Main Report

Service Port, Beira

Republic of Mozambique
Beira
SERVICE PORT FOR BEIRA HARBOUR,
MOZAMBIQUE

Main Report, site investigation, program of requirements, identification of
the alternatives and selection.

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This report is the result of the completion of my University education at
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Delft, 13th December 1990,
The Netherlands.
This report covers a study on the planning of the proposed service port of Beira Harbour, Mozambique. The need for this service port was identified in the Masterplan for Beira Harbour which was originally drawn up by NEDECO ten years ago. This following study is my project for graduating from the Faculty of Civil Engineering at the Delft University of Technology, The Netherlands.

Valuable support for the study was provided by a Dutch consulting firm, DHV Consultants. The trip to Beira was financed by the Lammingafonds and administered by the Delft University of Technology.

For me it was a very interesting project and the opportunity to visit Beira, Mozambique an enormous challenge. I gratefully acknowledge the support of my supervisors and would like to thank them for organizing the visit. I would also like to acknowledge the valuable contribution provided by my aunt Til Johnson-de Smet (England) for her assistance in correcting the final manuscript.
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SERVICE PORT, BEIRA

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    Project identification and feasibility study for Port Traffic Control Centre
    Beira Port, Mozambique.

M2. Peoples Republic of Mozambique
    BCA
    Beira Port Project - Dredging
    Contract No. P - A - 1
    Contract Documents - Volume 5
    S.1. - Physical Information - Part B

M3. Beira Port Projects
    Capital Dredging Works Contract P - A - 1
    Memorandum No. 3
    Pre-Dredging Survey
    DHV Consultants March 1989

M4. Beira Port Study
    Access Channel Study
    Main Report
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M5. Beira Port Study
    Access Channel Study
    Volume 3
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M6. Beira Port Study
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M10. Mozambique - a tale of terror
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ABBREVIATIONS

List of abbreviations:

APC Amsterdam Port Consultants
BCA Beira Corridor Authority
BMA Zimbabwean counterpart of BCA
CD Chart Datum
C.F.M./D.E.C. Caminhos de Ferro de Moçambique (Centro)
CIO Rhodesian military intelligence
Dev. Development
Dfl. Dutch florin
D.G.I.S. Directorate General for International Cooperation
DHV Consultants DHV Consultants *
E East
EC European Community
ECU European Currency Unity
Emodraga Empresa Mocambicana de Dragagem E.E.
(Mozambican Dredging Company)
h hour
IMF International Monetary Fund
Ing. Ingenieur
Ir. Ingenieur
ABBREVIATIONS—Continued

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>km</td>
<td>kilometer</td>
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<tr>
<td>Lat.</td>
<td>Latitude</td>
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<td>Long.</td>
<td>Longitude</td>
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<td>m</td>
<td>meter</td>
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<td>mm</td>
<td>millimeter</td>
</tr>
<tr>
<td>MNR</td>
<td>Mozambique National Resistance = Renamo</td>
</tr>
<tr>
<td>Mr.</td>
<td>Mister</td>
</tr>
<tr>
<td>MSL</td>
<td>Mean Sea Level</td>
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<td>NEDECO</td>
<td>Netherland Engineering Consultants</td>
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<td>No.</td>
<td>Number</td>
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<tr>
<td>P.A.</td>
<td>Port Administration</td>
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<td>Prof.</td>
<td>Professor</td>
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<td>PTCC</td>
<td>Port Traffic Control Centre</td>
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<td>Ref.</td>
<td>Reference</td>
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<td>Renamo</td>
<td>Resistência Nacional de Moçambique</td>
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<td>s</td>
<td>second</td>
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<td>S</td>
<td>South</td>
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<td>SADCC</td>
<td>Southern African Development Coordination Conference</td>
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<td>SE</td>
<td>South East</td>
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<tr>
<td>T.U.-Delft</td>
<td>Delft University of Technology</td>
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<tr>
<td>UNICEF</td>
<td>United Nations International Children’s Emergency Fund</td>
</tr>
<tr>
<td>US$</td>
<td>Dollar of the United States</td>
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<td>WB</td>
<td>World Bank</td>
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* DHV Consultants is Holland’s foremost consultancy firm operating abroad. The firm was founded in 1917 by three Dutch engineers and has over 1200 personnel.
This study for a service port in Beira Harbour can be divided into three different parts. These parts will be discussed below in the sequence in which they have been carried out.

The first part consists of the preparations for the journey to Beira and the actual site investigation. In Beira a site investigation had been carried out to obtain all the necessary data and information to make it possible to design the service port. In the Netherlands a study for this purpose started at the head-office of DHV Consultants. For this purpose use has been made of the existing studies for Beira Harbour. This study was not sufficient and the information that was lacking had to be obtained during the visit to Beira. In Beira there were a lot of meetings with the different authorities to get the data and an impression of the problems in Beira Harbour. A selection of the most suitable location for the new service port was also carried out in Beira. The conclusion of this selection is that Praia Nova is the best location for this purpose. There were no maps of this terrain at the time and a survey had to be done to make it possible to make the maps.

After returning to the Netherlands with all the obtained data and information acquired in Beira to design the service port, it was necessary to collect all the information clearly in a separate report. This is Volume 1, Site Investigation. The different alternatives could then be identified and compared with each other to estimate which one is the best. The first conclusion was that alternative 2 was the best one. This alternative provides a service port in the northern part of the terrain in combination with the use of the existing fishery port. The disadvantage of this alternative is the rate of siltation. This siltation rate is not acceptable because the maintenance costs would be enormous. For this reason alternative 2 has been improved in the final design. This has been done by situating the moorings along the river bank. These subjects are discussed in this Main Report.

The third part of the study is the construction of a floating breakwater. This floating breakwater is the mooring for the small passenger vessels. It has to provide a sheltered mooring. The breakwater is a construction made out of concrete which would slide up and down with the tide along piles driven into the river bottom. The piles would keep the breakwater in its correct position and absorb the pressures. The results of the design for this floating breakwater are listed in Volume 2.

Generally one can say that there is a real demand for a new service port in Beira in order to solve the problems in the existing fishery port. The difficulty is to design a port with as little siltation as possible and sufficient sheltering.
1. INTRODUCTION

1.1 Mozambique

Mozambique is situated on the continent of Africa on the east coast, north of South Africa. See also Figure 1.1.1 Africa.

![Figure 1.1.1 Africa](image)

The vast, low plateau, rising towards mountains in the west and north, accounts for nearly half the area of Mozambique. The coast which is nearly 2500 km long is generally sandy. Mangrove and marsh vegetation is common in coastal areas. Behind the coastline, the plateau supports a landscape dominated by savannah, more or less dry and open woodlands with occasional tracts of short-grass steppe. The western and northern highlands are patched with forest sometimes of needles-leaf trees.
The highest point is Monte Binga (2436 m) on the Zimbabwe border. The Zambezi is the largest and most important of the 25 main rivers which flow through Mozambique into the Indian Ocean. See Figure 1.1.2 Mozambique.

Area: 785,000 km²
Population: 15.2 million (World Bank 1986)
Capital: Maputo

Figure 1.1.2 Mozambique.

1.2 History

This section has been copied from [Ref. M10]

"In 1498 the Portuguese explorer Vasco da Gama landed on the Mozambique coast while seeking a new route to India. Among the earliest colonizers in Africa, the Portuguese took over the ports during the next century. They extracted wealth from the existing African trading communities,
in the form of gold, ivory and later slaves. In fact Portuguese colonialism was chronically over-extended. Metropolitan Portugal was weak in comparison with other European powers and its capitalism slow to develop.

In Mozambique the economy came more and more under the domination of South Africa, which by the early 1970's accounted for about two-thirds of the country's foreign currency earnings. Final recognition that the colonial wars could not be won was a vital factor in the overthrow of the Lisbon regime in April 1974. An attempt by the new Portuguese government to impose a neo-colonialist solution in Mozambique came to nothing in the face of a unified and popular liberation movement, Frelimo. Under the leadership of Samora Machel and Marcelino dos Santos it had consolidated its hold on the north of the country and continued to extend its influence southwards. The southward advance was greatly accelerated by the collapse of the Lisbon Regime and the demoralization of the Portuguese army. An attempted coup by white settlers in the autumn of 1974 was quickly crushed and Mozambique moved from transitional government in September 1974 to full independence on 25th June, 1975. In February 1977 Mozambique was formally constituted as a Marxist republic under the leadership of Frelimo.

But Mozambique and Frelimo were not to have a honeymoon. Right after independence, Portuguese settlers left in droves - despite Frelimo's appeal to stay on and become Mozambicans - depriving the country of much of its skills and expertise. Next the country was to experience a series of disasters, natural as well as man-made: floods, droughts, planning mistakes, aggression by Ian Smith's armed forces and sabotage by surrogate forces set-up by the Rhodesian military intelligence CID, in retaliation for Frelimo's support for the Zimbabwean freedom fighters.

The advent of Zimbabwean independence in 1980 brought new and high hopes to Mozambique and its friends abroad. The Government formulated a ten-year development blueprint for 1989-1990. And members of the international community rolled up their sleeves to help Mozambique in its ambitious development task, at home as well as in the regional context of SADCC, where Mozambique has a strategic position in the transport sector. However, one crucial factor was overlooked, or at least underestimated, by Mozambique and its partners alike. Was it political naïveté, or wishful thinking; or were the events to come simply beyond imagination? Whichever - the facts are there, cold and harsh. The South African regime, in its survival strategy, was determined to maintain its dominance, domestically as well as regionally. Therefore it did not want the region's transport network, to a large extent situated in Mozambique, to be upgraded. Nor did it like the implementation of Frelimo's policy of egalitarianism and non-racialism, the mirror that late President Machel used to hold up to all South Africans, black and white.

Pretoria took over control of the armed Mozambican rebels from Ian Smith and greatly improved their training, equipment, logistics and tactics. Regional destabilisation entered a new phase with the South African attack in early 1981 on the Maputo suburb of Matola and has developed throughout this decade. Using its own forces as well as Renamo (Resistência Nacional de Moçambique, also named MNR), Pretoria sabotaged social and economic infrastructure to the extent that many socio-economic indicators in Mozambique have fallen back to pre-independence levels. According to a recent UNICEF report, 600,000 Mozambicans have died, directly or indirectly, as a result of this destabilisation war."
1.3 Economic background

Before independence, 40% of Mozambique's foreign exchange revenues came from transport for land-locked countries. By the mid-1980's, however, this revenue had disappeared; and, even worse, exports had fallen to a small fraction of previous levels. In 1986 the country's import bill was seven times as high as its export revenues and by 1988 the position had not improved. There is therefore a chronic balance of payments deficit, leaving the country highly dependent on foreign aid.

An extremely large amount of aid money has now been committed to Mozambique and investment in transport rehabilitation is at the top of the list. About US$ 2 billion of aid has been sought for projects to revive three transport corridors from the main Mozambican harbours to the landlocked countries of Zimbabwe, Malawi and Zambia; and over US$ 600 million of this total has been committed to the Beira Corridor*, mostly for the port and the railway to Zimbabwe. The sums earmarked for transport are greater than those for structural adjustment and balance of payments support from the IMF, World Bank etc for the period from 1987 to mid-1989, which totalled about US$ 400 million.

Traffic is now returning to the harbour of Beira, but there is still room for improvement: in particular, 80% of Zimbabwe's exports still go out via the South African harbour of Durban, despite it being three times as far from Harare as Beira.

Also on fishing, the fishing authorities consider that all the quay space in their fishery-port is urgently needed for the development of quays for prawn/fishing vessels. Prawns are the largest single export from Mozambique and Beira is the main prawn exporting harbour.

* Beira Corridor is the popular expression for the official name "Beira Port Transport System".
1.4 Beira Harbour

The harbour of Beira (Lat. 19° 50' S, Long. 34° 51' E) is situated in the Mozambique coastal plain on the left bank of the river Pungué and opposite its confluence with the river Buzi. See Figure 1.4.1 Beira. The harbour of Beira is situated some 20-kilometer from the open sea. Ships calling at Beira Harbour have to negotiate a dredged channel of considerable length through an extensive area with gullies and shoals before being able to berth at the quays. This access channel is the Macuti Channel.

Beira, the second harbour of Mozambique serves the central part of the country and is a significant link in the Beira Corridor. There is a 300-kilometer long railway, road and oil pipeline link between Beira and Zimbabwe. This link is of critical importance for Zimbabwe's development and also for Zambia.

The history of the Harbour of Beira dates back to 1887 when a military post was founded at the mouth of the river Pungué. The first section of the existing wharfs was built immediately after the First World war and major extensions took place after 1930. The main trends in Beira’s cargo traffic have been a steady decline after independence in 1975, reaching a low point in 1986, followed by a sharp revival in the last five years. Similar trends were observed in all the three main categories of cargo handled at Beira—transit cargo, Mozambique’s international cargo and Mozambique’s domestic cargo (coastal). The main reasons for the deep decline were political. The economy was left in a poor state by the Portuguese, who compounded its problems by sabotaging equipment as they left.

Since 1986 the economy has started to revive. There are two main reasons. First, the government launched an Economic Rehabilitation Program in 1987. And secondly, the political climate appears to be improving. Partly as a result of economic revival, the refurbishment of the rail line, development of troops to guard it and the investment in port facilities and training, Beira’s traffic increased by 58% between 1985 and 1988. But they still have a long way to go, as about 80% of Zimbabwe’s exports still go via Durban.

The anticipated growth in transport—especially containers, coal and petroleum products—makes it necessary to open the harbour to larger vessels and to modernize the transhipment of goods.

Nowadays there are several building activities in the harbour of Beira:
- the reconstruction of quay 2 to 5 (the old wharf) into a 600-meter-long container and multipurpose terminal,
- quay 6 to 10 have been renovated recently,
- the laying-out of an access road and other roads to make the harbour more accessible,*
- preparations for a new oil-terminal that will be built in the near future,
- maintenance dredging for the Macuti Channel, and
- the depth of the Macuti Channel has been increased recently. **

* This new access road will limit the damage to loading and unloading equipment, cars and load. The old access road was in very bad condition and caused a lot of damage because of it.
** To open the harbour to larger vessels.
1.5 Organization of the Port Projects

In the year 1980 the SADCC was founded. SADCC means the Southern African Development Coordination Conference. Ten states are members of this organization and their purposes are international and economic cooperation. In this organization Mozambique has the responsibility to coordinate the Transportation and Communication factor and also has to ensure that it achieves its objectives.

After the foundation of the SADCC, the government of Mozambique founded the BCA. BCA is the Beira Corridor Authority and it coordinates and supervises the Beira Corridor projects. A second task is to find donors for the various projects of the 10-year development plan for the Beira Corridor. Within this overall plan are 76 priority projects - under preparation, under implementation and some finished - in the harbour, railways and road sector, amounting to US$ 530 million. The Director of the BCA is Mr. Fonseca. The four Nordic countries give support to the BCA with a team of ten experts. The Zimbabwean counterpart is the BMA. In 1986 the first donor conference was organized in Beira. The interest for this conference was enormous because the position of Beira is very strategic and the Beira Corridor is all-important for the Southern African Region.

Before this conference, The Netherlands was the only donor and for this reason the eldest one. The Netherlands has supported Mozambique since 1974 on a bilateral basis. The Dutch cooperation with the SADCC has been concentrated on the activities in Beira. As a result of the first Conference on the Beira Corridor substantial financial support has been given by the Nordic Countries and the EC.

At the donor conference, The Netherlands knew all about Beira and its surroundings because a Masterplan study had been executed by NEDECO for the next ten years, together with a Port Rehabilitation Study. These two studies were financed by the Netherlands. The Masterplan contains future plans which are very expensive. The total costs have been estimated at approximately 1 milliard guilders. On the basis of this plan the costs were too high and the conference seemed to fail. Under guidance of the Netherlands and with the approval of the BCA a small committee consisting of the Netherlands, the EC, the Nordic Countries and the Worldbank was formed to discuss this problem at once and they decided to make a list of projects with a high priority. The costs of these projects were US$ 400 million. This was still a huge amount of money and so they made a list of the most urgent projects. This was called the "short list" and those costs amounted to US$ 160 million. Finally this list formed the basis for donor support during this Conference (In 1991 85% of the required foreign financing has been secured, being US$ 530 million). At this first conference a decision was made about who would be the donor of a special project. So at this conference for example was agreed that the EC would be the donor for the quay rehabilitation project.

Now there is such a donor coordination conference every two years in Brussels where the EC is the host. The last one was held in 1989. Each year bilateral negotiations take place between BCA and the Netherlands. Ongoing projects and possibilities for future financing are discussed then. The Netherlands now via D.G.I.S. is supporting the Beira projects for a total amount of Dfl. 25 to 30 million each year. D.G.I.S. has a special budget for this purpose. D.G.I.S. is part of the Dutch Ministry of Foreign Affairs.
After the results of the NEDECO study became available, the support to the harbour of Beira consisted mainly of supplies of materials and equipment. Four years ago the harbour was given the main materials and equipment and The Netherlands government has now changed their help to management support. Amsterdam Port Consultants (APC) started a collaboration between the harbours of Beira and Amsterdam and nowadays they provide 13 managers for the harbour operations, container handling, maintenance, management and training. The result of this change has been good so far as the turnover of the harbour increases every year. Besides this management support, another important field of the Netherlands-Mozambican bilateral cooperation is the dredging sector (Dfl 230 million increased to 521). These choices are made by mutual arrangement with BCA, the counterpart of D.G.I.S.

Starting up the quay project was too expensive for the EC and upon request of the EC, D.G.I.S. decided to pay for the supervision. DHV Consultants are supervising. Nowadays many donors are involved in the implementation of a great number of sub-projects of the Beira Corridor Development project. Among them the most important financial supporters for the harbour of Beira are: (in ECU's)

<table>
<thead>
<tr>
<th>Country</th>
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<tr>
<td>EC</td>
<td>69</td>
</tr>
<tr>
<td>Italy</td>
<td>68</td>
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<tr>
<td>Sweden</td>
<td>43</td>
</tr>
<tr>
<td>Finland</td>
<td>35.5</td>
</tr>
<tr>
<td>Netherlands</td>
<td>35</td>
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<tr>
<td>WB</td>
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<td>African Dev. Bank</td>
<td>21</td>
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<tr>
<td>Canada</td>
<td>17</td>
</tr>
<tr>
<td>USA, Japan and others</td>
<td>33</td>
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This section has been written with the assistance of:
Mr. Robbert J.M. Crul.
Senior Programme Officer for SADCC and Zimbabwe.
2. SYSTEMATICAL DESIGN

2.1 Problem delimitation

2.1.1 Signalizing the problem

DI-N Consultants indicated the need for a service port in their Masterplan study. They supported the present detailed study in order to have a feasibility study for a service port in Beira Harbour. For them it could be very interesting to have a blueprint for such a service port when the plans to build such a port become serious. In case the service port is built in reality, the Beira Corridor Authority (BCA) will be the principal.

2.1.2 Analysis of the problem

The need for a service port is growing because of the increasing number of service vessels, which need a place to moor and as the commercial traffic through the port is picking up, mooring along the existing quays is getting more and more problematic.

At the moment, there are no proper facilities to moor the service crafts such as tug-boats, pilot vessels and other ships owned by the Port Administration (vessels for surveillance, maintenance of buoys and beacons, hydrography and salvage services). There are also no proper facilities to moor the passenger vessels and the dredging equipment for the maintenance of the improved access channel (Macuti Channel) and the fishery-port.

Currently most of these vessels are moored in the fishery-port but there is a lack of capacity in this port and the presence of so many ships has a negative influence on the function of the fishery-port. The dredging equipment is now moored on a buoy in the river and access for maintenance is poor. During heavy weather conditions, the dredging fleet also moors in the fishery-port. In that case the port will be congested.

The passenger vessels can be subdivided into two categories:
1. The small passenger vessels which are moored in the fishery-port at present and that is not mean to happen.
2. The two large passenger vessels which use the actual harbour to moor. This situation is no longer acceptable. Before departure, people live and sleep on the quay, where the transhipment of goods and dangerous cargo takes place.

2.1.3 The problem

After analyzing the problem in the previous section it is possible to define the problem. The main problems are:
- there is no service port in Beira Harbour at present and it is needed badly, and
- there is a lack of facilities which are requirements of such a port.
2.1.4 Objectives

Main objective:
Designing a service port for Beira Harbour to create good and sufficient moorings for the following vessels:

a. the ships owned by the Port Administration:
   - 3 tug-boats,
   - 3 mooring vessels, and
   - 2 pilot vessels.

b. the passenger vessels:
   - 17 vessels administered by Administração Marítima da Beira, and
   - 2 vessels owned by Trans Marítima de Sofala.

c. the dredging fleet owned by Emodraga:
   - 1 trailer hopper,
   - 1 backhoe dredger,
   - 1 tug-boat,
   - 1 survey vessel, and
   - 1 speedboat.

For a detailed description of all these vessels see Appendix 6 in Volume 1.

Sub objectives:

a. Creating all other facilities needed, like facilities for storage, maintenance, spare parts and equipment.

b. Creating a good and safe infrastructure for workpeople and users.

c. Provide good accessibility.

d. Limit the building and construction costs.

e. Limit the damage to the environment.

f. Possibility for extension.

2.2 Limiting conditions and assumptions

2.2.1 Limiting conditions

Limiting conditions are conditions which restrict the designer in his possibilities to solve the problem. The design has to fulfil the limiting conditions.

The limiting conditions in this project are:

1. current velocity,
2. wave attack,
3. tide,
4. nature of the soil,
5. sedimentation,
6. climate,
7. economy, and
8. local situation.
2.2.2 Assumptions

Assumptions are in first instance explicit presuppositions which in case of lack of information will be used as established facts.

The assumptions are:
- the data obtained from all organizations and derived from earlier studies are right,
- the profiles of the soil in an area are characteristic for the whole area, and
- the survey is accurate enough for this study.

2.3 Analysis of function and operations

2.3.1 Introduction to the operational analysis

An operational analysis has been made to get insight into all the processes which take place in the service port. The processes will be used to determine the program of requirements. In this report the following subdivision of processes will be used:
- primary processes,
- secondary processes, and
- natural processes.

For the enumeration of the processes see below.

2.3.1.1 Primary processes

- berthing/ mooring,
- sailing,
- safety,
- sheltering (against waves, wind, tide and currents),
- maintenance, repairs,
- transport of goods and equipment,
- fuel and water supply/ energy, and
- embarkation and disembarkation of the passenger vessels.

2.3.1.2 Secondary processes

- waiting for the passenger vessels,
- use of toilets (general),
- administration,
- education,
- parking of cars, busses and lorries,
- sale of tickets,
- give information,
- port management, and
- administrative or private services (weather forecast, customs, medical needs).
2.3.1.3 Natural processes

- climatic influences (temperature, sunlight, rainfall, humidity, wind),
- silting up (entrance channel to the port, port basin),
- erosion (near constructions, slopes),
- tide,
- waves,
- current velocity,
- growth of mangrove, and
- wear and tear.

2.3.2 Introduction to the analysis of function

In the analysis of function it is possible to analyze the primary and secondary processes. For each function which had been found in the operational analysis (2.3.1), will be investigated, which facilities are needed. The results of this analysis have been listed below.

2.3.2.1 Primary processes

<table>
<thead>
<tr>
<th>Function</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berthing/mooring</td>
<td>- jetties, quays, pontoons/ bollards/ accessible at all times without the need for a lock</td>
</tr>
<tr>
<td>Sailing</td>
<td>- entrance channel to the port, with a sufficient depth/ good, safe and surveyable entrance/ enough manoeuvring space in the port</td>
</tr>
<tr>
<td>Safety</td>
<td>- safe moorings/ clear marking within the port</td>
</tr>
<tr>
<td>Protection against waves, wind and currents</td>
<td>- sheltered moorings/ breakwaters</td>
</tr>
<tr>
<td>Maintenance, repairs</td>
<td>- areas to store equipment and materials/ a mobile crane/ sheds</td>
</tr>
<tr>
<td>Transport of goods and equipment</td>
<td>- roads/ good accessible moorings</td>
</tr>
<tr>
<td>Fuel and water supply/ energy</td>
<td>- special jetty with fuel and water facility or facilities at the moorings</td>
</tr>
<tr>
<td>Embarkation/ disembarkation passengers</td>
<td>- a mooring facility with the entrance/ exit on the same level</td>
</tr>
</tbody>
</table>

2.3.2.2 Secondary processes

<table>
<thead>
<tr>
<th>Function</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waiting for the passenger vessels</td>
<td>- waiting-room with seats, give protection against bad weather/ shop</td>
</tr>
<tr>
<td>Use of toilets (general)</td>
<td>- building with sanitary facilities</td>
</tr>
<tr>
<td>Administration</td>
<td>- office/ counter</td>
</tr>
<tr>
<td>Education (P.A.)</td>
<td>- classroom</td>
</tr>
<tr>
<td>Parking of cars, busses and lorries</td>
<td>- parking places</td>
</tr>
</tbody>
</table>
Sale of tickets - ticket office
Give information to passengers - information office
Port management - office
Administrative or private services: building for these purposes
  weather forecast,
  customs, and
  medical needs.

These results are used in chapter 3 to compose the program of requirements.
In this study most attention will be paid to the primary processes.
3. PROGRAM OF REQUIREMENTS

3.1 Introduction

The program of requirements has been estimated in the following way. During the visit to Beira a few meetings were organized with the authorities who are involved with the plans of the new service port. The purpose of these meetings was to obtain a good impression of the service port, to collect all available data about the vessels and the facilities required for such a service port. For the survey of the meetings (date/authority), the collected data and the reports of these meetings see Appendix 6 in Volume 1.

In chapter 2, an analysis of function has been carried out and also the facilities required for each function have been listed. These results and those of the meetings are used in this chapter to make the program of requirements. For the program of requirements see the following sections.

3.2 General program of requirements

- Durability of live at least 40 years.
- Design a service port which is maintenance free.
- The relation between costs and quality is very important.
- The costs of a new service port must be low (donor).
- The actual service port has to be located as near as possible to the fishery-port.
- Possibility for extension in the future:
  - New trailer hopper for Emobraga.
  - Dock for maintenance of the dredging equipment.
  - Marina when economy of Mozambique becomes healthy (low priority).
- Safety for vessels and all persons who use the service port.
- Port must give sufficient sheltering.
- Port must stay accessible for the vessels (sedimentation).

3.3 Program for the layout

The service port has to be designed for the following vessels and provisions:
- Mooring facilities for the service vessels owned by the Port Administration:
  - 3 tug-boats,
  - 3 mooring vessels, and
  - 2 pilot vessels.
- For the dimensions see Table 1.1.1 Service vessels in Appendix 6 in Volume 1.
- A special mooring for the tug "Messalo".
- The other two tugs (Buzi and Pungué) may be moored side by side.
- The pilot vessels may also be moored side by side.
- Mooring facilities for the passenger vessels administered by ADMINISTRAÇÃO MARITIMA DA BEIRA:
  - 17 passenger vessels.
  For the dimensions see Table 3.1.1 Passenger vessels in Appendix 6 in Volume 1.
- Mooring facilities for the passengers vessel owned by TRANS MARITIMA DE SOPALI:
  - 2 passenger vessels.
  For the dimensions see Table 4.1.1 Passenger vessels in Appendix 6 in Volume 1.
- A separate entrance for the passengers to the port area.
- Mooring facilities for the dredging fleet of Emodraga:
  - 1 trailer hopper,
  - 1 backhoe dredger,
  - 1 tug-boat,
  - 1 survey vessel, and
  - 1 speedboat.
  For the dimensions see Table 2.1.1 Dredging vessels in Appendix 6 in Volume 1.
- The dredging equipment may be moored side by side.
- Facility for storage of water and fuel for all vessels.
- Mobile crane with a lifting capacity of 40 tons, P.A. would like this crane for the maintenance of the pilot vessels and mooring vessels and Emodraga needs such a facility too.
- Good accessibility for the mobile crane from the maintenance area to the moorings.
- Police facilities.
- Medical facilities.
- Workshop for maintenance and storage of materials.
- Port Traffic Control Centre (PTCC).

3.4 Program for the dimensions

For this program see Appendix 8 in Volume 1. In this appendix are described the calculations to determine the dimensions of the different parts of the port. Only the most important results are listed here.

- Length of the mooring facilities:
  - service vessels 90 m
  - small passenger vessels 96 m
  - large passenger vessels 95 m
  - dredging vessels 122 m

- Depth of the different port components:
  - the access channel CD-5.86 m
  - the entrance channel CD-5.19 m
  - the part for the service vessels CD-4.18 m
  - the part for the small passenger vessels CD-3.13 m
  - the part for the dredging fleet CD-5.00 m

These programs have been used for the development of the three alternatives. These are discussed in chapter 7 and Appendix 9 in Volume 1.
4. SELECTION OF LOCATION

4.1 Introduction

To investigate the best location for the service port, considering the whole neighbourhood of Beira Harbour, it is essential that this is done in a systematical way. For this purpose there are several methods. In this report the following two methods will be used:
- A "Sieve" Analysis.
- A Potential Surface Analysis.

These methods and the results are described in the following sections.

4.2 The "Sieve" Analysis

Contemplating the map of the neighbourhood of Beira, the conclusion can be drawn that there are a few locations which are not at all suitable for the service port. Looking for the areas which are not acceptable at all is called "a sieve analysis". By drawing these areas on a map one can obtain a clear view of the locations which are not relevant. The locations which are not relevant are marked on Figure 4.2.1 and Figure 4.2.2. For these figures see the next page and for a description of these areas see the explanation below.

The locations which are not suitable are:

1. The existing harbour on the east side of the river Pungué (the horizontal shading on Figure 4.2.1).
   - The economic value of the existing harbour is so high that it is not a good solution to demolish an existing harbour especially when this is a useful one. There is also a lack of mooring capacity. Building a service port on these locations would be very expensive.

2. The area with the designation for the new oil terminal (the horizontal hatching on Figure 4.2.2).
   - The plan to build a new oil terminal on this location is at a very advanced stage. A service port on this location would have very little chance to succeed.

3. The west side of the river Pungué (the vertical shading on Figure 4.2.1).
   - This bank has no access to land. There is no bridge connecting the two banks. The only possibility to get there is by boat and that is not at all convenient. The distance to the west bank is quite big and for this reason the costs would be enormous.
   - This bank is situated at the inner corner of the river. In this area there is a high siltation and the water is shallow. Both the capital dredging costs to build a port and the maintenance dredging costs would be very high. Considering these costs, this location must be rejected.
Figure 4.2.1 and 4.2.2 The "Sieve" Analysis.

For legend see next page.
Legend for Figure 4.2.1 and 4.2.2:

= The existing harbour on the east side of the river Pungué.
= The area with the designation for the new oil terminal.
= The west side of the river Pungué.
= Remaining locations for the service port.

4.3 The Potential Surface Analysis

The areas which still remain as a proper location must be investigated with a so called "Potential Surface Analysis". With the aid of criteria it is possible to evaluate the remaining areas for their suitability as location for the service port.

Generally the next criteria will be used to compare the locations with each other for a port design:
- availability of land and water surface (and potential for extension),
- oceanographical considerations (wave attack, current velocity),
- nautical considerations,
- coastal engineering considerations,
- subsoil aspects,
- environmental aspects,
- connections with the hinterland,
- social aspects (urbanization, availability of labour),
- industrial engineering aspects (position and height of the field, cooling water, safety),
- costs (first cost, cost of maintenance), and
- accessibility (by land, to existing facilities).

In this case the following criteria will be used to compare the locations for a service port:
1. availability of land and water surface (and potential for extension),
2. oceanographical considerations,
   This criterium has to be subdivided into the following two:
   a. wave attack, and
   b. current velocity.
3. nautical considerations (manoeuvering into and out of the port),
4. subsoil aspects,
5. environmental aspects,
6. social aspects (housing),
7. industrial engineering aspects (safety),
8. costs (first cost, cost of maintenance), and
9. accessibility (by land, to existing facilities).

Considering the remaining areas, their suitability as a service port will be expressed with the use of the following value judgement:
+ = positive value judgement
o = neutral value judgement
- = negative value judgement
In fact there are three remaining locations for the service port. All of them are large enough to accommodate the service port. These locations are marked on the maps with a diagonal shading and are called A, B or C (See page 17).

The description of the locations:

Location A:
This location is north of the new oil terminal. For the time being there is no designation for this area. The area is covered by mangrove and a few wrecks.

Location B:
This location is between the existing oil terminal and the new oil terminal. This area is reserved for future multipurpose berths. Looking at this designation, it could be a possible location for the service port. At the moment the area is covered by mangrove and there are also a few wrecks. An army basis is situated behind this area.

Location C:
This location consists of two parts. One is the old fishery-port and the other is "Praia Nova" (New Beach). Both of these could be used for the service port. People live at Praia Nova and there are many economic activities. A part of it is covered by mangrove and there are lots of wrecks.

4.4 Results and conclusions

The results of the "Potential Surface Analysis" are shown in Table 4.4.1 below.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. availability of land and water surface (and potential for extension)</td>
<td>A</td>
</tr>
<tr>
<td>2. oceanographical considerations (wave attack, current velocity)</td>
<td>-</td>
</tr>
<tr>
<td>3. nautical considerations (manoeuvring into and out of the port)</td>
<td>-</td>
</tr>
<tr>
<td>4. subsoil aspects</td>
<td>+</td>
</tr>
<tr>
<td>5. environmental aspects</td>
<td>0</td>
</tr>
<tr>
<td>6. social aspects (housing)</td>
<td>+</td>
</tr>
<tr>
<td>7. industrial engineering aspects (safety)</td>
<td>-</td>
</tr>
<tr>
<td>8. costs (first cost, cost of maintenance)</td>
<td>-</td>
</tr>
<tr>
<td>9. accessibility (by land, to existing facilities)</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4.4.1 The "Potential Surface Analysis".
The conclusions which can be drawn from the above survey table are:

Location A is not a suitable location. This location has as disadvantages:
- The accessibility is bad. At present there are no good connections to this area.
- It is situated at the end of the entrance channel. One needs to dredge at this location to enlarge the entrance channel to make the service port accessible. The costs will be higher than at the other two locations.
- This location is not safe. It is dangerous because accidents can occur at the oil terminal.

Location B is more suitable because the dredging and maintenance costs will be lower. It is closer to the existing harbour and other facilities. Disadvantages are:
- The designation of future multipurpose berths (service port eventual possibility).
- The distance to the existing facilities is still quite large.
- Potential for extension is bad because it is between the existing and new oil terminal.
- The safety is the same as at location A.
- The presence of an army basis makes it difficult to plan the service port at this location (procedures).

Location C is the most suitable one as can be seen in the survey table. This location has more advantages than the other two locations. These advantages are:
- The accessibility by land is good and it is near the existing facilities especially for Emodraga who has a maintenance yard near this location.
- It is easy to provide good access to the area. Taking into account the plans to build a new Port Traffic Control Centre (PTCC) north of the old fishery-port it is also in this view a more central location.
- Considering the area of location C, a number of wrecks can be observed. This is a disaster for the area now. Planning the service port here means that they have to clear this area, which is good, but this will result in higher costs.
- Depending on the way of construction the first and the maintenance costs can be reduced.
- The use of the existing old fishery-port could save costs.

Location C has also disadvantages which are:
- A social problem. At present there are a lot of people "living" at location C who will have to move if the service port is going to be built there.
- A second disadvantage is the attack of the waves which is at this location the biggest. To provide for sufficient sheltered mooring facilities the costs might be higher.
- The subsoil at this location is worst because the lower layers consist mostly of mud.
In this report the study for a service port will continue at location C and the possibility to use the old fishery-port will be investigated.

4.5 An impression of "Praia Nova"

On the next two pages are some photographs showing the surroundings of Praia Nova to give an idea of this area.

The photographs show:
Photograph 1: the existing fishery-port with in the centre the tug-boats of the Port Administration and in the background the River Pungué.
Photograph 2: a view over the mangrove directly behind the wall which is on the left side of the photograph.
Photograph 3: Remains of the jetty with in the background a few wrecks.
Photograph 4: shows the economic activities and gives a general impression of the area.

For the maps of Praia Nova see Appendix 5 in Volume 1.
Photograph 1 The existing fishery-port and facilities.

Photograph 2 Mangrove vegetation at Praia Nova.
Photograph 3 Remains of the jetty at Praia Nova.

Photograph 4 A general impression.
5. SITE INVESTIGATION

5.1 Meteorological information

This information has partly been obtained by a literature study in the Netherlands at the head-office of DHV Consultants in Amersfoort. This study was done before the journey to Beira.
The source which has been used for this purpose is [Ref. M4].
Secondly a literature study was done in Beira. The source is [Ref. M2].

The data required for this service port study has been abstracted out of these two sources. For a detailed summary of the results of this investigation see Appendix 1 in Volume 1.

The most important results are listed below:
- The climate is tropical, but also influenced by the sea. The dry and calm season at Beira covers the period from May to September. The wet season which coincides with rougher conditions at sea lasts from December to April. In between both seasons transitory periods can exist.
- Seasonal variation in the wind direction is small. Most frequent wind directions are from the SE.
- Wind velocity is moderate. The mean wind speed is 13.2 km/h (3.7 m/s).
- The higher wind velocity shows a preference of the SE quadrant.
- The average annual rainfall in the Beira region amounts to 1,200-1,500 mm with strong local variations.

5.2 Tidal data

The tidal data has been gathered in the same way like the meteorological information. The sources which have been used are: [Ref. M2], [Ref. M5], [Ref. M6] and [Ref. M7].

For a detailed summary of the results of this literature study of the tidal data see Appendix 2 in Volume 1.

The most important results are listed below:
- The horizontal reference level, Chart Datum is defined as at a level of MSL-3.56 m.
- The large tidal range is a dominant factor in the area for the strong tidal currents and huge sediment transport.
- The tide is semi-diurnal with a daily difference of about 0.4 m in the tidal range.
- The tidal range at Beira is large; mean spring tidal range and mean neap tidal range amount to 5.7 and 1.6 m respectively.
- In general the flow velocities appear to be low during neap tides but can reach high values on the surface at the port site during spring tide.
- Ebb current velocities in front of the quays during spring tides in the wet season, may well exceed 2 m/s.
5.3 Wave data

The work plan is the same as described above. The sources used are: [Ref. M2.], [Ref. M4.] and [Ref. M6.].
For a detailed summary of the wave data see Appendix 3 in Volume 1. See also Volume 2 for data about the waves.

The most important results are listed below:
- Visual observations indicate that the main wave direction varies between east and south.
- Local winds can generate waves with periods of up to 8 seconds.
- Waves with longer periods, of which the swell originates from distant wind fields.
- The maximum wave height just outside the breaker zone is 1.4 m.

5.4 Nature of the soil

In earlier site investigations, the subsoil was investigated by C.F.M./D.E.C. These results were present at the office of DHV Consultants in Beira. These have been translated from the Portuguese language into the English language and transformed into a useful form. During the literature study in the Netherlands [Ref. M8.] was useful. For the profiles and other results see Appendix 4 in Volume 1.

The most important results are listed below:
- The subsoil consists of sandy clay.
- The upper layers are recent marine sediments.

5.5 Survey

The survey was executed during the stay in Beira. There were no maps of Praia Nova (location C) available. For a description of the methods used, the calculations and finally the maps of the area see Chapter 6 in the Main Report and Appendix 5 in Volume 1. For the preparations of the survey [Ref. M9.] has been used.

5.6 Ships/equipment data

To obtain this information there were some discussions with the different authorities during the visit to Beira. In Chapter 3 some information about the vessels has already been listed. For the authorities, the meetings and a detailed summary of the obtained data see Appendix 6 in Volume 1.
5.7 The wall

As one can see clearly on the maps in Appendix 5 in Volume 1 and Figure 6.2.1 in Chapter 6 of this report, there is a wall surrounding Praia Nova. During the visit to Beira efforts were made to get the most important data about this wall but without success. It was not possible to obtain the required information during the stay in Beira so this information is based on observations.

See Appendix 7 in Volume 1.
6. SURVEY

6.1 Introduction

The field work for the survey was executed over the period October 24th to November 14th in the year 1990. During this period there were four days on which the measurements were carried out. The area which had to be surveyed is called "Praia Nova" and is situated south of the existing fishery-port. This is the most suitable location for the new service port as was proved in Chapter 4. For the result see also the figures on page 17 (location C).

6.2 Description of the surveyed area

For the description of Praia Nova and the measurements, the terrain is subdivided into four areas. These areas are evaluated below. See Figure 6.2.1 for the four different areas.
In English, "Praia Nova" means "New Beach".

6.2.1 Area I

At the moment Praia Nova is an area with a lot of activities. After carrying out a detailed site visit, to determine the measuring strategy, it was clear that on the beach side of the terrain one can see several economic activities. There are two sawmills and there is a lot of work for both of these because of the repairs on the wrecks. For an impression of the number of wrecks at the terrain see photograph 3 and 4 on page 23. The terrain is called the churchyard for ships. Most of them are in a very bad condition. But there are also some ships which are in a relatively good condition. These are being repaired at the moment. Walking through the area one will see people repairing these old wrecks. The beach has a second function as a port for a few little fishing-boats that land on the beach. There is a fishery building named "Pescon". Finally there is a factory where they repair engines.

6.2.2 Area II

From the entrance of the terrain to the beach described above (Area I), one can see a few paths. One main path leads from the entrance to the beach. Some other paths join the main path. On both sides of the paths are little sheds where people live. Most of them are fishery families. The paths are a little bit higher than the other parts of the terrain so the paths do not flood at high water. The paths give the people a natural protection. At this part of the terrain there is also a market. Immediately behind the entrance is the maintenance area for Emodraga.

6.2.3 Area III

On the east side of the terrain which is considered for the project there is a border between the terrain and the town of Beira. This border is formed by a wall which leads from the entrance of the terrain to the north of the existing fishery-port. Thus in fact Area III is only the wall.
Figure 6.2.1 The four Areas.
6.2.4 Area IV

Finally there is the area directly on the west side, to the left of the wall. This is the lowest part of the terrain and influenced by the tide. This area is divided into two parts:
1. The northern part is the lower of the two. It is very muddy and has no trees.
2. The southern part is slightly higher and has trees. This is called a mangrove (See photograph 2 on page 22).
Both parts of this area are not inhabited.

6.3 Methods and Equipment

In this section follows a list of the equipment used and a description of the survey method used on the site. The results of the measurements have been used to draw some maps.

6.3.1 Equipment

The equipment used for the measurements on the site were:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>levelling instrument</td>
<td>Wild Nak 1</td>
</tr>
<tr>
<td>standard</td>
<td>Wild GST 20</td>
</tr>
<tr>
<td>beacon (2*)</td>
<td>Wild GTLE 4</td>
</tr>
<tr>
<td>measuring tape</td>
<td>Stanley Master acielak</td>
</tr>
<tr>
<td></td>
<td>34-419</td>
</tr>
</tbody>
</table>

For a description of the equipment see Appendix 5 in Volume 1.

6.3.2 Methods

The measurements were carried out over four days, with the aid of one or two Mozambican survey assistants, as follows:
- on the first day measurements were carried out on the beach starting from the jetty towards the north end of the spit of land (Area I),
- on the second day measurements were carried out on the part of the terrain between the jetty and the entrance of the terrain (Area II),
- on the third day the wall (Area III) and measurements to connect the measurements of the first two days with the Benchmarks at the jetty, and
- on the fourth day measurements were carried out on the lower parts (Area IV).

Two good positions were chosen for the beacons and one for the levelling instrument. A good position implies that it is visible from the point where the levelling instrument is erected and that it will give as much information as possible about the area. This is necessary to get useful maps.
Now the measuring started and these are called the measurements to the "backside". These readings from the levelling instrument have been written on a special form. After these readings the beacons were moved to two new
locations and the readings were taken again, these are called the measurements to the "foreside".

Then the height of the levelling instrument was measured. After measuring one cycle the levelling instrument was moved to a new location and the measuring was started all over again. This time the beacons stayed on their location for the readings to the backside this time. This procedure went on till all measurements were done. For a survey of these readings see Appendix 5 in Volume 1. In this way the beach (Area I) was measured and also the area between the beach and the entrance to the terrain (Area II).

The wall (Area III) was measured in another way. Interest was only paid to the topography of this wall and so only the directions and the length of the different parts of the wall were measured. In this case the length was measured with the use of a measurement tape.

The lower part of the terrain (Area IV) was measured to obtain an impression of the depth-contours. It was not possible to walk on this part and the depth-contours were estimated with the aid of the tide. During one flood period the water line was drawn as accurate as possible each half hour. At the same time the distance between the water-level and the upper side of the jetty (Benchmark) was measured. On the beach the distance of the water line to well-known points was measured and the time was noted.

6.4 Processing of the data

Once the measurements were carried out, the obtained data could be processed. This was done with the use of a spread sheet. The spread sheet which was used, was the Symphony 2.0. With the aid of this spread sheet it was easier to process the data. Of all measured points coordinates and their levels were calculated.

For the coordinates the existing local system in Beira was used. On the Jetty are two benchmarks and all the measurements have been related to these two benchmarks. These benchmarks are known in coordinates and height [Ref. M3.] so it is logical to use them for the measurements. See Appendix 5 in Volume 1 for the coordinates and the level of the benchmarks.

After calculating the coordinates, they were collected altogether in a new file and this file was used to make a map of the coordinates. This was done with the use of another program called Freelance 2.0. This is a program especially designed to display figures and so on.

With the aid of Freelance it was possible to print the coordinates at a scale of 1 to 5000. This print has been used to draw all the maps in this report. This print is also shown in Appendix 5 in Volume 1.

One can distinguish between two kinds of maps:
- maps showing the topography of the area, and
- maps showing the height of the area (contours).

For a good impression of the area, slides have been made of the whole terrain.

For an explanation of the method of calculations see Appendix 5 in Volume 1.
7. THE IDENTIFICATION OF THE ALTERNATIVES

7.1 Method of identification

In first instance three draft alternatives were identified during the visit to Beira. This was done with the aid of a simple program of requirements. These alternatives were discussed with a few authorities at the second meeting. See Appendix 6 in Volume 1. The purpose of these meetings was to discuss the alternatives and to acquire new information and good ideas for the best solution.

After returning to The Netherlands, the identification of the alternatives started again. The three draft alternatives were good so the concept was there. It was therefore possible to work out these three alternatives. First it was necessary to make a final program of requirements for the layout and for the dimensions. See Chapter 3 and Appendix 8 in Volume 1.

Then the alternatives were investigated once more and the final designs completed. All the alternatives are situated at location C, (Praia Nova) the most suitable location for the new service port.

7.2 Description of the alternatives

7.2.1 Alternative 1

This alternative is situated in the southern part of Praia Nova. It consists of a new port for all the different types of vessels. This port would be constructed partly as a basin cut into the land along the river bank and partly as a mooring on the outside for the large passenger vessels. The port entrance is close to the Macuti Channel and the entire surface area is about 63,100 m². For a more detailed description see Appendix 9 in Volume 1.
7.2.2 Alternative 2

This alternative is situated in the northern part of Praia Nova. The existing fishery-port will also be used to moor the vessels owned by the Port Administration and this is where the new Port Traffic Control Centre (PTCC) is projected. The new part in this solution envisages a port basin protected by two breakwaters perpendicular to the present river bank. One of them floats to take into account the possibility of a future extension. The entire surface area is about 54,700 m². For a detailed description of this alternative see Appendix 9 in Volume 1.
Figure 7.2.2 Alternative 2.

7.2.3 Alternative 3

This alternative is situated in the central part of Praia Nova. This plan also envisages a new port. It can be subdivided into a basin for the smaller vessels and a mooring along the river bank for the larger passenger vessels. The entire surface area is about 82,500 m². For a more detailed description see Appendix 9 in Volume 1.
Figure 7.2.3 Alternative 3.
8. SELECTION OF THE FINAL DESIGN

8.1 Introduction

In this chapter, the best alternative will finally be investigated. In this study three different alternatives have been identified. These alternatives are called Alternative 1, Alternative 2 and Alternative 3 and all three are situated at Praia Nova (location C) which is the most suitable location for a new service port. For the investigation of the most suitable location see Chapter 4 and for a detailed description of the alternatives see Appendix 9 in Volume 1. Looking for the best alternative, use will be made of a multi criteria analysis. With the aid of criteria it is possible to evaluate the best alternative as the solution for the service port.

A multi criteria analysis is a kind of numeric evaluation. Here the simplest method will be used which is called "the weighed index of success". A frame of primary, secondary, etc criteria can be formed which all get their own factor of weighing. For these criteria see the next section.

Furthermore all criteria will obtain a valuation for each alternative. Multiplying the factors of weighing and the valuations, and finally a summation will result in a quantitative judgement. See section 8.3.

8.2 The criteria

In this study the following primary and secondary criteria will be used to compare the alternatives with each other for a port design:

<table>
<thead>
<tr>
<th>Primary criteria</th>
<th>Primary factor of weighing</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) port-technical</td>
<td>9</td>
</tr>
<tr>
<td>(ii) town and country planning</td>
<td>7</td>
</tr>
<tr>
<td>(iii) social aspects</td>
<td>5</td>
</tr>
<tr>
<td>(iv) coastal engineering aspects</td>
<td>4</td>
</tr>
<tr>
<td>(v) cost</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Secondary and tertiary criteria</th>
<th>Secondary factor of weighing</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) port-technical</td>
<td>8</td>
</tr>
<tr>
<td>(a) nautical and hydraulic criteria</td>
<td>8</td>
</tr>
<tr>
<td>1. going to and returning from the sea</td>
<td>8</td>
</tr>
<tr>
<td>2. stopping distance</td>
<td>8</td>
</tr>
<tr>
<td>3. manoeuvring room in the port</td>
<td>8</td>
</tr>
<tr>
<td>4. nautical safety</td>
<td>8</td>
</tr>
<tr>
<td>5. traffic-regulation</td>
<td>8</td>
</tr>
<tr>
<td>6. waves penetration in the port</td>
<td>8</td>
</tr>
<tr>
<td>7. waves in front of the port</td>
<td>8</td>
</tr>
<tr>
<td>8. crosscurrent in front of the port</td>
<td>8</td>
</tr>
</tbody>
</table>
(b) **flexibility**

1. potential for extension
2. availability of land and water surface

(c) **safety**

1. collisions
2. separate zones for passengers

(d) **time of construction**

2

(ii) **town and country development**

(a) **traffic and transport**

accessibility, connections
(by land, to existing facilities)

(b) **environmental aspects**

1. necessary clearing (wrecks)
2. affection of the mangrove

(iii) **social aspects**

1. disturbance of economic activities
2. re-housing of people

(iv) **coastal engineering aspects**

(a) **approach channels**

7

(b) **siltation**

5

(c) **currents**

6

(v) **cost**

(a) **first cost**

1. constructions
2. dredging

(b) **cost of maintenance**

dredging

9
8.3 The multi criteria analysis

It is now possible to carry out the actual multi criteria analysis. The results of the multi criteria analysis are shown in Table 8.3.1 below.

<table>
<thead>
<tr>
<th>Primary Criteria</th>
<th>Secondary Criteria</th>
<th>Alt. 1</th>
<th>Alt. 2</th>
<th>Alt. 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) port-technical</td>
<td>(a) nautical and hydraulic criteria</td>
<td>6 432</td>
<td>7 504</td>
<td>4 288</td>
</tr>
<tr>
<td>9</td>
<td>(b) flexibility</td>
<td>7 441</td>
<td>9 567</td>
<td>5 315</td>
</tr>
<tr>
<td>8</td>
<td>(c) safety</td>
<td>2 126</td>
<td>8 504</td>
<td>6 378</td>
</tr>
<tr>
<td>7</td>
<td>(d) time of construction</td>
<td>5 90</td>
<td>7 126</td>
<td>2 36</td>
</tr>
<tr>
<td>(ii) town and country planning</td>
<td>(a) traffic and transport</td>
<td>6 336</td>
<td>8 448</td>
<td>6 336</td>
</tr>
<tr>
<td>7</td>
<td>(b) environmental aspects</td>
<td>6 168</td>
<td>5 140</td>
<td>8 224</td>
</tr>
<tr>
<td>(iii) social aspects</td>
<td></td>
<td>5 25</td>
<td>8 40</td>
<td>3 15</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(iv) coastal engineering aspects</td>
<td>(a) approach channels</td>
<td>7 196</td>
<td>9 252</td>
<td>4 112</td>
</tr>
<tr>
<td>4</td>
<td>(b) siltation</td>
<td>7 140</td>
<td>7 140</td>
<td>5 100</td>
</tr>
<tr>
<td>7</td>
<td>(c) currents</td>
<td>7 168</td>
<td>5 120</td>
<td>9 216</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(v) cost</td>
<td>(a) first cost</td>
<td>6 216</td>
<td>7 252</td>
<td>4 114</td>
</tr>
<tr>
<td>6</td>
<td>(b) cost of maintenance</td>
<td>6 324</td>
<td>6 324</td>
<td>4 216</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8.3.1 The multi criteria analysis.
8.4 Results and conclusions

The total number of points which each alternative has as a result of the multi criteria analysis is as follows:
- Alternative 1: 2662 points
- Alternative 2: 3417 points
- Alternative 3: 2380 points

The conclusion may be drawn that alternative 2 will be the best solution for the service port and alternative 3 the worst. The difference between alternative 1 and 3 is only small but the difference of both with alternative 2 is quite big. Thus, alternative 2 is clearly the best.

The main advantages and disadvantages of the three alternatives are listed below:

Alternative 1
Advantages:
- close to the Macuti Channel and easy to enter,
- good accessibility, near the entrance of Praia Nova,
- Emodraga is close to the maintenance area,
- clearing of the wrecks is a necessity, and
- cost of maintenance reduced because the basin is small and the approach channels are short.

Disadvantages:
- moorings for the vessels owned by the Port Administration and the other facilities are too far from the port,
- all passenger facilities are far apart,
- no separate entrance for passengers and work-people,
- big cross currents at the port entrance, and
- not so safe because of the currents and the crossing approach channels.

Alternative 2
Advantages:
- moorings for the vessels owned by the Port Administration in the existing service port where also the PTCC is planned,
- facilities for the passengers close to each other,
- good accessibility to the town and close to the centre,
- good possibilities for extension (floating breakwater),
- almost no re-housing,
- no disturbance of economic activities,
- approach channels very short, first- and maintenance costs are lower,
- to call at the port is easy for all kind of vessels, and
- a safe traffic pattern.

Disadvantages:
- Emodraga is too far from their maintenance area,
- cross currents at the port entrance, and
- no reason to clear Praia Nova.

Alternative 3
Advantages:
- fewer cross currents at the port entrance,
- one needs to clear the whole area,
- passenger facilities near each other, and
- less wave attack.

Disadvantages:
- almost the whole area is required,
- almost all the people need to move,
- disturbance of economic activities,
- Port Administration not at a central location,
- facilities for passengers far from town, and
- long construction time.

In the improved Alternative 2 is a plan to build a floating breakwater. For the study, design and construction of this breakwater see the Appendices in Volume 2.
9. IMPROVEMENT OF THE DESIGN

9.1 Introduction

As was proved in the previous chapter, alternative 2 is the most suitable solution for the service port. Such a solution, a basin cut into the land, has the disadvantage of heavy siltation which may occur. All three alternatives identified in this study have to deal with this problem. In Appendix 10 in Volume 1, one can find the calculations for the siltation. In the wet season the expected siltation is about 0.8 m. For reasons like maintenance of the port it is not acceptable and the design has to be improved to decrease the amount of siltation. Generally one can say that in an estuary such as in Beira with its very high sediment concentrations a basin cut has to be avoided. In such a basin cut it is very difficult to decrease the siltation rate. The most successful way to decrease the siltation rate is to create a port with a current velocity which is able to cause sediment transport. The problems that may occur mean that the port will be less sheltered against waves and currents. Designing a port with less siltation but still providing sufficient sheltering especially for the small passenger vessels, has been tried. In this chapter and in Appendix 9 in Volume 1 the improved alternative 2 will be discussed.

9.2 Description of the improved alternative 2

To avoid the heavy siltation it has been decided not to build a basin cut, but have mooring facilities along the river bank. The moorings for the dredging vessels owned by Emodraga will be situated at the southern part of the terrain as close as possible to their maintenance facilities. The mooring for the larger passenger vessels will stay at the same location as suggested in alternative 2. The vessels owned by the Port Administration will also get their moorings in the existing fishery port as suggested in alternative 2.

The big change is that a basin cut with two breakwaters will not be built but instead there will be moorings along the river bank. For this purpose a land extension will be built at the same place as the proposed basin cut. At the border of this extension and the water, a wall will be built with mooring facilities for the small passenger vessels. In order to protect them against waves a floating breakwater will be designed. For the design of the floating breakwater see Volume 2. Between the moorings for the passenger vessels and the vessels owned by Emodraga is an area for future extension. For a more detailed description see Appendix 9 in Volume 1.
Figure 9.2.1 The improved Alternative 2.
10. REPORT OF THE VISIT TO BEIRA

This journey was my first visit to a developing country and also my first visit to the continent of Africa. Before the visit I had prepared myself by reading books and old newspaper-articles about this continent and especially Mozambique. In this way I tried to get an idea of the things I would see on my journey and visit to Beira. But on arrival in Beira the confrontation was hard and I could not believe what I saw. Mozambique is really a developing country with all its problems and the civil war as well. Mozambique is one of the four poorest countries of the world. This altogether gives the country a serious drawback in it's development efforts.

In Beira I was living in the guest-house of DHV Consultants. This house is for people who are there for a short time. The house stands on a compound near the shore of the Indian Ocean. There is a guard on the compound and it is surrounded by a fence. On the compound, life is very good with all western luxuries and facilities, like clean water and electricity.
This in combination with the climate makes you believe you are in paradise. During my stay it was spring and it was getting warm.

But on the other side of the fence you are not in paradise. Here one will see people who have to live and work in bad conditions. In the Netherlands we may say bad but most Mozambican people are proud of their jobs and satisfied with their way of living. Coming from a rich country the differences are big and on the first days of my stay in Beira I had a real culture shock. I think it is good for my social education to be confronted with people who have to live in worse conditions. Here I saw how hard life can be in reality! People struggling for food, fighting against illness, looking for clothes and glad with a shed for the night.
After a few days I got used to it and then I wondered about the fact that the people of Mozambique really are trying to make the best of it and have a very positive attitude.

During my visit to Beira I had a lot of discussions with other western people who had been living in Beira for a few years. They could tell me a lot about the problems in this country and have tried to explain some unusual things. The problem in fact is that we always look through western eyes and then it is hard to believe why the people of Mozambique are living in the way they do. Our society is so different from theirs that you have to observe it through their eyes and consider their priorities. When I acted in this way there were also positive things to see and some of them were also understandable. This was a very interesting part of the journey.

Because I had only six weeks to fulfill the site investigation and to obtain all the required data to make it possible to design a service port, I had to work very hard. The job was so interesting that I did not notice the time. In developing countries it is normal to work long days and also saturday morning is work-time. In the office of DHV Consultants I had my own office and I could use a portable computer. After work I took the computer home and so I worked full days. Their office was on the site in the harbour and we got there by car. Most important was the good and efficient supervision.
All this together with a firm work schedule made it possible to make good progress and to get almost all the information in time.

The survey work at Praia Nova was carried out with the aid of Mozambican surveyors. They were very kind and tried to help as much as possible. I very much enjoyed working with them. I also had to co-operate with the directors of TRANS MARITIMA DE SOFALA and ADMINISTRACAO DA BEIRA because they could give me very important data for my service port study. From them I learned that you have to be very patient and polite if things are taking longer than at home otherwise you will achieve nothing. Generally I enjoyed it very much, to do this site investigation in a totally different and impressive world.

On the journey there and back I visited Harare. Here I had to wait for my connecting flights. Harare is the capital of Zimbabwe. There is an enormous difference between both countries. They are neighbours and still two completely different countries. Life in Zimbabwe is more sophisticated and most things are well organized. There is no lack of food and there is something like a national health service. On my first visit I went on a little safari which was very nice. The nature and the animals are wonderful in this country. I also visited the town. On my second visit I had arranged a one day trip to the Victoria Falls in the east of the country. These are immense Falls in the Zambezi river. They say that it is one of the seven wonders of nature and I must say I think they are right. It was really majestic.

Finally I will finish this report with saying that I am very glad that it was possible to make this study trip to Beira and to do this interesting project.