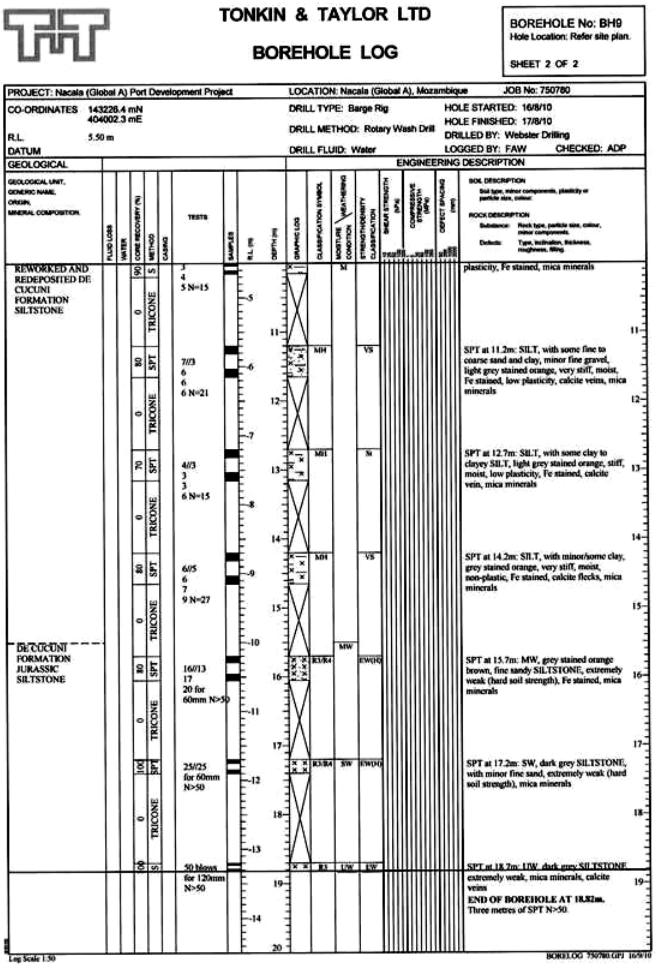




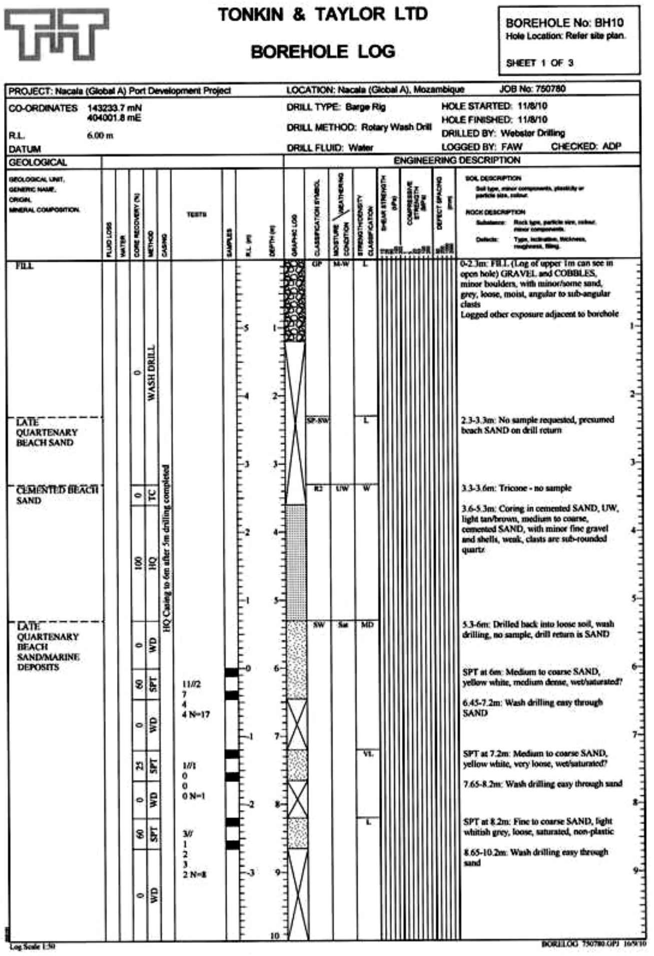
BH-9,1/2

Figure Ap4.2(4) Borehole Logs (4)

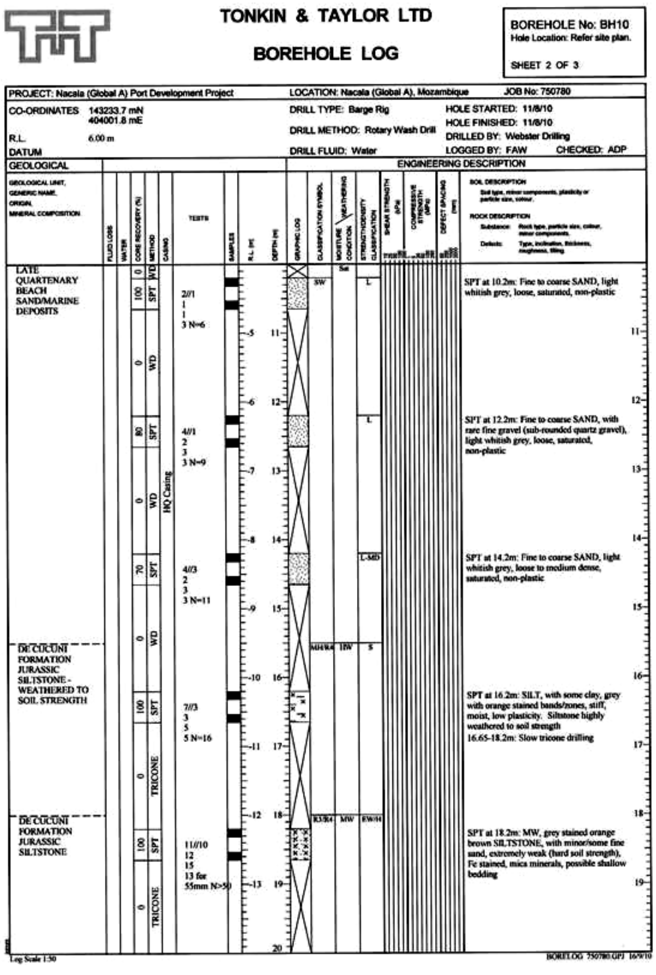
BH-8,1/1



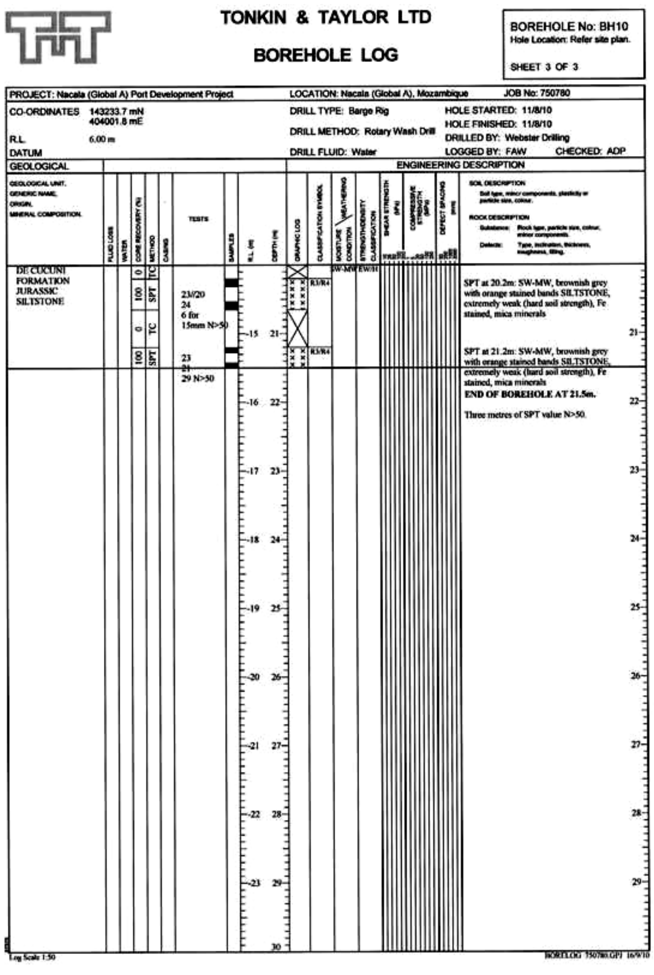
BH-9,2/2



BH-10,1/3

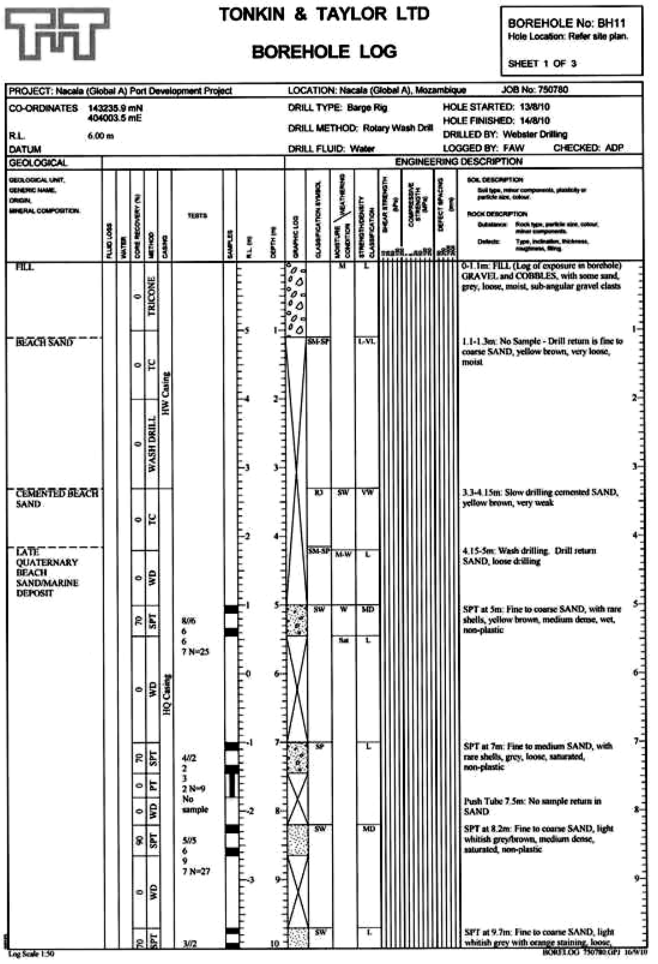


BH-9,2/3

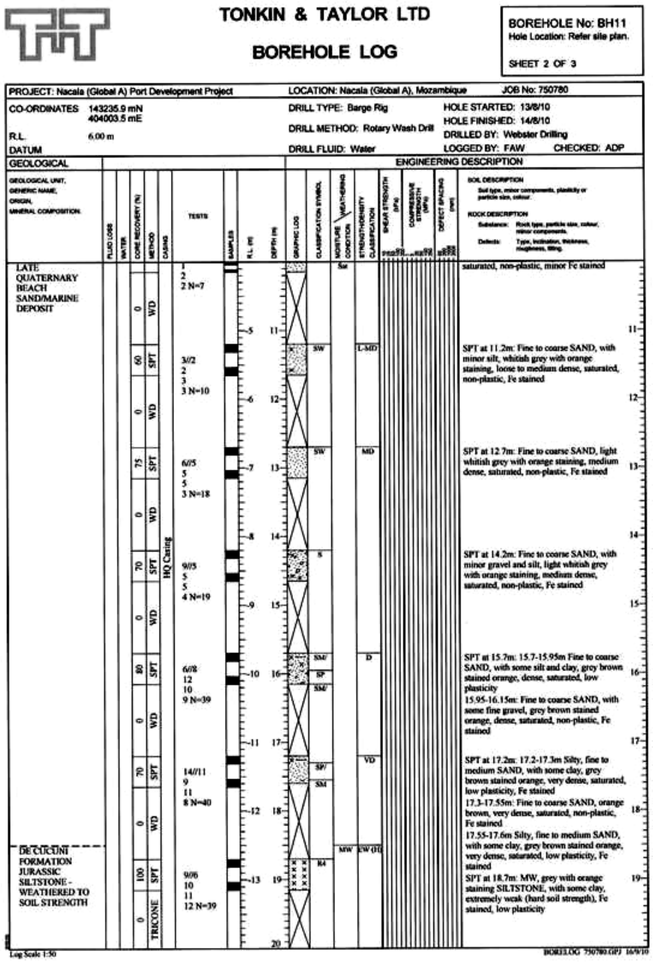


BH-9,3/3

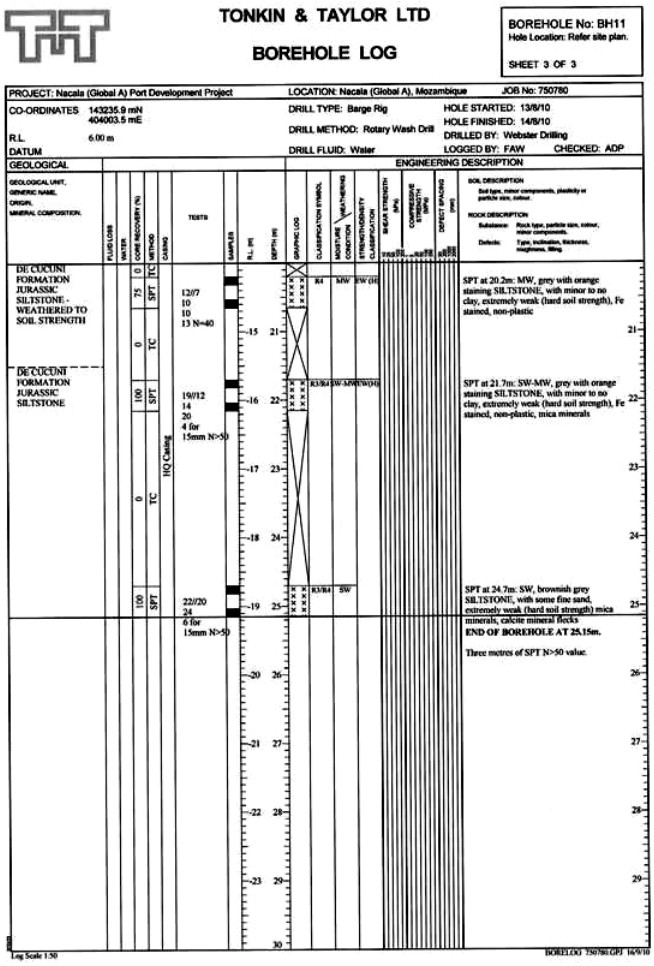
Figure Ap4.2(5) Borehole Logs (5)



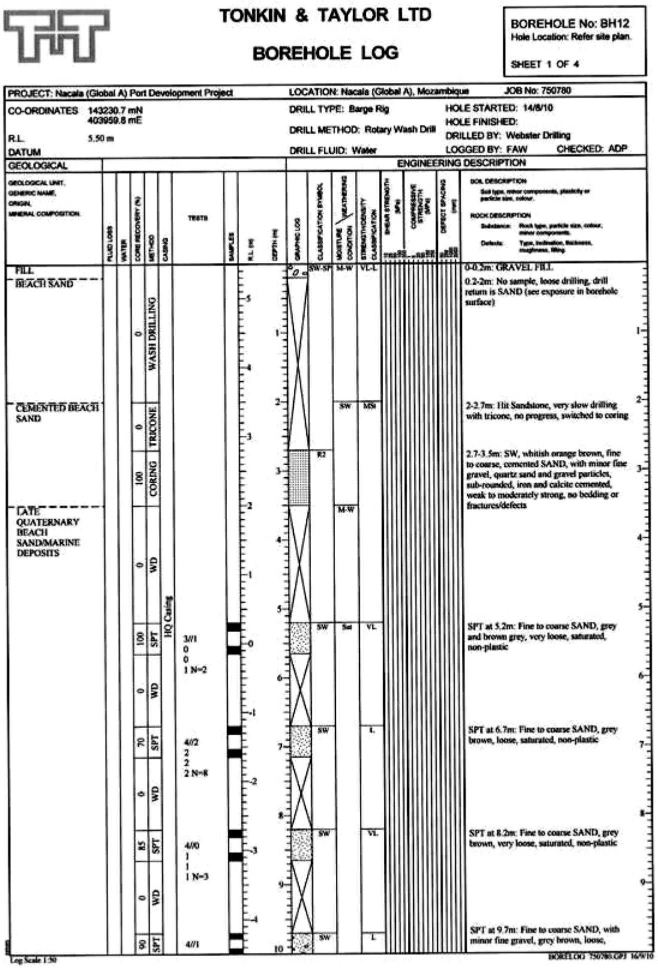
BH-11,1/3



BH-11,2/3

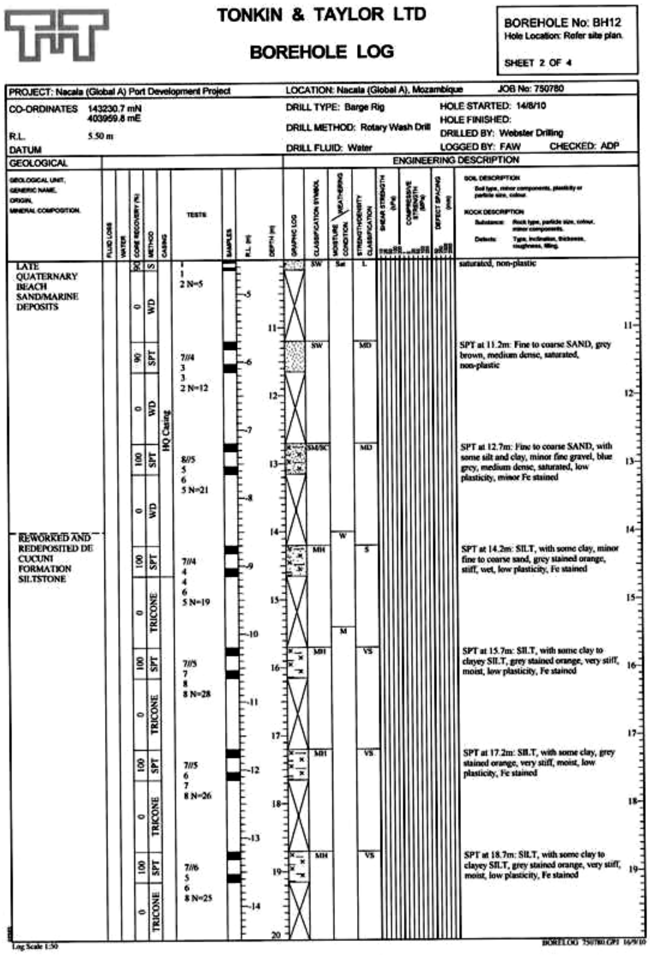


BH-11,3/3



BH-12,1/4

Figure Ap4.2(6) Borehole Logs (6)



TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: BH12
Hole Location: Refer site plan.
SHEET 2 OF 4

PROJECT: Nacala (Global A) Port Development Project | LOCATION: Nacala (Global A), Mozambique | JOB No: 750780
CO-ORDINATES 143230.7 mN 403959.8 mE | DRILL TYPE: Barge Rig | HOLE STARTED: 14/8/10
HOLE FINISHED:
R.L. 5.50 m | DRILL METHOD: Rotary Wash Drill | DRILLED BY: Webster Drilling
DATUM | DRILL FLUID: Water | LOGGED BY: FAW | CHECKED: ADP

GEOLOGICAL: LATE QUATERNARY BEACH SAND/MARINE DEPOSITS; REWORKED AND REDEPOSITED DE CUCUNI FORMATION SILTSTONE

Tests: 1 1 2 N=5; 7//4 3 3 2 N=12; 8//5 5 6 5 N=21; 7//4 4 4 6 5 N=19; 7//5 7 8 8 N=28; 7//5 6 7 8 N=26; 7//6 5 6 8 N=25

ENGINEERING DESCRIPTION:

saturated, non-plastic

SPT at 11.2m: Fine to coarse SAND, grey brown, medium dense, saturated, non-plastic

SPT at 12.7m: Fine to coarse SAND, with some silt and clay, minor fine gravel, blue grey, medium dense, saturated, low plasticity, minor Fe stained

SPT at 14.2m: SILT, with some clay, minor fine to coarse sand, grey stained orange, stiff, wet, low plasticity, Fe stained

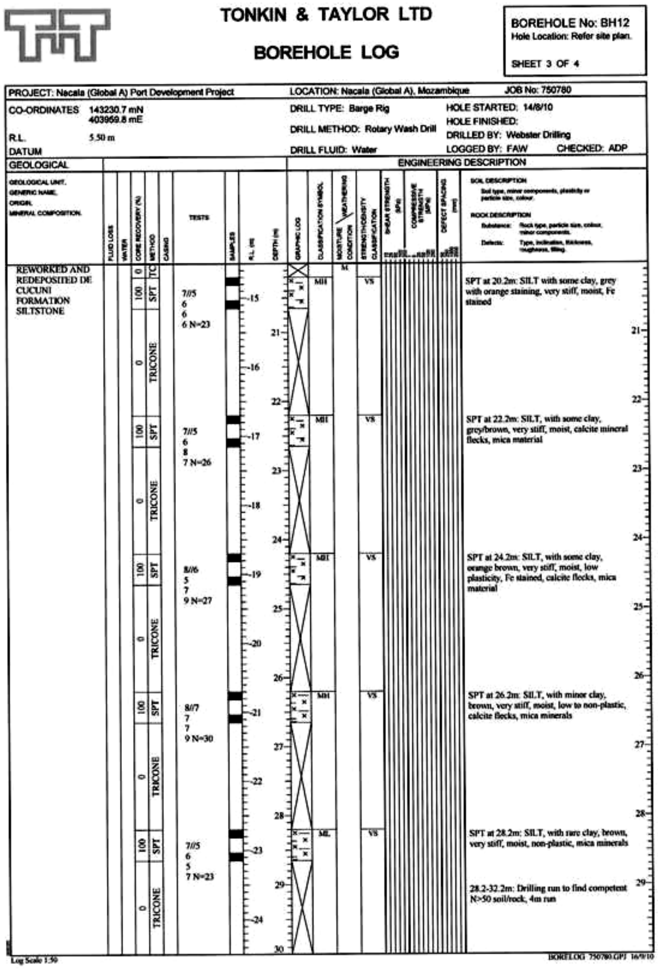
SPT at 15.7m: SILT, with some clay to clayey SILT, grey stained orange, very stiff, moist, low plasticity, Fe stained

SPT at 17.2m: SILT, with some clay, grey stained orange, very stiff, moist, low plasticity, Fe stained

SPT at 18.7m: SILT, with some clay to clayey SILT, grey stained orange, very stiff, moist, low plasticity, Fe stained

Log Scale 1:50 | BORELOG 750780.GPJ 16/9/10

BH-12,2/4



TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: BH12
Hole Location: Refer site plan.
SHEET 3 OF 4

PROJECT: Nacala (Global A) Port Development Project | LOCATION: Nacala (Global A), Mozambique | JOB No: 750780
CO-ORDINATES 143230.7 mN 403959.8 mE | DRILL TYPE: Barge Rig | HOLE STARTED: 14/8/10
HOLE FINISHED:
R.L. 5.50 m | DRILL METHOD: Rotary Wash Drill | DRILLED BY: Webster Drilling
DATUM | DRILL FLUID: Water | LOGGED BY: FAW | CHECKED: ADP

GEOLOGICAL: REWORKED AND REDEPOSITED DE CUCUNI FORMATION SILTSTONE

Tests: 7//5 6 6 6 N=23; 7//5 6 8 7 N=26; 8//6 5 7 9 N=27; 8//7 7 7 9 N=30; 7//5 6 5 7 N=23

ENGINEERING DESCRIPTION:

SPT at 20.2m: SILT with some clay, grey with orange staining, very stiff, moist, Fe stained

SPT at 22.2m: SILT, with some clay, grey/brown, very stiff, moist, calcite mineral flecks, mica material

SPT at 24.2m: SILT, with some clay, orange brown, very stiff, moist, low plasticity, Fe stained, calcite flecks, mica material

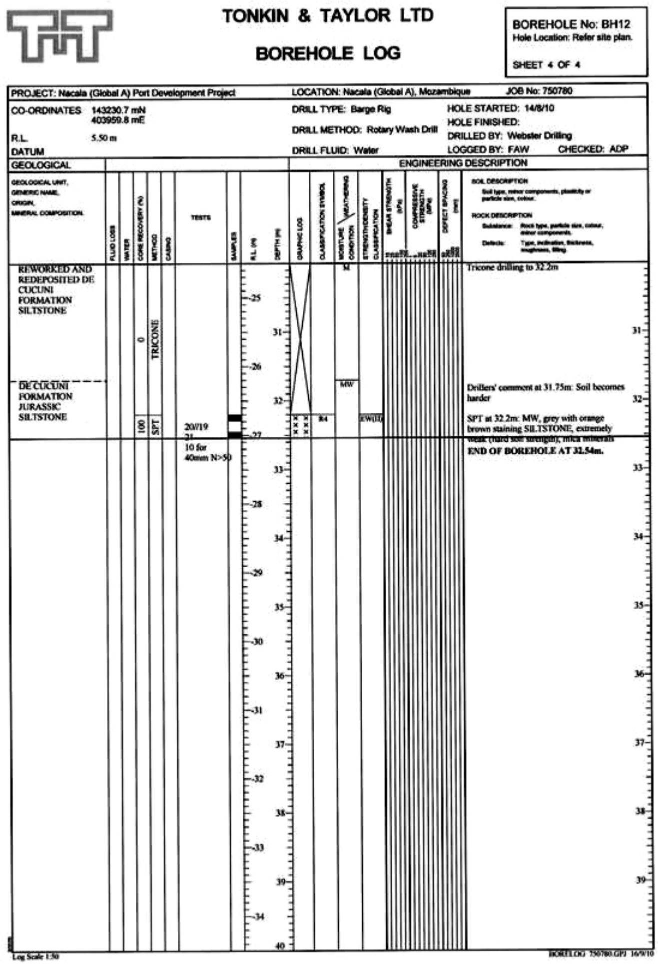
SPT at 26.2m: SILT, with minor clay, brown, very stiff, moist, low to non-plastic, calcite flecks, mica minerals

SPT at 28.2m: SILT, with rare clay, brown, very stiff, moist, non-plastic, mica minerals

28.2-32.2m: Drilling run to find competent N>50 soil/rock, 4m run

Log Scale 1:50 | BORELOG 750780.GPJ 16/9/10

BH-12,3/4



TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: BH12
Hole Location: Refer site plan.
SHEET 4 OF 4

PROJECT: Nacala (Global A) Port Development Project | LOCATION: Nacala (Global A), Mozambique | JOB No: 750780
CO-ORDINATES 143230.7 mN 403959.8 mE | DRILL TYPE: Barge Rig | HOLE STARTED: 14/8/10
HOLE FINISHED:
R.L. 5.50 m | DRILL METHOD: Rotary Wash Drill | DRILLED BY: Webster Drilling
DATUM | DRILL FLUID: Water | LOGGED BY: FAW | CHECKED: ADP

GEOLOGICAL: REWORKED AND REDEPOSITED DE CUCUNI FORMATION SILTSTONE; DE CUCUNI FORMATION JURASSIC SILTSTONE

Tests: 20//19 21 10 for 40mm N>50

ENGINEERING DESCRIPTION:

Tricone drilling to 32.2m

Drillers' comment at 31.75m: Soil becomes harder

SPT at 32.2m: MW, grey with orange brown staining SILTSTONE, extremely weak (hard soil strength), mica minerals

END OF BOREHOLE AT 32.54m.

Log Scale 1:50 | BORELOG 750780.GPJ 16/9/10

BH-12,4/4

Figure Ap4.2(7) Borehole Logs (7)

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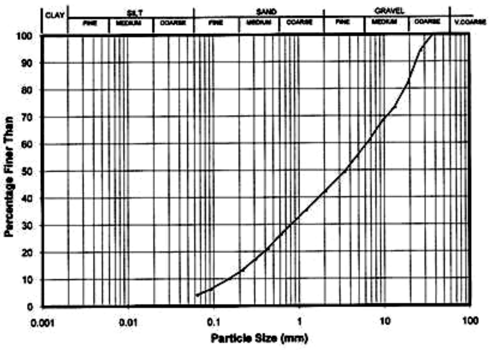
Form No.: P5
Form Date: JANUARY 2004

Plate No.: Page of
Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.000
BH No.: 1 Sample No.: 1
Depth: 2.0 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	—
53.0	—
37.5	100
26.5	94
19.0	82
13.2	73
9.50	68
6.70	61
4.75	55
3.35	49

Sieve (mm)	Total % Passing
2.00	42
1.18	35
0.600	26
0.425	21
0.300	17
0.212	13
0.150	10
0.090	6
0.063	4

Sample history : As received at natural water content.
Description: CORAL-SAND, trace of silt, loose/saturated, light yellowish brown and white - (Description based on the particle size analysis).
Remarks: The mass of sample was ~ 0.22 kg.
Percentage passing the finest sieve was obtained by difference.

Entered by : ST Date : 27/9/10 Checked by : MJRA Date : 27/9/10

BH-1,-10.15m

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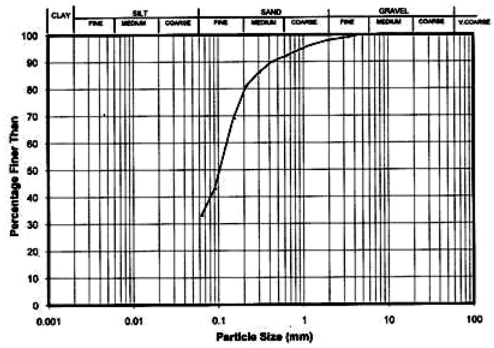
Form No.: P5
Form Date: JANUARY 2004

Plate No.: Page of
Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.000
BH No.: 2 Sample No.: 1
Depth: 2.0 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	—
53.0	—
37.5	—
26.5	—
19.0	—
13.2	—
9.50	—
6.70	—
4.75	100
3.35	99

Sieve (mm)	Total % Passing
2.00	98
1.18	96
0.600	92
0.425	90
0.300	86
0.212	81
0.150	69
0.090	43
0.063	33

Sample history : As received at natural water content.
Description: silty SAND with minor clay and trace of coral, soft to firm, dark brownish grey - (Description based on the particle size analysis).
Remarks: Percentage passing the finest sieve was obtained by difference.

Entered by : ST Date : 27/9/10 Checked by : MJRA Date : 27/9/10

BH-2,-15.35m

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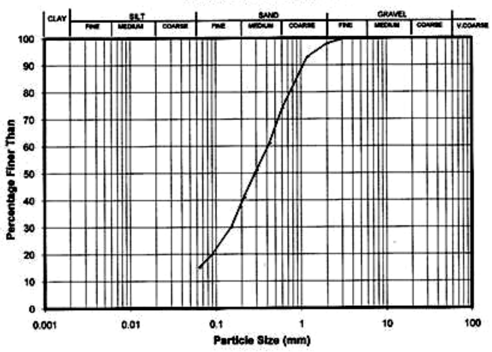
Form No.: P5
Form Date: JANUARY 2004

Plate No.: Page of
Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.000
BH No.: 3 Sample No.: 2
Depth: 4.0 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	—
53.0	—
37.5	—
26.5	—
19.0	—
13.2	—
9.50	—
6.70	100
4.75	100
3.35	100

Sieve (mm)	Total % Passing
2.00	98
1.18	93
0.600	74
0.425	61
0.300	51
0.212	41
0.150	30
0.090	20
0.063	15

Sample history : As received at natural water content.
Description: SAND with some silt and trace of clay, trace of coral, loose/saturated, grey - (Description based on the particle size analysis).
Remarks: Percentage passing the finest sieve was obtained by difference.

Entered by : ST Date : 27/9/10 Checked by : MJRA Date : 27/9/10

BH-3,-14.45m

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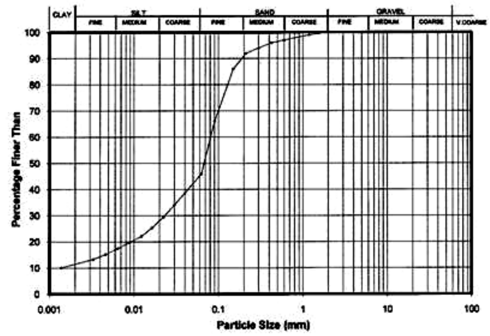
Form No.: P6
Form Date: January 2004

Plate No.: Page of
Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.001
BH No.: 3 Sample No.: 4
Depth: 8.0 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	—	0.425	96
19.0	—	0.300	94
13.2	—	0.212	92
9.50	—	0.150	86
6.70	100	0.090	66
4.75	100	0.063	46
3.35	100		
2.00	100		
1.18	99		
0.600	97		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0400	39
0.0300	34
0.0223	29
0.0164	25
0.0123	22
0.0089	20
0.0064	17
0.0046	15
0.0033	13
0.0014	10

Sample history : As received.
Solid Density (assumed) : 2.70 t/m^3
Description : silty SAND with minor clay and trace of shell fragments, very stiff, dark grey.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

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BH-3,-18.45m

Figure Ap4.3(1) Results of Particle Size Analysis(1)

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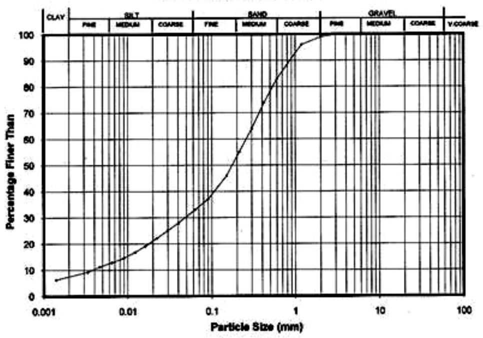
Form No.: P6
Form Date: January 2004

Plate No.: | Page of | Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique** | Our Job No.: 615388.001
BH No.: 3 | Sample No.: 8a | Depth: 16.0 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	---	0.425	74
19.0	---	0.300	64
13.2	---	0.212	55
9.50	---	0.150	46
6.70	---	0.090	37
4.75	100	0.063	33
3.35	100		
2.00	99		
1.18	96		
0.600	83		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0404	28
0.0300	25
0.0221	22
0.0163	19
0.0122	17
0.0089	15
0.0064	13
0.0046	11
0.0033	9
0.0014	6

Sample history : As received.
Solid Density (assumed) : 2.70 t/m^3
Description : silty SAND with minor clay and trace of fine gravel, loose to stiff, light greenish grey with brown, mottled orange.
Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

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BH-3,-26.45m

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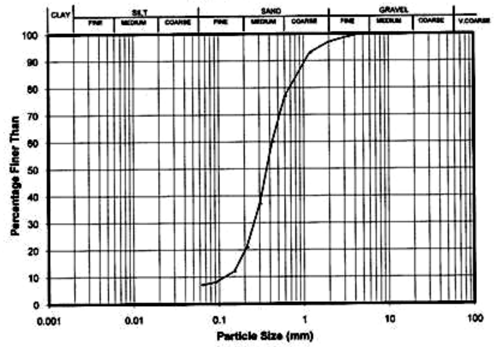
Form No.: S5
Form Date: JANUARY 2004

Plate No.: | Page of | Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique** | Our Job No.: 615388.000
BH No.: 4 | Sample No.: 2 | Depth: 4.0 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	---
9.50	---
6.70	100
4.75	100
3.35	99

Sieve (mm)	Total % Passing
2.00	97
1.18	93
0.600	77
0.425	60
0.300	37
0.212	21
0.150	12
0.090	8
0.063	7

Sample history : As received at natural water content.
Description: SAND with minor silt and trace of clay/fine gravel, loose/saturated, grey - (Description based on the particle size analysis).
Remarks: The mass of sample was ~ 0.12 kg.
Percentage passing the finest sieve was obtained by difference.

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BH-4,-16.55m

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Form No.: P6
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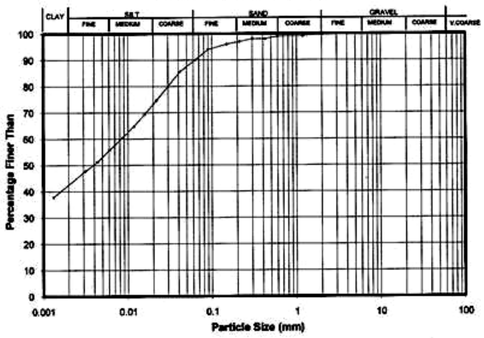
Plate No.: | Page of | Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique** | Our Job No.: 615388.001
BH No.: 4 | Sample No.: 7 | Depth: 14.0 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	---	0.425	98
19.0	---	0.300	98
13.2	---	0.212	97
9.50	---	0.150	96
6.70	100	0.090	94
4.75	100	0.063	90
3.35	100		
2.00	100		
1.18	99		
0.600	99		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0416	86
0.0302	80
0.0219	75
0.0158	69
0.0118	65
0.0085	60
0.0061	56
0.0044	51
0.0031	48
0.0013	38

Sample history : As received.
Solid Density (assumed) : 2.70 t/m^3
Description : clayey SILT with minor sand and trace of shell fragments, stiff, dark grey.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

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BH-4,-26.55m

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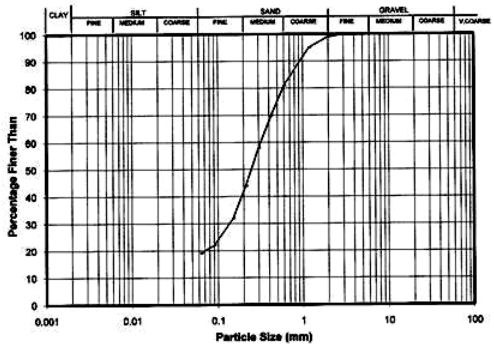
Form Date: JANUARY 2004

Plate No.: | Page of | Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique** | Our Job No.: 615388.000
BH No.: 4 | Sample No.: 9 | Depth: 18.0 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	---
9.50	---
6.70	---
4.75	100
3.35	100

Sieve (mm)	Total % Passing
2.00	99
1.18	95
0.600	81
0.425	70
0.300	58
0.212	44
0.150	32
0.090	22
0.063	19

Sample history : As received at natural water content.
Description: SAND with some silt and trace of clay, trace of shell fragments, loose/saturated, light brownish grey - (Description based on the particle size analysis).
Remarks: The mass of sample was ~ 0.12 kg.
Percentage passing the finest sieve was obtained by difference.

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BH-4,-30.55m

Figure Ap4.3(2) Results of Particle Size Analysis(2)

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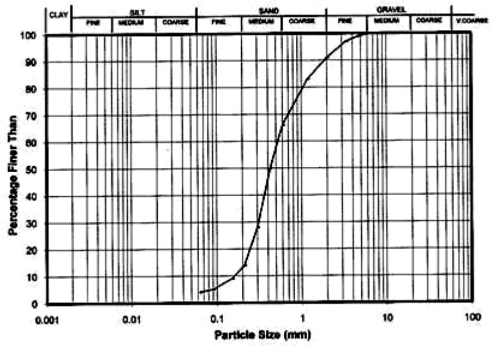
Plate No.: Page of
Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.000
BH No.: 5 Sample No.: 1
Depth: 2.0 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	—
53.0	—
37.5	—
26.5	—
19.0	—
13.2	—
9.50	—
6.70	100
4.75	99
3.35	97

Sieve (mm)	Total % Passing
2.00	91
1.18	83
0.600	66
0.425	50
0.300	28
0.212	14
0.150	9
0.090	5
0.063	4

Sample history : As received at natural water content.
Description: SAND with trace of silt and minor shell fragments, loose/saturated, light greenish grey - (Description based on the particle size analysis).
Remarks: The mass of sample was ~ 0.14 kg.
Percentage passing the finest sieve was obtained by difference.

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BH-5,-8.25m

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Form No: P6
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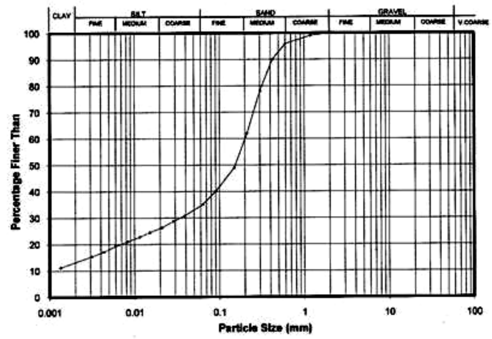
Plate No.: Page of
Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.001
BH No.: 5 Sample No.: 7
Depth: 14.0 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	—	0.425	90
19.0	—	0.300	78
13.2	—	0.212	62
9.50	—	0.150	49
6.70	—	0.090	40
4.75	100	0.063	35
3.35	100		
2.00	100		
1.18	99		
0.600	96		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0388	31
0.0286	29
0.0210	26
0.0152	25
0.0114	23
0.0083	21
0.0060	19
0.0043	17
0.0031	15
0.0013	11

Sample history : As received.
Solid Density (assumed) : 2.70 t/m^3
Description : silty SAND with some clay and trace of shell fragments, soft to firm, dark grey.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

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BH-5,-20.25m

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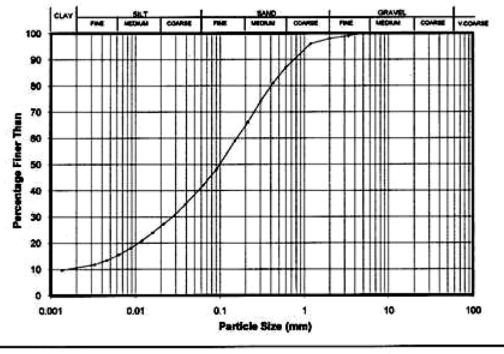
Form No: P6
Form Date: January 2004

Plate No.: Page of
Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.001
BH No.: 5 Sample No.: 8
Depth: 15.0 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	—	0.425	81
19.0	—	0.300	74
13.2	—	0.212	66
9.50	—	0.150	59
6.70	100	0.090	48
4.75	100	0.063	42
3.35	99		
2.00	98		
1.18	96		
0.600	87		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0390	35
0.0293	31
0.0216	27
0.0159	24
0.0120	21
0.0087	18
0.0063	16
0.0046	13
0.0033	12
0.0014	10

Sample history : As received.
Solid Density (assumed) : 2.75 t/m^3
Description : silty SAND with minor clay and trace of shell fragments, soft to stiff, dark grey.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

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BH-5,-21.25m

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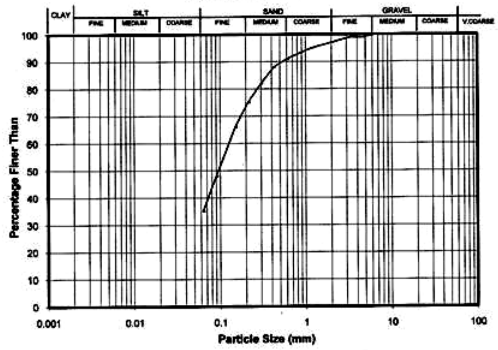
Form No: S5
Form Date: JANUARY 2004

Plate No.: Page of
Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.000
BH No.: 6 Sample No.: 1
Depth: 2.0 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	—
53.0	—
37.5	—
26.5	—
19.0	—
13.2	100
9.50	100
6.70	100
4.75	99
3.35	99

Sieve (mm)	Total % Passing
2.00	97
1.18	95
0.600	91
0.425	88
0.300	82
0.212	75
0.150	66
0.090	48
0.063	35

Sample history : As received at natural water content.
Description: silty SAND with minor clay and trace of shell fragments, soft to firm, dark grey - (Description based on the particle size analysis).
Remarks: The mass of sample was ~ 0.19 kg.
Percentage passing the finest sieve was obtained by difference.

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BH-6,-8.25m

Figure Ap4.3(3) Results of Particle Size Analysis(3)

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Form No.: P6
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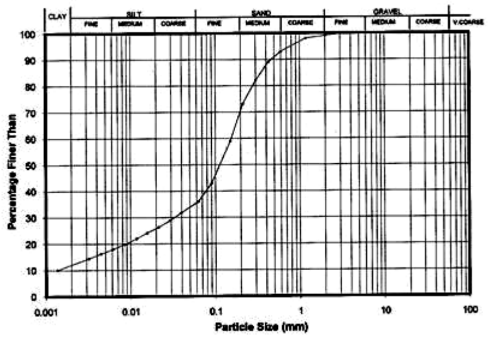
Plate No.: Page of Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique** Our Job No.: 615388.001
BH No.: 6 Sample No.: 4 Depth: 8.0 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	---	0.425	89
19.0	---	0.300	82
13.2	---	0.212	73
9.50	---	0.150	59
6.70	---	0.090	43
4.75	100	0.063	36
3.35	100		
2.00	99		
1.18	98		
0.600	93		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0392	32
0.0291	29
0.0214	26
0.0155	24
0.0117	22
0.0085	20
0.0061	18
0.0044	16
0.0032	14
0.0014	10

Sample history : As received.
Solid Density (assumed) : 2.70 t/m^3
Description : silty SAND with minor clay and trace of shell fragments, soft to firm, dark grey.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

Entered by : ST Date : 22/10/10 Checked by : MURA Date : 22/10/10

BH-6,-14.25m

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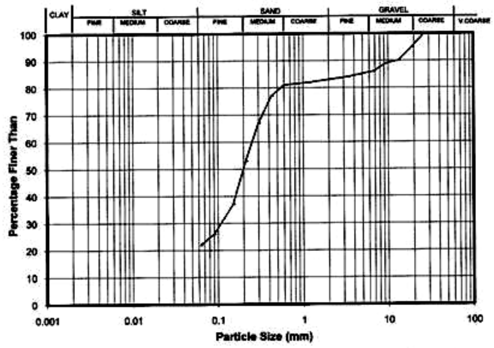
Form No.: S5
Form Date: JANUARY 2004

Plate No.: Page of Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique** Our Job No.: 615388.000
BH No.: 6 Sample No.: 8 Depth: 14.0 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	100
19.0	95
13.2	90
9.50	89
6.70	86
4.75	85
3.35	84

Sieve (mm)	Total % Passing
2.00	83
1.18	82
0.600	81
0.425	77
0.300	67
0.212	53
0.150	37
0.090	26
0.063	22

Sample history : As received at natural water content.
Description: SAND with some gravel, some silt and trace of clay, loose/saturated, light greenish grey - (Description based on the particle size analysis).
Remarks: The mass of sample was ~ 0.26 kg.
Percentage passing the finest sieve was obtained by difference.

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BH-6,-29.25m

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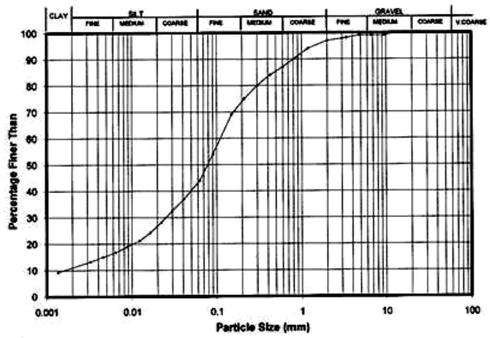
Plate No.: Page of Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique** Our Job No.: 615388.001
BH No.: 7 Sample No.: 1 Depth: 2.0 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	---	0.425	84
19.0	100	0.300	80
13.2	100	0.212	75
9.50	99	0.150	69
6.70	99	0.090	54
4.75	99	0.063	44
3.35	98		
2.00	97		
1.18	94		
0.600	87		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0409	37
0.0302	33
0.0223	28
0.0163	24
0.0122	21
0.0088	19
0.0063	17
0.0045	15
0.0032	13
0.0014	9

Sample history : As received.
Solid Density (assumed) : 2.80 t/m^3
Description : silty SAND with minor clay and trace of shell fragments, soft to firm, dark grey.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

Entered by : ST Date : 22/10/10 Checked by : MURA Date : 27/10/10

BH-7,-8.85m

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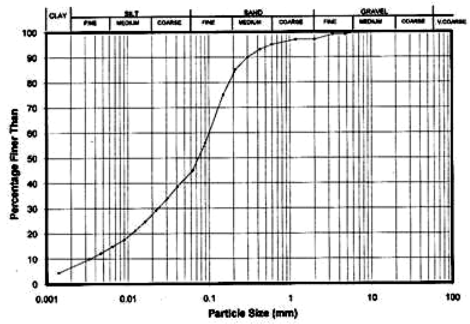
Form No.: P6
Form Date: January 2004

Plate No.: Page of Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique** Our Job No.: 615388.001
BH No.: 7 Sample No.: 3 Depth: 6.0 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	---	0.425	93
19.0	---	0.300	90
13.2	100	0.212	85
9.50	100	0.150	75
6.70	100	0.090	56
4.75	99	0.063	45
3.35	99		
2.00	97		
1.18	97		
0.600	95		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0409	39
0.0304	34
0.0224	29
0.0164	25
0.0123	21
0.0089	18
0.0064	15
0.0046	12
0.0033	10
0.0014	5

Sample history : As received.
Solid Density (assumed) : 2.80 t/m^3
Description : silty SAND with minor clay and trace of shell fragments, hard, dark brownish grey.

Remarks : A light masonry hammer was used to pulverize the sample mass down to smaller fragments which were then soaked with a dispersing agent for ~ 4 hours, prior to washing. The wet sieve sample was washed to waste over 0.063mm test sieve. The individual sand/silt/clay lump aggregations were further broken down with a frequent stirring using a rubber pestle, until the particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

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BH-7,-12.85m

Figure Ap4.3(4) Results of Particle Size Analysis(4)

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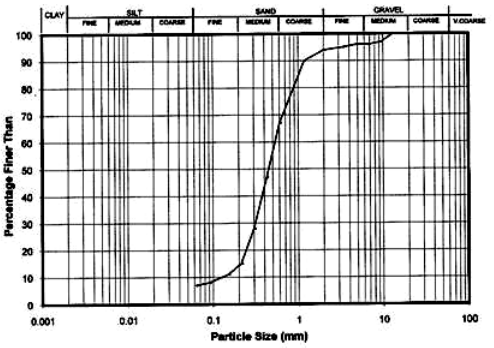
Form No.: 55
Form Date: JANUARY 2004

Plate No.: Page of
Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.000
BH No.: 8 Sample No.: 1
Depth: 6.0 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	100
9.50	97
6.70	96
4.75	96
3.35	95

Sieve (mm)	Total % Passing
2.00	94
1.18	90
0.600	67
0.425	47
0.300	28
0.212	15
0.150	11
0.090	8
0.063	7

Sample history : As received at natural water content.
Description: SAND, minor gravel, minor silt, trace of clay, loose/saturated, light greenish grey with light yellowish brown - (Description based on the particle size analysis).
Remarks: The mass of sample was ~ 0.11 kg.
Percentage passing the finest sieve was obtained by difference.

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BH-8,-0.5m

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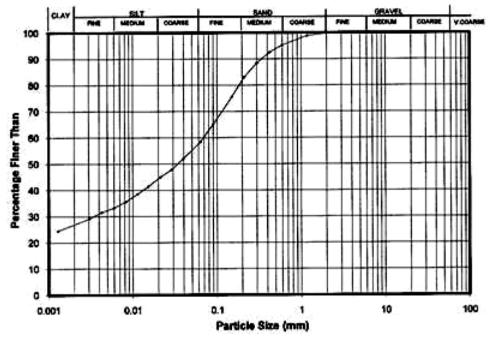
Form No.: P6
Form Date: January 2004

Plate No.: Page of
Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.001
BH No.: 9 Sample No.: 2
Depth: 8.2 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	—	0.425	92
19.0	—	0.300	88
13.2	—	0.212	83
9.50	—	0.150	75
6.70	100	0.090	65
4.75	100	0.063	58
3.35	100		
2.00	100		
1.18	99		
0.600	95		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0392	52
0.0289	48
0.0210	45
0.0152	41
0.0114	38
0.0083	36
0.0059	33
0.0043	31
0.0031	29
0.0013	24

Sample history : As received.
Solid Density (assumed) : 2.70 t/m^3
Description : silty clayey SAND, trace of fine gravel, stiff, light greenish grey with brown, orange stains.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

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BH-9,-2.7m

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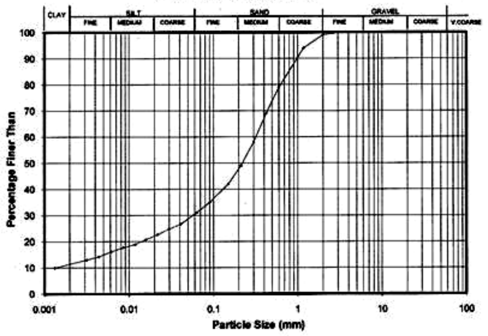
Plate No.: Page of
Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.001
BH No.: 9 Sample No.: 4
Depth: 11.2 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	---	0.425	69
19.0	---	0.300	58
13.2	---	0.212	49
9.50	---	0.150	42
6.70	100	0.090	35
4.75	100	0.063	31
3.35	100		
2.00	99		
1.18	94		
0.600	79		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0410	27
0.0298	25
0.0218	23
0.0158	21
0.0118	19
0.0085	18
0.0061	16
0.0044	14
0.0032	13
0.0013	10

Sample history : As received.
Solid Density (assumed) : 2.75 t/m^3
Description : silty SAND with minor clay and trace of fine gravel, stiff, light greenish grey with brown, orange stains.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

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BH-9,-5.7m

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Form No.: P6
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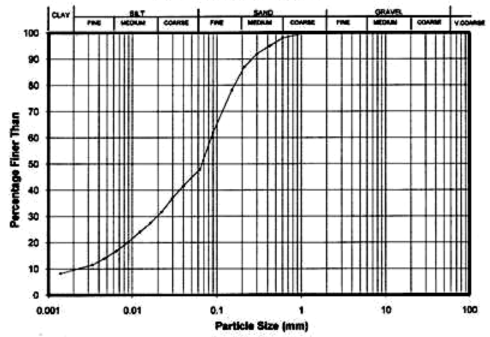
Plate No.: Page of
Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.001
BH No.: 9 Sample No.: 6
Depth: 14.2 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	—	0.425	95
19.0	---	0.300	92
13.2	---	0.212	87
9.50	---	0.150	78
6.70	---	0.090	62
4.75	100	0.063	48
3.35	100		
2.00	100		
1.18	100		
0.600	98		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0402	42
0.0298	37
0.0221	32
0.0163	27
0.0122	24
0.0089	20
0.0064	17
0.0046	14
0.0033	12
0.0014	8

Sample history : As received.
Solid Density (assumed) : 2.75 t/m^3
Description : silty SAND with minor clay, very stiff, grey with brown, orange stains.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

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BH-9,-8.7m

Figure Ap4.3(5) Results of Particle Size Analysis(5)

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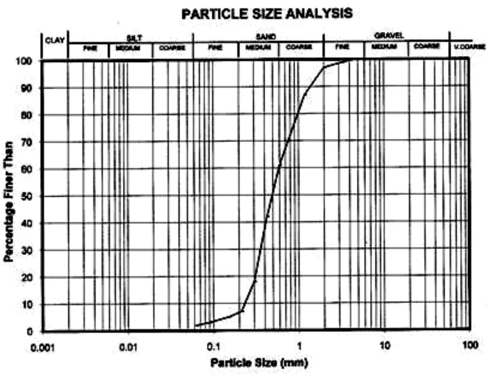
Form No.: 55
Form Date: JANUARY 2004

Plate No.: Page of
Site : **Nacala Port Redevelopment, Mozambique**
BH No.: 10 Sample No.: 1
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

Your Job No.: 750780
Our Job No.: 615388.000
Depth: 6.0 (m)

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	100
9.50	100
6.70	100
4.75	100
3.35	99

Sieve (mm)	Total % Passing
2.00	97
1.18	87
0.600	61
0.425	42
0.300	18
0.212	7
0.150	5
0.090	3
0.063	2

Sample history : As received at natural water content.
Description: SAND with trace of shell fragments and trace of silt, loose/saturated, light brownish grey - (Description based on the particle size analysis).
Remarks: The mass of sample was ~ 0.28 kg.
Percentage passing the finest sieve was obtained by difference.

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BH-10,0.0m

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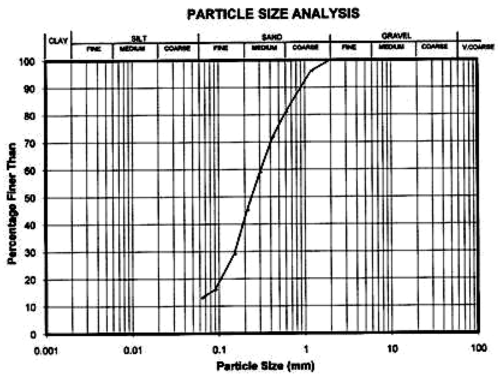
Form No.: 55
Form Date: JANUARY 2004

Plate No.: Page of
Site : **Nacala Port Redevelopment, Mozambique**
BH No.: 10 Sample No.: 3
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

Your Job No.: 750780
Our Job No.: 615388.000
Depth: 8.2 (m)

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	---
9.50	---
6.70	---
4.75	---
3.35	100

Sieve (mm)	Total % Passing
2.00	100
1.18	96
0.600	81
0.425	72
0.300	59
0.212	45
0.150	29
0.090	16
0.063	13

Sample history : As received at natural water content.
Description: SAND with minor silt and trace of clay, loose/saturated, light whitish grey - (Description based on the particle size analysis).
Remarks: Percentage passing the finest sieve was obtained by difference.

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BH-10,-2.2m

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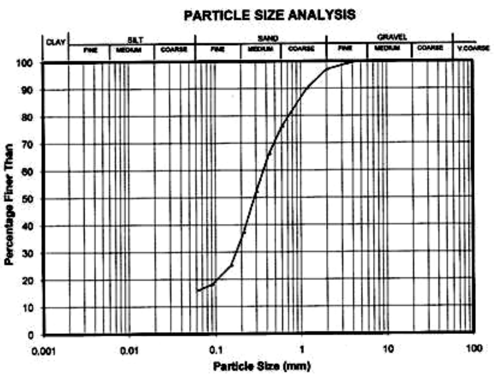
Plate No.: Page of
Site : **Nacala Port Redevelopment, Mozambique**
BH No.: 10 Sample No.: 5
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

Your Job No.: 750780
Our Job No.: 615388.000
Depth: 12.2 (m)

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	---
9.50	---
6.70	100
4.75	100
3.35	99

Sieve (mm)	Total % Passing
2.00	97
1.18	90
0.600	76
0.425	66
0.300	52
0.212	37
0.150	25
0.090	18
0.063	16

Sample history : As received at natural water content.
Description: SAND with some silt and trace of fine gravel/trace of clay, loose/saturated, light greenish grey - (Description based on the particle size analysis).
Remarks: Percentage passing the finest sieve was obtained by difference.

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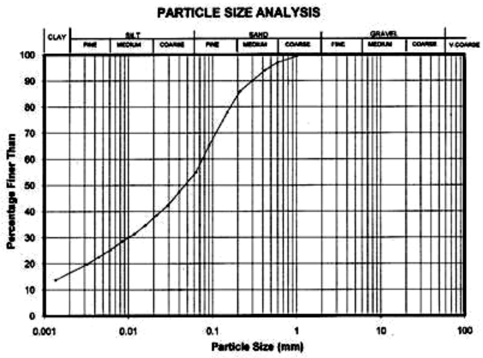
Form No.: P6
Form Date: January 2004

Plate No.: Page of
Site : **Nacala Port Redevelopment, Mozambique**
BH No.: 10 Sample No.: 7
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

Your Job No.:750780
Our Job No.: 615388.001
Depth: 16.2 (m)

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	---	0.425	94
19.0	---	0.300	90
13.2	---	0.212	86
9.50	---	0.150	78
6.70	---	0.090	65
4.75	---	0.063	55
3.35	100		
2.00	100		
1.18	100		
0.600	97		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0398	47
0.0295	42
0.0216	39
0.0158	35
0.0118	31
0.0085	29
0.0062	25
0.0044	23
0.0032	20
0.0014	14

Sample history : As received.
Solid Density (assumed) : 2.75 t/m^3
Description : silty SAND with some clay, stiff, light greenish grey with brown, orange stains.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

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BH-10,-6.2m

Figure Ap4.3(6) Results of Particle Size Analysis(6)

BH-10,-10.2m

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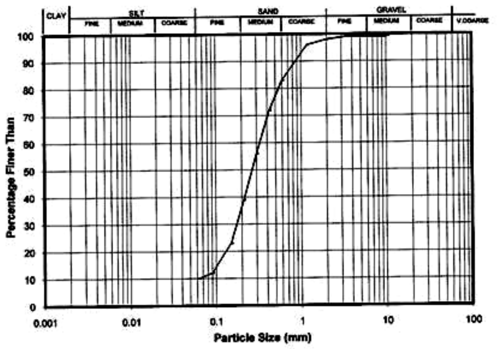
Form Date: JANUARY 2004

Plate No.: Page of
Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.000
BH No.: 11 Sample No.: 2
Depth: 7.0 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	100
9.50	99
6.70	99
4.75	99
3.35	99

Sieve (mm)	Total % Passing
2.00	98
1.18	96
0.600	83
0.425	72
0.300	56
0.212	39
0.150	23
0.090	12
0.063	10

Sample history : As received at natural water content.
Description: SAND with minor silt and trace of clay/trace of fine gravel, loose/saturated, light greenish grey with light brown, mottled black - (Description based on the particle size analysis).
Remarks: The mass of sample was ~ 0.29 kg.
Percentage passing the finest sieve was obtained by difference.

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BH-11,-1.0m

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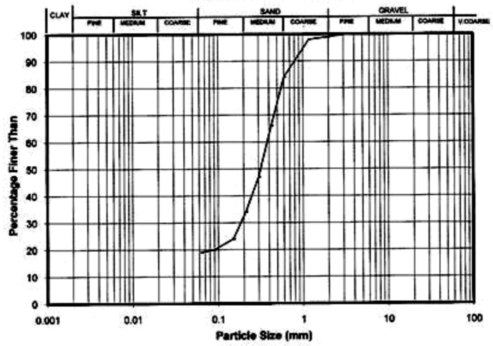
Form No.: S5
Form Date: JANUARY 2004

Plate No.: Page of
Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.000
BH No.: 11 Sample No.: 4
Depth: 9.7 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	---
9.50	---
6.70	100
4.75	100
3.35	100

Sieve (mm)	Total % Passing
2.00	99
1.18	98
0.600	84
0.425	66
0.300	47
0.212	34
0.150	24
0.090	20
0.063	19

Sample history : As received at natural water content.
Description: SAND with some silt and trace of clay/trace of fine gravel, loose/saturated, light greenish grey with light brown, mottled light yellow/light red, orange stains - (Description based on the particle size analysis).
Remarks: Percentage passing the finest sieve was obtained by difference.

Entered by : ST Date : 27/9/10 Checked by : [illegible] Date : 28/9/10

BH-11,-3.7m

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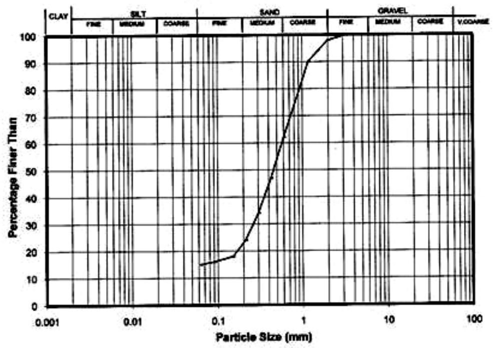
Plate No.: Page of
Your Job No.: 750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.000
BH No.: 11 Sample No.: 7
Depth: 14.2 (m)
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	---
9.50	---
6.70	---
4.75	100
3.35	100

Sieve (mm)	Total % Passing
2.00	98
1.18	90
0.600	62
0.425	47
0.300	34
0.212	24
0.150	18
0.090	16
0.063	15

Sample history : As received at natural water content.
Description: SAND with some silt and trace of clay/trace of fine gravel, loose/saturated, light greenish grey with light brown, orange stains - (Description based on the particle size analysis).
Remarks: Percentage passing the finest sieve was obtained by difference.

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BH-11,-8.2m

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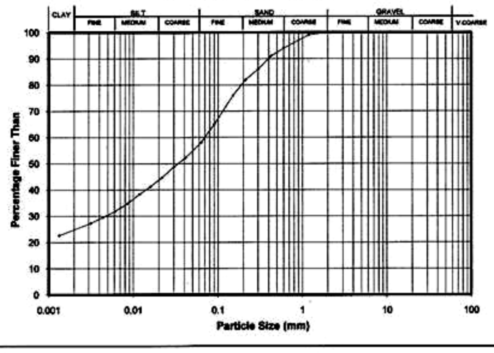
Plate No.: Page of
Your Job No.:750780
Site : **Nacala Port Redevelopment, Mozambique**
Our Job No.: 615388.001
BH No.: 11 Sample No.: 10
Depth: 18.7 (m)
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	---	0.425	91
19.0	---	0.300	86
13.2	---	0.212	82
9.50	---	0.150	76
6.70	100	0.090	65
4.75	100	0.063	58
3.35	100		
2.00	100		
1.18	99		
0.600	94		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0412	52
0.0300	49
0.0218	45
0.0158	41
0.0118	38
0.0085	35
0.0062	32
0.0044	30
0.0032	27
0.0013	23

Sample history : As received.
Solid Density (assumed) : 2.70 t/m^3
Description : silty clayey SAND, stiff, light greenish grey with brown, orange stains.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

Entered by : ST Date : 22/10/10 Checked by : [illegible] Date : 22/10/10

BH-11,-12.7m

Figure Ap4.3(7) Results of Particle Size Analysis(7)

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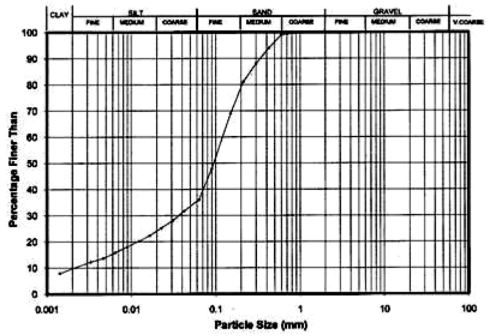
Form No.: P6
Form Date: January 2004

Plate No.: Page of
Site : **Nacala Port Redevelopment, Mozambique**
BH No.: 11 Sample No.: 11
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

Your Job No.:750780
Our Job No.: 615388.001
Depth: 20.2 (m)

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	---	0.425	94
19.0	---	0.300	88
13.2	---	0.212	81
9.50	---	0.150	69
6.70	---	0.090	48
4.75	---	0.063	36
3.35	---		
2.00	---		
1.18	100		
0.600	99		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0420	32
0.0310	28
0.0226	25
0.0165	22
0.0123	20
0.0089	18
0.0064	16
0.0046	14
0.0033	12
0.0014	8

Sample history : As received.
Solid Density (assumed) : 2.70 t/m^3
Description : silty SAND with minor clay, very stiff, grey with brown, orange stains.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

Entered by : ST Date : 22/10/10 Checked by : HURA Date : 24/10/10

BH-11,-14.2m

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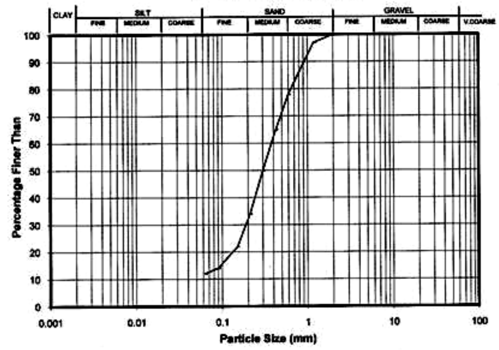
Form No.: S5
Form Date: JANUARY 2004

Plate No.: Page of
Site : **Nacala Port Redevelopment, Mozambique**
BH No.: 12 Sample No.: 2
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

Your Job No.: 750780
Our Job No.: 615388.000
Depth: 6.7 (m)

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	---
9.50	---
6.70	---
4.75	---
3.35	100

Sieve (mm)	Total % Passing
2.00	100
1.18	97
0.600	78
0.425	65
0.300	50
0.212	34
0.150	22
0.090	14
0.063	12

Sample history : As received at natural water content.
Description: SAND with minor silt and trace of clay, loose/saturated, light greenish grey with brown - (Description based on the particle size analysis).
Remarks: Percentage passing the finest sieve was obtained by difference.

Entered by : ST Date : 27/9/10 Checked by : HURA Date : 29/9/10

BH-12,-0.7m

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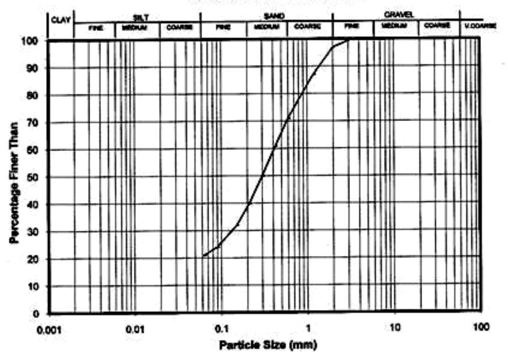
Form No.: S5
Form Date: JANUARY 2004

Plate No.: Page of
Site : **Nacala Port Redevelopment, Mozambique**
BH No.: 12 Sample No.: 6
Test Method Used : NZS 4402 : 1986 Test 2.8.1 Wet Sieve

Your Job No.: 750780
Our Job No.: 615388.000
Depth: 12.7 (m)

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing
63.0	---
53.0	---
37.5	---
26.5	---
19.0	---
13.2	---
9.50	---
6.70	100
4.75	100
3.35	100

Sieve (mm)	Total % Passing
2.00	97
1.18	87
0.600	71
0.425	61
0.300	50
0.212	40
0.150	32
0.090	24
0.063	21

Sample history : As received at natural water content.
Description: SAND with some silt and minor clay/trace of fine gravel, tightly compact, light greenish grey with brown - (Description based on the particle size analysis).
Remarks: Percentage passing the finest sieve was obtained by difference.

Entered by : ST Date : 27/9/10 Checked by : HURA Date : 29/9/10

BH-12,-6.7m

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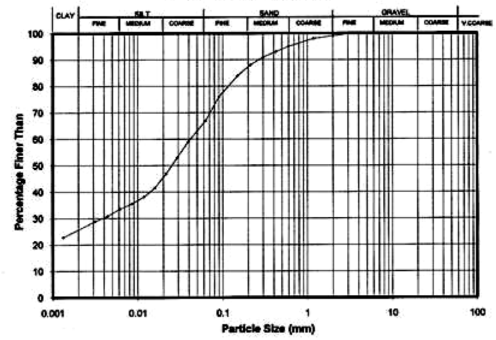
GEOTECHNICS

Form No.: P6
Form Date: January 2004

Plate No.: Page of
Site : **Nacala Port Redevelopment, Mozambique**
BH No.: 12 Sample No.: 10
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

Your Job No.:750780
Our Job No.: 615388.001
Depth: 18.7 (m)

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	---	0.425	93
19.0	---	0.300	91
13.2	---	0.212	88
9.50	---	0.150	84
6.70	---	0.090	76
4.75	---	0.063	67
3.35	100		
2.00	99		
1.18	96		
0.600	95		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0392	59
0.0291	53
0.0216	47
0.0159	42
0.0119	38
0.0085	36
0.0061	34
0.0044	31
0.0031	29
0.0013	23

Sample history : As received.
Solid Density (assumed) : 2.70 t/m^3
Description : sandy clayey SILT, trace of fine gravel, stiff, light greenish grey with brown, orange stains.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 8.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

Entered by : ST Date : 22/10/10 Checked by : HURA Date : 24/10/10

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Figure Ap4.3(8) Results of Particle Size Analysis(8)

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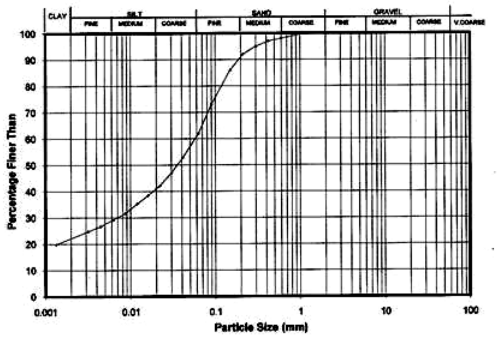
Form No.: P6
Form Date: January 2004

Plate No.: Page of
Site : Nacala Port Redevelopment, Mozambique
BH No.: 12 Sample No.: 13
Test Method Used : NZS 4402:1986 Test 2.8.1 Wet Sieve Test 2.8.4 Hydrometer

Your Job No.:750780
Our Job No.: 615388.001
Depth: 24.2 (m)

PARTICLE SIZE ANALYSIS



Sieve (mm)	Total % Passing	Sieve (mm)	Total % Passing
26.5	—	0.425	97
19.0	—	0.300	95
13.2	—	0.212	92
9.50	—	0.150	86
6.70	—	0.090	73
4.75	—	0.063	62
3.35	100		
2.00	100		
1.18	100		
0.600	98		

Equivalent Particle Diameter D (mm)	% of Particles Finer than D
0.0410	53
0.0303	47
0.0221	42
0.0160	38
0.0120	35
0.0086	32
0.0062	29
0.0044	27
0.0032	25
0.0013	20

Sample history : As received.
Solid Density (assumed) : 2.75 t/m^3
Description : sandy clayey SILT, very stiff, medium brown, orange stains, calcite flecks.

Remarks : The wet sieve sample was washed to waste over 0.063mm test sieve, until the individual particles were clean. The material retained on 0.063mm test sieve was oven dried and dry sieved. Later it was advised by the engineer, to carry out a hydrometer analysis on the remaining sample. The hydrometer sample was oven dried at the end of the test to determine the mass passing 0.063mm test seive for hydrometer calculations. The sieve data was combined with the hydrometer analysis to give a continuous curve.
Suspension pH 6.0
The classification of sand-silt-clay components are described on the basis of particle size analysis.
Sample description is not IANZ endorsed.

Entered by : [illegible] Date : [illegible] Checked by : [illegible] Date : [illegible]

BH-12,-18.2m

Figure Ap4.3(9) Results of Particle Size Analysis(9)