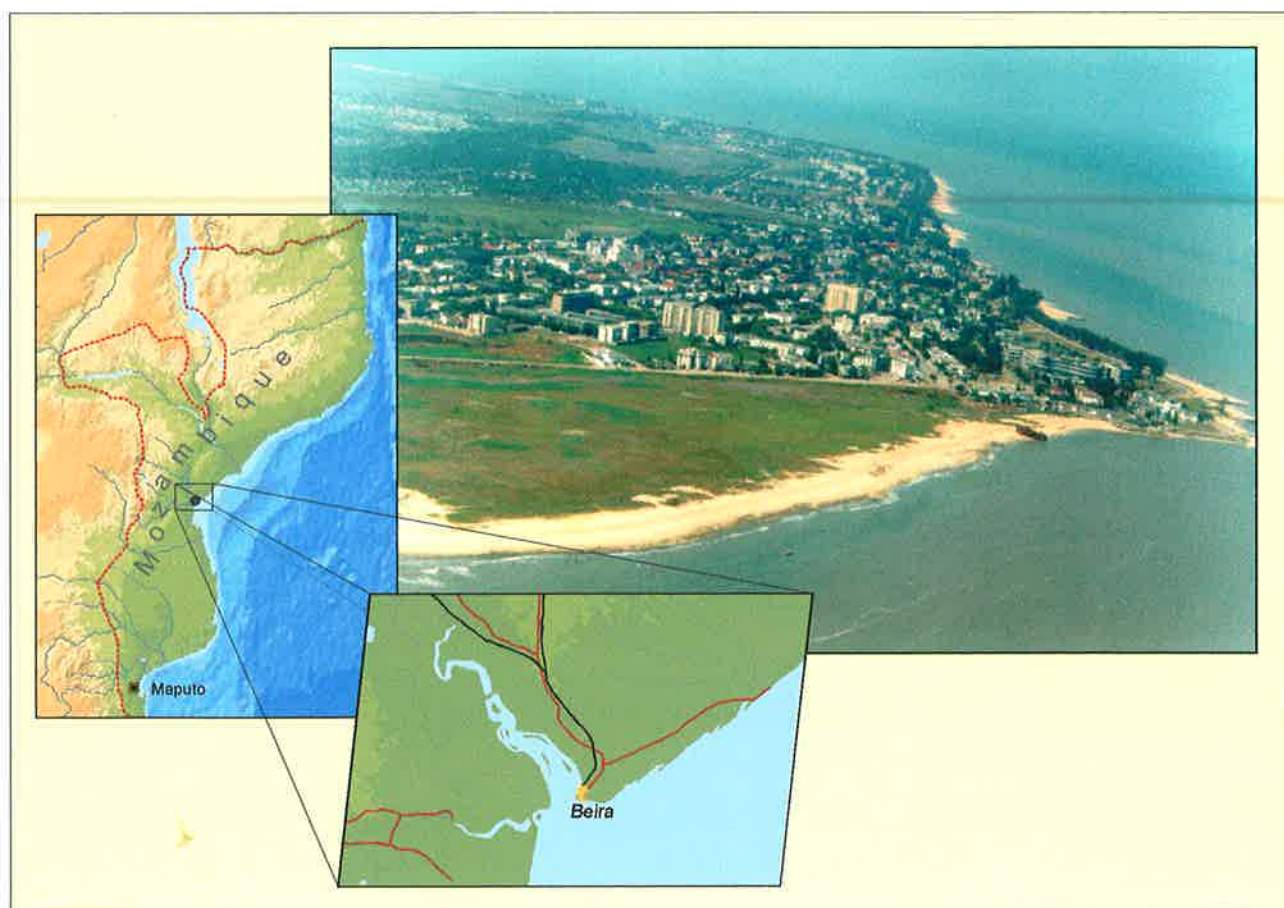


for *Conselho Municipal da Beira*

The Royal Netherlands Embassy
Maputo, Mozambique

INTEGRATED COASTAL ZONE MANAGEMENT PROGRAMME FOR BEIRA, MOZAMBIQUE

Final Report of the Beira Integrated Coastal Zone Management Project



The Royal Netherlands Embassy
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MOZAMBIQUE

Final Report of the Beira Integrated Coastal Zone Management Project

March 1999

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ARCADIS Euroconsult
Arnhem, the Netherlands
for
Conselho Municipal da Beira

IDENTIFICATION OF PROJECT

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PREAMBLE

This report presents the results of the *Beira Integrated Coastal Zone Management Project* that was carried out between April 1998 and February 1999. Apart from the coastal protection works, most activities were completed by October 1998. The draft version of this report consisted of four parts in three separate volumes, but for convenience all parts, now called Chapters, have been included in one volume in the current, final version. Comments received from various sources on the draft reports have to the fullest extent possible been incorporated in the current version.

Chapter 1 provides an oversight of Project objectives, and planned and achieved activities.

Chapter 2 outlines basic data, and reports on the outcome of specific investigations that were conducted by the Project.

Chapter 3 describes the Emergency Works, i.e. the coastal defence structures that were constructed or repaired by the Project.

Chapter 4 presents the Integrated Coastal Zone Management Strategy Plan. It is not a completed and detailed ICZM Action Plan, but it serves a base for preparation of such Action Plan.

ACKNOWLEDGEMENTS

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LIST OF ACRONYMS AND ABBREVIATIONS

ARA	Centro - Central Region, Administration of Waters
CD	<i>carte datum</i>
CMB	<i>Conselho</i> Municipal da Beira (Municipal Council of Beira)
CMF	Ports and Railroads of Mozambique
EIA	Environmental Impact Assessment
EoI	Expression of Interest
EMODRAGA	Mozambique Dredging Company
GIS	Geographic Information System
ha	hectare
ICZM	Integrated Coastal Zone Management
INAHINA	National Institute of Hydrography and Navigation
IUCN	International Union for Conservation of Nature
km	kilometre
m	metre
MARITIMA	Maritime Administration of Sofala Province
MICOA	Ministry for Co-ordination of Environment
NGO	Non-Governmental Organisation
NIZA	Netherlands Institute for Southern Africa
OCP	Office of Coastal Protection
PROL	Local Government Reorganisation Programme
RSR	Rapid Storm Response
USD	United States Dollar
4WD	Four-wheel Drive (vehicle)

1 ACTIVITIES REPORT

1.1 Project context

Beira is Mozambique's second largest city, and has the country's most important harbour (*Figure 1.1*). In the past, it was also a highly popular tourist destination because of fine beaches, warm climate, and idyllic setting. The city faces a 7 km coastline, east of the mouth of the Rio Pungue where Beira's important seaport is located.

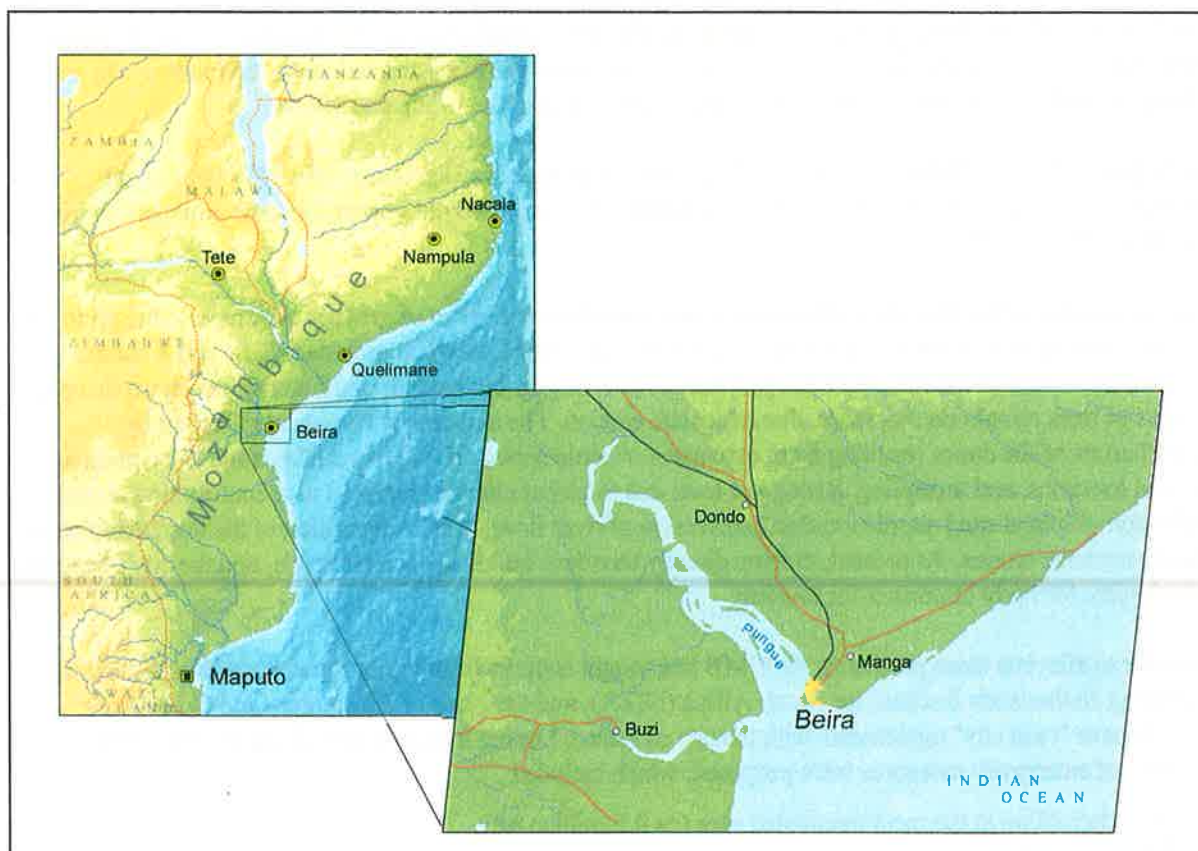


Figure 1.1 - Location of Beira on the Mozambique coast

1.1.1 The Project

The Consultant was engaged to assist the city of Beira in the execution of emergency coastal protection works to combat coastal erosion, flooding and saline water intrusion, and to assist in the preparation of an Integrated Coastal Zone Management (ICZM) plan for the city of Beira. During the course of preparation of the plan, the focus was on institutional strengthening, including training, and the identification of specific roles for all parties concerned.

The Project was funded by the Netherlands government and the city of Beira in a partnership arrangement. It had two main objectives: (1) implementation of emergency repairs to existing coastal protection works, and (2) development of a ICZM plan for Beira. The former is to alleviate the most urgent problems, while the plan is to set the scope for future development in the Beira coastal zone, including more basic and thorough coastal protection works.

The Project included direct input by a variety of experts. The counterpart agency was the Office of Coastal Protection (OCP) of the *Conselho Municipal da Beira* (CMB; Municipal Council of Beira). The Project was implemented by a consortium led by the Dutch consultancy firm ARCADIS Euroconsult, in co-operation with the Dutch firms ARCADIS Bouw/Infra and Alkyon, the Portuguese firm Profabril (with offices in Maputo), and the International Union for Conservation of Nature (IUCN).

1.1.2 Situation

Part of the city is built on dunes, especially the eastern half. A road runs along the entire coast, often close to the dune crest. Coastal erosion became a problem after the coastal road was hardened and fixed in place and many houses, restaurants, holiday cottages and campgrounds were constructed along the roadway. In an attempt to stabilise the beachfront, groynes were constructed in the 1950s and 1960s.

In the years of unrest - which lasted several decades, up to the peace agreement of 1992 - the coastal protection works fell into disrepair, as little maintenance was carried out except for some emergency repairs; e.g. those of 1989-1990.

Coastal erosion of the Beira beachfront has been combatted by a series of groynes and, reportedly, up to 14 parallel rows of trees, mainly *Casuarina* (*Casuarina equisetifolia*) which provided shade and a natural wind break. Due to lack of maintenance, the groynes are now largely in disrepair and function poorly while only 1-4 rows of trees remain on the dunes, due to coastal erosion. The situation is complicated further by disturbances of the dunes resulting from expansion of settlements, driving of vehicles, sand excavation at several locations, and trampling. Rising sea level due to global climate change is also contributing as well as reduction of inland sand suppletion due to diversion of river flows. Major disruption of the beachfront occurs during cyclonic storms. At present, erosion directly threatens buildings, coastal roads, and the city's beaches, which were formerly important for tourism.

In order to alleviate these problems, the CMB has sought support from various donor agencies and partners, including Netherlands Institute for South Africa (NIZA), and the cities of Amsterdam and Gothenburg (which have "twin city" agreements with the city of Beira). During missions carried out in 1994-1996, a number of emergency measures were proposed, which included:

- sand deposition at the most threatened sites (ca 0.5 million m³);
- repair of groynes;
- halting of sand mining in all areas;
- repair of sluices of the drainage canal;
- dune and beach management.

In addition to the erosion problem, large parts of Beira are located at low elevation that are highly susceptible to flooding in the wet season. In the past, this was partly ameliorated by means of a drainage canal system that drained excess water to the sea. However, sluices controlling inflow and outflow no longer function, and as a result, the incidence of flooding has increased. Also, there is saline water intrusion, which affects both crops and drinking water supplies. Both flooding and saline water intrusion have added to health problems related to general sanitation and water-borne diseases (cholera, malaria).

Also, saline water intrusion occurs in the lower reaches of the Rio Pungue during the dry season with extremely low river flows. Salt water occurs as far as 82 km upstream from the mouth where the intake for Beira's water supply is located.

The rural areas to the north and east of the central city have important functions for drainage and need to protect sensitive areas like mangroves and ecologically important tidal creeks but these functions are threatened by pollution and over-development. However, these problems are minor compared to what may occur if the protective coastal dunes are breached because of erosion, as flooding could cause major problems during storm events.

Efforts have been made in the past to counteract these problems but so far with little success. First because of lack of sufficient funding. Second, motivation to solve the problems has been low. Third, the required institutional framework for effective coastal management is little developed and needs revision.

1.2 General project objectives

1.2.1 Target group

The target group is the population of Beira city, although certain stakeholders may benefit more than others, particularly beach and lowland residents.

1.2.2 IZCM planning and set goals

Integrated Coastal Zone Management (ICZM) planning is carried out where different management options or land uses conflict with each other or threaten the environment. ICZM planning is employed to ensure that single-purpose uses do not have negative impacts on other sectoral uses of the coastal zone. ICZM planning aims at resolving conflicts among users of coastal resources (line departments, private developers, coastal stakeholders, etc) and tries to determine the optimal mix of environmental protection and resource use over time, recognising the dynamic nature of both resources and demands on those resources. Inter-agency co-ordination is essential and a key element of ICZM planning.

The main project goals at commencement were:

- (1) to conduct as much emergency repair of beachfront defences as the available budget permits, utilising both private contractors and resources of the CMB;
- (2) to prepare an ICZM plan in co-operation with CMB, including issues on environment, development, long-term coastal protection, land use management, and public awareness.

1.3 Planned Project activities

1.3.1 Planning

(a) Task allocation

In conjunction with the counterpart agency (CMB), the tasks to be completed were formulated and planned; these are summarised in *Annex 1*. The estimated time intervals in Project-weeks (1-26) scheduled for each task is also given in this *Annex 1*. It was learnt that the timing of workshops often required adjustment.

(b) Works to protect the beachfront

The programme strategy has been to divide engineering concepts and design elements of the works into three categories: (1) Urgent Works to be commenced currently by CMB; (2) Emergency Works to be designed and sub-contracted (to the limit of the funds available to the Project); and (3) the needs for Long Term Works to be explored and engineering concepts developed for work to be done (after Project completion).

Under the arrangements agreed by the client, the city of Beira, and ARCADIS Euroconsult, the Consultant served as both designer of the Emergency Works and the Prime Contractor. The Consultant was responsible for selecting sub-contractors and supervising the work. An equivalent approach was used with the Urgent Works executed by the city; that is, the Consultant provided a supervisor (and facilitator) for CMB work.

Following additional studies and a first round of ICZM planning, a final selection was made of which specific emergency measures were to be implemented, and to what extent. For alleviation of immediate problems, the following package of interventions was implemented:

- (1) Sand deposition at the most threatened sites;
- (2) Repair and rebuild of the essential damaged groynes, from Macuti to Ponta Gea;
- (3) Repair of the most vulnerable sections of seawall, particularly at Miramar and Ponta Gea;
- (4) Repair of the sluices of the drainage canal;
- (5) Pilot dune restoration.

The Urgent Works done by the city were mainly to solve problems with backwash of groynes and undermining of foundations, subsidence or collapsing of part of groynes, and failure of breakwalls. Corrective measures were relatively simple in nature. Without quick action, worsening of the situation could result in serious damage and increase of the cost for repair.

The measures for dune protection were considered important for long-term protection and management. Most measures were not very costly, except the construction of several kilometers of brick wall. While most of the budget went to beach repairs, dune restoration was considered important enough to at least make a start with a pilot restoration project.

In terms of reducing dune erosion, several solutions were recommended for the Emergency Works programme: (1) Repair critical breaks in the wall between the coastal road and the dune crest; (2) construct windbreaks in the front of the dune crest; (3) placing of branches/palm fronds in wind-eroding gaps in the dunes; (4) prohibit vehicles access in the dune area, and an effective prohibition of sand mining (legally prohibited at present but enforcement is weak); (5) stabilise by planting vegetation in these reclaimed areas (ground cover).

A key aspect of all these measures is follow up. Attention is required for training, management, maintenance and patrolling. There may be opportunities for additional support for one of the donors mentioned earlier.

(c) ICZM planning

At the core of the ICZM process lies the understanding that: (1) all sectors, all levels of government and all stakeholders (coastal communities, private sector, etc.) are to be involved in the decision-making process; (2) preservation of entire ecosystems is required to sustain biodiversity and life-support functions; and (3) maintenance of the production and buffering function of coastal ecosystems is essential for long-term coastal development. ICZM planning involves assisting government authorities and the private sector in integrating environmental and natural resource management requirements with overall development planning needs, in order to realise optimum ICZM.

1.3.2 Adjustments and limitations

Preliminary cost estimates were made for the above works. The total cost to perform all described works with sub-contractors was about three times the available budget. It was therefore of main importance to minimise costs as much as possible and designs were made accordingly. Importing materials is expensive and slow and needed to be minimised.

Estimates were between USD 627,500 (top-end) and USD 367,000 (bottom-end) plus costs incurred by CMB of approximately USD 35,000. The total amount available for works was about USD 370,000. Therefore, some planned measures were cancelled or reduced but lack of these measures could result in additional damage to the coastal defence system (for example in case of groyne maintenance) or damage to infrastructure (for example Ponta Gea and Palmeiras site).

Such effects depend on, among others, the period before additional measures or long-term measures are taken, extreme weather conditions in the intermediate period, and continued effectiveness of maintenance and dune management efforts by CMB. Fortunately, the client was able to provide additional funds to complete the most essential additional works, deemed to be restoration of the headland at Ponta Gea.

1.3.3 Planned implementation period

The Project was scheduled to last 6 months, commencing on 13 April and ending on 13 October 1998 (including demobilisation).

1.4 Activities carried out

1.4.1 Activities completed

All planned Emergency Works have been completed. The responsibility for implementation of the works as resumed by CMB continues after Project termination. Construction work along the beachfront by contractors continued until February 1999. This was due to delays in contractor work and (some) constraints in specifications and funding.

An Integrated Coastal Zone Management Strategy Plan has been completed. This Strategy Plan is the one but last step in the time-consuming process of preparation of a detailed ICZM Action Plan, as is explained in *Chapter 4*.

1.4.2 Adjustments required

Some adjustments were necessary in deploying ARCADIS Euroconsult staff; all staffing requirements were met. Additional staff were able to be deployed within the allocated budget.

The Emergency Works programme was prioritised so as to fit as many as possible of the most urgent works into the client's budgetary allowance. The major adjustment to the works was to extend the programme to cover essential works at Ponta Gea (which had already been designed and which were included as optional items in the contractor's bid) for which the client provided the required additional funding.

1.4.3 Implementation period

The Project commenced on 13 April 1998. Completion of the last Emergency Works materialised in February 1999.

1.5 Assessment of activities

All Project -short-term- goals are considered as completed. The long-term success of the Project depends on the extent to which the city and the province follow up on the ICZM programme, institutional change, commitment of resources, maintenance of engineering works, enforcement of rules, etc.

1.6 Results

1.6.1 Achievement of overall goals

Goals achieved were as was originally outlined; i.e.:

- (1) Conduct as much emergency repair of the beachfront defences as the available budget permits;
- (2) Prepare an ICZM plan - to the extent possible- in co-operation with CMB.

1.6.2 Target group

Citizens of Beira will benefit through improved security and a better protected coastline. The city is provided with enhanced planning capability. It is believed that the following specific target groups were reached:

- the city will be protected against effects of storms and shore-erosion and improved access to better beaches;
- persons owning shorefront properties will benefit through reducing erosion threats and storms and from improved planning of shoreline use;
- persons living in flood-prone areas will be protected from flooding of houses and lands and from improved sanitation and health conditions;
- persons conducting agriculture in lowlands will benefit from reduction of floods and control of groundwater;
- persons conducting fishing along Beira shores will benefit from conservation of habitats that produce fish;
- persons keen on environmental quality will benefit from conservation and from beautification of the landscape;
- tourists and tourism industry will benefit from improved landscape and environmental conditions;
- officials of CMB and Sofala province benefited from improved planning and facilitation of beach defence works programmes and an improved institutional framework.

1.6.3 Capacity/skills of implementing body

Staff of agencies involved in implementation have increased knowledge and management capabilities as resulting from the ten Workshops held during the Project period. Counterpart staff, i.e. of the Office of Coastal Protection, has received valuable on-the-job training. Still, further informal training is recommended over time, as well as formal training for key persons as suggested in the ICZM Strategy Plan.

1.6.4 Lessons learned and suggestions for the future

Several lessons were learned that may be helpful to future projects:

- (1) Providing technical assistance and investments as simultaneous components of a project, works out well. Actual work going on improves the chance of success because the beneficiaries build interest, confidence and appreciation.
- (2) Project ideas and implementation is to be "pushed" to, but not beyond, the limits of absorption capacity of the institutions involved. Trying to achieve too ambitious objectives will fail.
- (3) Participation is important but must not be pushed beyond the limits of the abilities or interests of participants to respond. Workshop participants can lose interest if there is too much demand on their time and be bored by items not squarely in their interest. Facilitators are to make meetings as interesting as possible and to limit boring discussion. Visual presentation is the key to successful communication. The environment of the meetings must be attractive and comfortable, so people enjoy coming. These approaches are more appropriate than paying people honorariums.
- (4) Optimism, even in the face of disappointment, is essential. The project can benefit from encouraging optimistic visions, but progress towards that vision should be made in small steps and according to the kind of measured progress people will accept. "Think big but take little steps".

2 BASE DATA AND INVESTIGATIONS

2.1 Coastal sub-zones

The coastal area at Beira is highly variable in terms of land use and conservation values, reason why for planning purposes the area was divided in sub-zones. For the ICZM planning activities, the following sub-zones were distinguished; data were collected per sub-zone:

- Urban Sea Coast Sub-Zone;
- Urban Lowlands Sub-Zone;
- Eastern Rural Sub-Zone;
- Northern Rural Sub-Zone.

2.2 Urban Sea Coast Sub-Zone

2.2.1 Geomorphology and Hydrography

A complete description of the geomorphological studies performed by Alkyon are given in Annexes 2 and 3 of the Inception Report for the Beira Integrated Coastal Zone Management Project (ARCADIS Euroconsult, 1998). The following paragraphs provide a summary.

(a) *Hydrography*

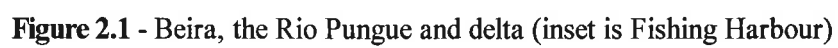
The coast of Beira faces the shallow sandbar area of the delta of the Rio Pungue, which slopes gradually eastward from the river mouth to the continental shelf. The discharge of the Rio Pungue is about 600 m³/s during the wet season and only 80 m³/s during the dry season. Soundings of the sandbar area show a complex system of channels and shoals formed by tidal currents (*Figure 2.1*). High sand banks occur in the form of a spit at Ponta Gea and in the bend of the access channel. Three channels run eastward, ending in U-shaped banks at their eastern end. Another channel runs from Macuti westward along the coast, gradually decreasing in depth. Soundings show sand banks of 1 to 2 m high and approximately 100 m in length, perpendicular to the main currents (DHV, 1990).

(b) *Climate*

The climate at Beira is influenced by the south-east trade winds over the Indian Ocean. Winds are predominantly blowing from directions between east and south with a gradual increasing force during the day, combined with a change of direction from SSE to ESE. Maximum wind speeds occur from directions between E and S with speeds between 30 to 40 m/s. Extremes are 1.5 times as high (NEDECO, 1982). The rainy summer (November to March) is tropically hot, winter months are dry.

(c) *Tides and currents*

The tide in Beira is semi-diurnal with a strong variation in tidal range from +0.2 m to +7.1 m CD (*chart datum*), and a tidal amplitude of nearly 7 m. The tidal range at sea is about 0.9 times the range at the port of Beira; time lag is 30-50 minutes.



Flood tide currents are predominantly along the coast and over shallow banks between the channels. Ebb flows occur in three deep channels across Macuti *Shoals* and in the access channel. Closer to shore, these channels run more or less parallel to the beach except for local dislocations, like the Palmeiras drainage outlet. Strong winds from easterly directions and also waves strengthen the westward flows and weaken the eastward flows in the shallow waters over the Macuti *Shoals*.

(d) *Waves*

Two types of waves can be distinguished, i.e. sea waves generated by local winds, and swells generated at large distance (e.g. in the Antarctic Ocean). Wave heights along the Beira coastline are much influenced by vertical tidal movement. The ratio of reduction of wave height at the outer- and inner buoy varies between 0.3 and 0.6 during low water, and between 0.7 and 0.9 during high water (NEDECO, 1982). This prevails during cyclones; e.g. a reduction from a 4.2 m wave to 2.2 m during Cyclone Lisette, 2 March 1997 (TETRA, 1998; see *Figure 2.20*).

Waves from SE usually prevail as a result of local wind directions (between E and S) and because of swell influence. Wave height at the outer buoy is higher than 1 m during 35% of the time, and higher than 2 m during 1.3% of the time. Average swell wave height is 0.5 m to 1.0 m (NEDECO, 1982).

(e) *Dunes*

The coast along the beachfront of Beira consists of an approximately 3.5 km long, slightly concave part between Ponta Gea and the outlet of the drainage canal at Palmeiras and a 3.5 km long convex part further east to the Macuti lighthouse. The coast was formed by a ridge of dunes, up to a few hundred metres wide with its crest at CD +9 m to CD +11 m. A road runs over the dune ridge with a few houses seaward of the road. The dune ridge moved landward at Ponta Gea at an average of 5 m/yr in the period between 1956 and 1982 and 14 to 20 m/yr in the period between 1982 and 1993. The dunes between Ponta Gea and Macuti lighthouse are narrow and weak, as a result of continuous coastal erosion, which is in the order of 1 m/yr. The development of the dune ridge is determined by the forces of winds, waves, tide and by human interference (*Figure 2.2*).

Accretion and erosion are determined by the sediment balance in which the following parameters play a role:

- the gradient of the longshore transport;
- the cross-shore transport;
- the wind transport;
- sand mining;
- storm surge and waves.

With an average recession of the open beach at about 1 m/yr and with a length of 7 km and a shore face of 13 m, there is a calculated loss of sand of 80,000 m³/year. If it is assumed that the annual loss by wind transport amounts to about 7,000 m³, that the cross-shore transports are only small, and that the sand mining contributes to about 15,000 m³ per year, then the gradient in the longshore transport and the cross-shore transports between Macuti lighthouse and Ponta Gea should be about 60,000 m³/yr. The estimates performed indicate a westerly directed littoral drift at Macuti lighthouse of about 95,000 m³/yr (Alkyon, 1998b).

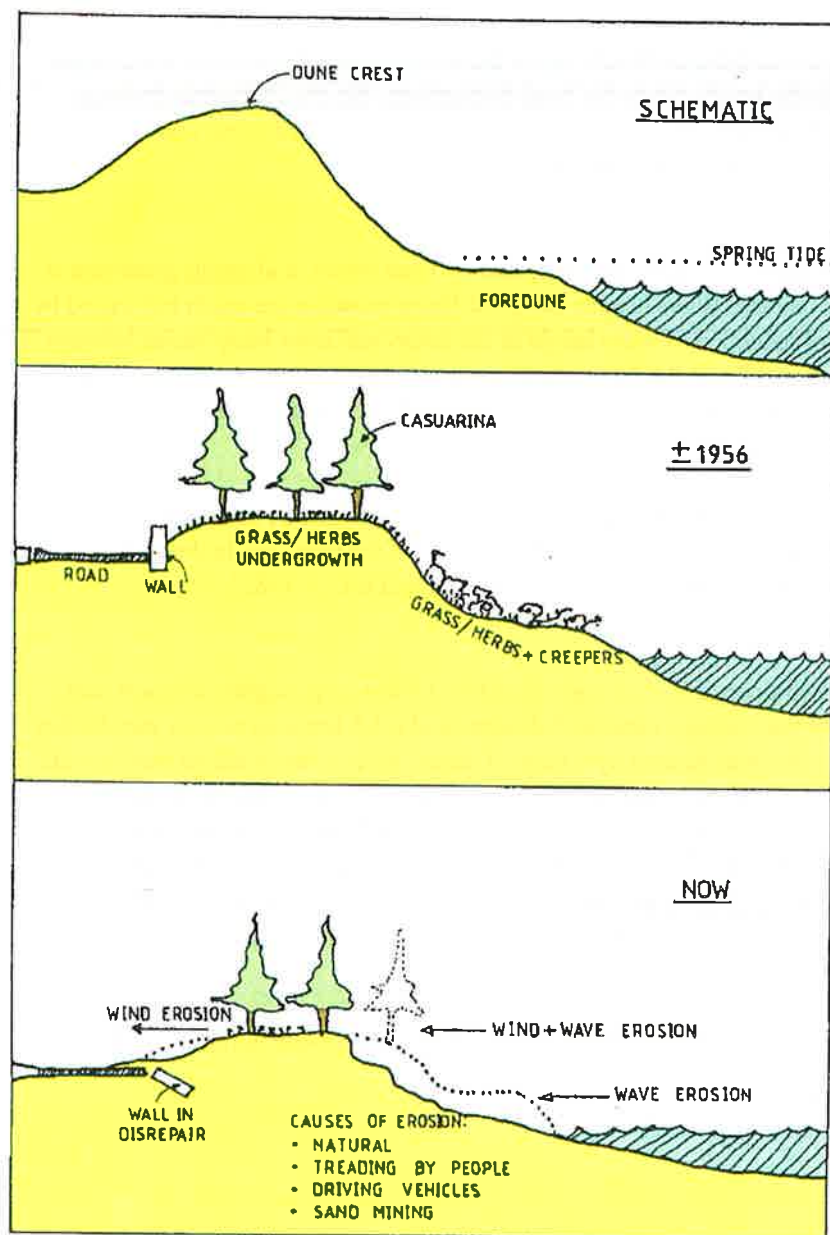


Figure 2.2 - Changes in the dune system from 1956-1998

2.2.2 Shorefront problems

(a) Status of coastal structures

Groynes have been constructed at intervals of about 200 m to protect the entire coast between Ponta Gea and Macuti lighthouse. Most of the groynes reach to the low water (LW) line. Their effect is a saw-tooth shaped coastline with a considerable difference in beach level across the groyne, which demonstrates the effectiveness of the groynes (*Figure 2.3*). This impression is enforced by the lack of effect of damaged groynes.

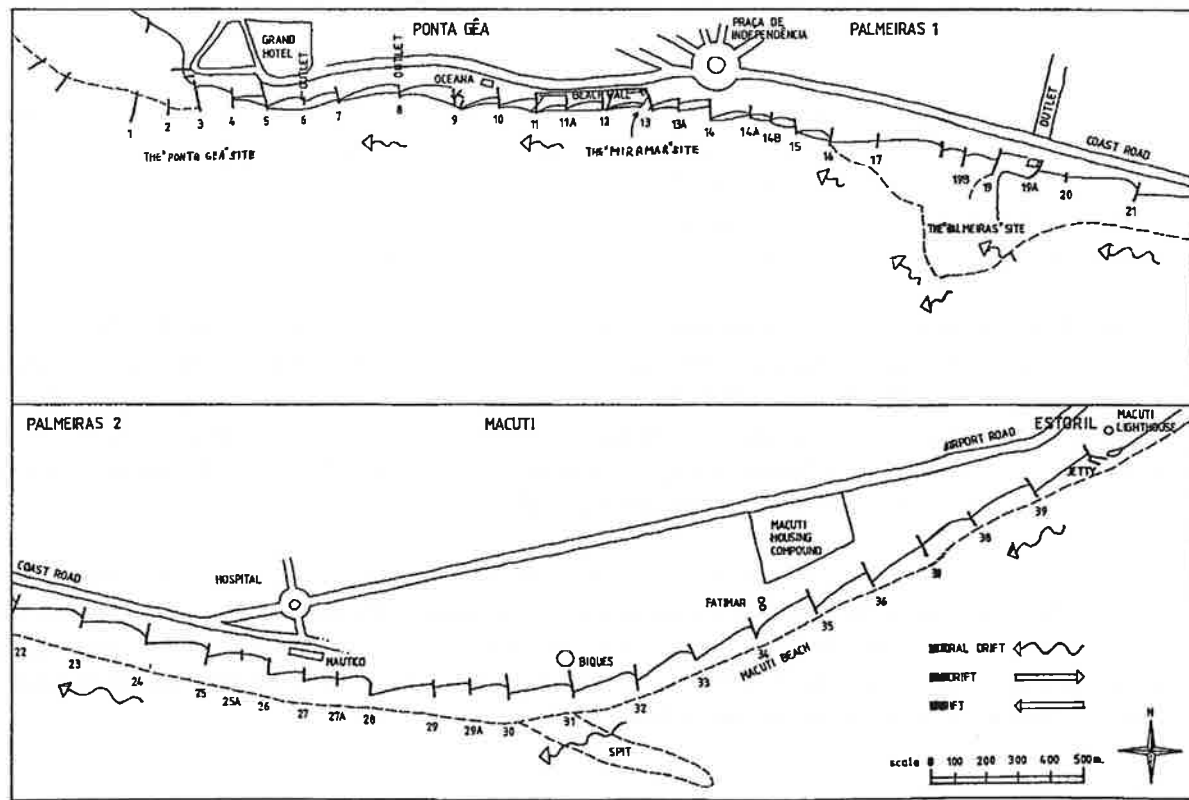


Figure 2.3 - Groyne locations and numbers with littoral drift direction

An impressive feature in the central part of the coastline is the delta in front of the *Desaquadouro* at Las Palmeiras. The volume of this delta is estimated to be much more than 1 million m³. The delta extends from 200 m eastward of the outlet to more than 500 m westward and also more than 500 m into the sea.

Besides, bars are running from the tip of the delta towards Macuti shoals, resulting in sand loss from the underwater delta towards the bar area of Macuti shoals. Due to the presence of the delta, part of the littoral drift is diverted from the shoreline to deeper water and probably even further towards the Macuti shoals.

The *Desaquadouro* was in operation until about 1993 and then became inoperable and left in full open status. Therefore, the drainage system acts like a tidal river and is filled and emptied with sea water during every tide. The strong outflow carves into the bar which is present just downdrift of a "dolos" groyne. The sand of this bar is transported in an offshore direction and therefore not available anymore for transport to the downdrift beaches, causing erosion of these beaches.

In the sixties and seventies, two dams have been built over the Zambezi River. These dams have caused severe coastal erosion of the delta of the Zambezi and the delta erosion will propagate along the coast towards the Beira coastline.

(b) Dune condition

A dune line runs along the entire coastline of Beira, extending over 7 km, and is as wide as 150 metres in some areas in the eastern half of town. However, most of this is not directly noticeable because the city has expanded onto the dune ridge, with a coastal road running along the original dune crest. The dune crest itself was usually about 10-30 metres wide, but is now even absent in some places, and in general it is only 1.5-3 m above the road. In many places the dune crest is planted with *Casuarina* trees and has a typical undergrowth

of grasses, vines and herbs. Where it is stable, the foredune or berm is covered with a vegetation dominated by creepers.

A study of aerial photographs shows that in 1956 the average width of the beach berm, or foredune, along the 7 km of coastline was 8.2 m, but by 1998 this average had declined to just 0.4 m. These losses are not uniformly spread. The area between groynes 9 and 14b had no foredune in 1956, and this has remained unchanged today. The main decline occurred between groynes 29-39, where between 14-50 m of foredune have disappeared, and between groynes 3-9, where 3-17.5 m of foredune disappeared.

Reports about coastal protection in Beira tend to exaggerate the loss of dune width, stating that formerly there were 8, 9, or even 14 rows of *Casuarina* along the Beira coastline, and that this has now largely disappeared (Schoon, 1998; IBA, 1996; Dahmen, 1994). Such statements are misleading, as the average number of rows along this 7 km stretch of coastline was only 3 in the 1950's. By 1998, the maximum number of rows encountered had dropped to 6, while the average number of rows now totals 1.8. In all, the loss of dune and foredune is about 15-16 m, on average, for the entire coastline.

Natural erosion of the foredune and seawardly exposed dune crest is driven by a combination of wave- and wind erosion, while that of the landward side of the dune crest is caused by wind erosion only. Under natural conditions dunes tend to "migrate", the extent of which depends on a combination of variables, including sand deposition, wave and wind energy, particle size, slopes, storm frequency, vegetation cover and dune stability. At Beira, erosion has been accelerated due to factors such as:

- sand mining (*Figure 2.4*);
- excessive trampling (by people);
- driving vehicles in the dunes;
- construction of the drainage outlet at Palmeiras (reducing sand transport -littoral drift-, in area from groyne 1-19);
- groyne collapse; and
- lack of maintenance to the wall between dune crest and road.

Trampling of the dunes is done by tourists, fishermen, recreationalists and persons seeking places to defecate. With sanitation facilities absent in many of the poorer parts of town, many people defecate in the dune vegetation.

Apart from coastal works (groynes, breakwalls, and drainage outlet), the two most damaging factors are evidently sand mining and driving of vehicles in the dunes. This is obvious in the compartments adjacent to the Biques camping area, from where cars enter the dunes. According to local sources, sand mining is carried out on a small but insidious scale along much of the dune zone. In reports on Beira coastal protection (e.g. IBA, 1996) it has been suggested that cutting of *Casuarina* trees contributed to accelerated erosion, but little evidence was found to support this.

If sand mining is prohibited, then alternative sand sources must be found. In the long term EMODRAGA may be able to supply sand from its dredging operation (e.g., bring the last load to port), but this will require that certain off-loading arrangements are made.

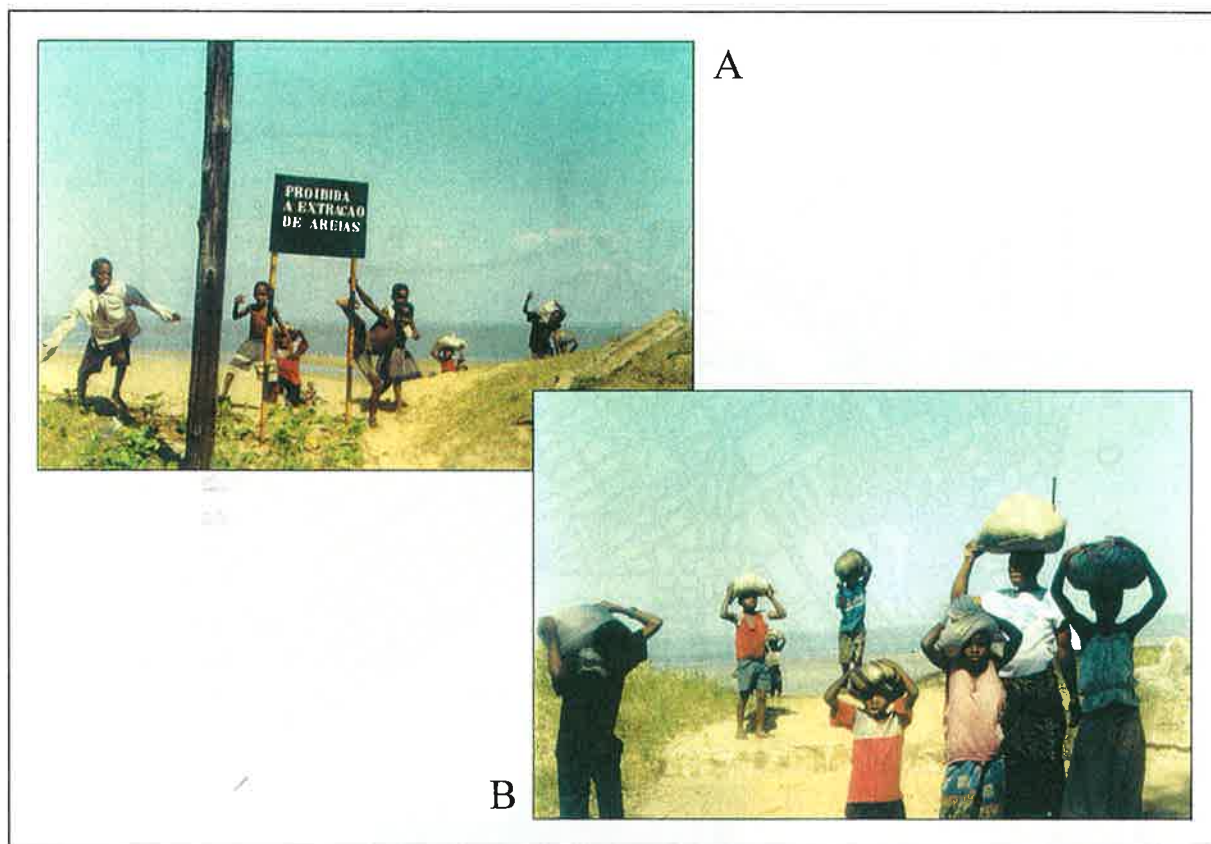


Figure 2.4 - A&B hauling away sand

(c) *Desaquadouro*

The construction of the sluice in the outlet at Palmeiras was completed in 1961 and a special *dolos* groyne was built in 1983 to reduce sand impaction of the outlet (*Figure 2.5*). Measurements performed in 1989, when the sluice was still operational, show a considerable delta in front of the outlet (*Figure 2.6*). The sand accumulated in the dune and the adjacent beach at the updrift side of the outlet was estimated in 1989 to be about 150,000 to 200,000 m³.

The function of the outlet is the regulated drainage of rainwater from the major part of suburban Beira and the surrounding agricultural areas. It is connected with three main drain-canals, which serve agricultural and residential areas. Two of these are equipped with control structures to regulate groundwater tables, but neither are operational at present.

Due to the presence of the delta, part of the littoral drift is diverted to deeper water and probably even further towards the Macuti shoals. Some of this littoral drift reaches the downdrift coastline in the vicinity of groyne no.17.

Due to the absence of functioning slide doors (*comportas*) in the three sluiceways of the water control structure at Palmeiras, the long hinterlying drain-canals do at present serve as a tidal channel that fill up with seawater during every tide, extending far inland into the agricultural fields and residential areas (particularly the spontaneous settlements where many of the poor people live). During high tides, agricultural zones as well as urbanised areas are flooded with water of varying salinity.

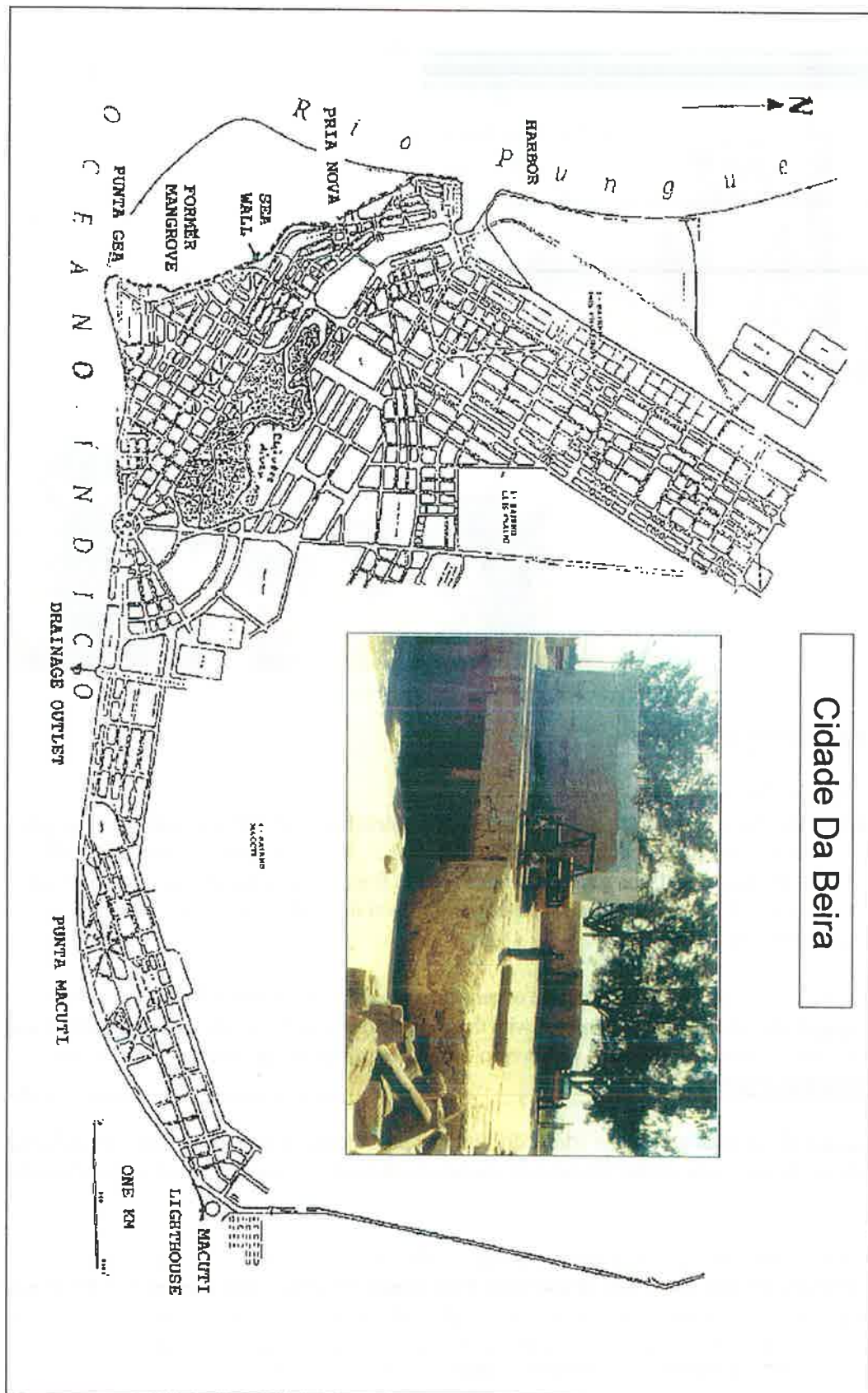


Figure 2.5 - The desaquadouro drainage outlet at Palmeiras and its location



Figure 2.6 - The delta formed by tidal ebb and flow at Palmeiras

(d) Shorelands

Many types of constructions in what is called the Primary Urban Zone have upset the stability of the Beira beachfront, mostly residences and commercial structures such as restaurants and campsites. Such structures when built on the coastal dunes, intrude into the dynamic process of the beach and result in disruption of the flow of sand and its distribution along the beachfront, resulting in increased erosion.

Moreover, such structures are most vulnerable to direct attack from storms. For example, one commercial structure near Plaza de Independencia was lost to the sea. Also a residential structure at Ponta Gea was lost and others were damaged. When such structures are threatened, owners often ask the Municipality to assist in defending these, which can be quite costly.

In the area from Praia Nova to Estoril, 6 commercial facilities exist on the dune (one collapsed) and 20 formal residences (one collapsed); these structures cause serious problems. Furthermore, numerous informal

residences have been installed around Praia Nova. Also, there are several derelict public facilities on the dunes. All such structures violate the rules established by the Provincial Maritime Administration and conflict with city land use regulations.

It is essential not to allow further construction in the dunes and that owners of existing structures be prevented from any expansion and be required to provide their own protection (*Figure 2.7*). No private protective works should be allowed which harm neighbouring properties through alteration of beach dynamics.

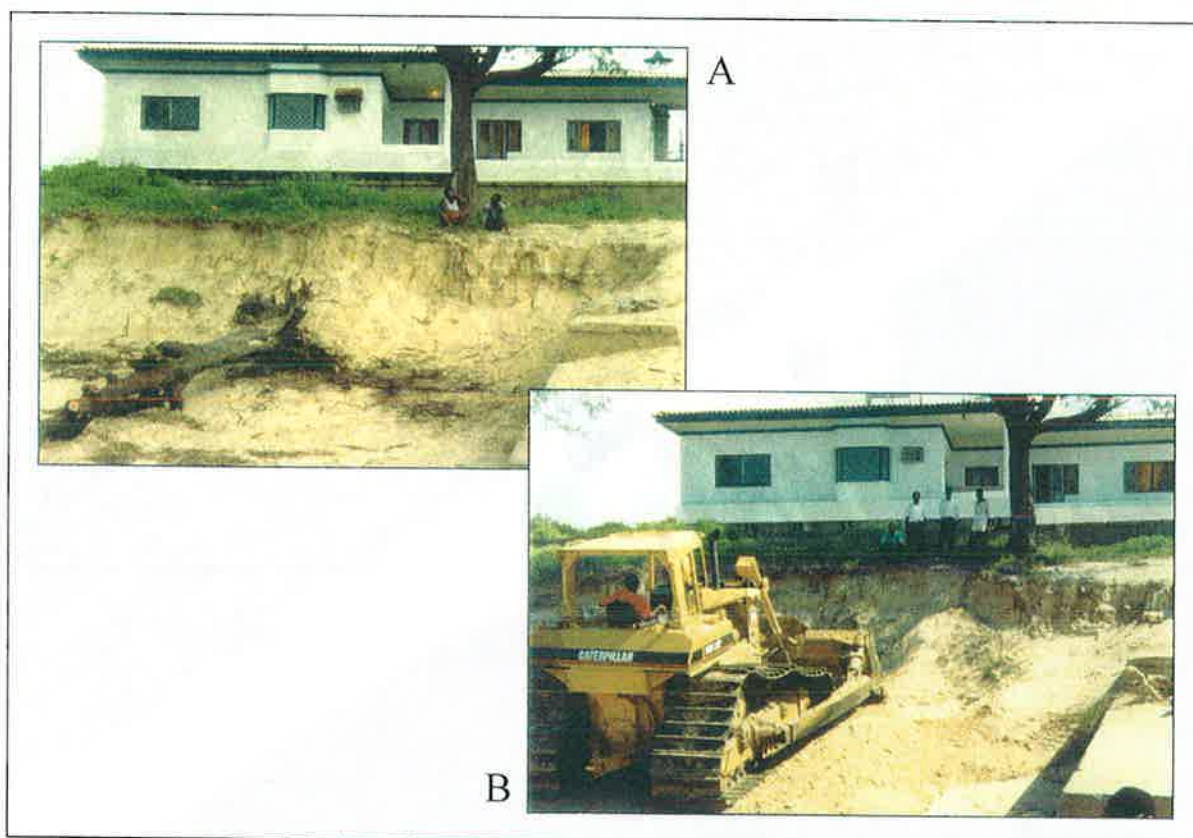


Figure 2.7 – Loss of beach caused by storm endangers house (A) requiring city to rebuild beach (B)

2.2.3 Engineering for emergency works

(a) Approach

A large number of groynes and breakwalls along the Beira coastline suffer from lack of maintenance, resulting in the loss of sand from the updrift compartment to the downdrift compartment(s). This leads to a retreating coastline which further undermines the foundation of the updrift groyne. Once groynes get affected by erosional force, this will in the end have an impact on the entire coastal defence works. Maintenance should be done continuously by the Beira's coastal protection unit.

Sites recommended for repair and some general activities related to the coastal defence are described below. Selection criteria for the emergency works include avoiding further deterioration of existing coastal defences and damage to infrastructure and houses, thereby reducing the risk of flooding. The information given below

is presented in more detail in Annex 5, "Emergency Works Engineering Report", and in Annex 2 and Annex 4 of the project's Inception Report (ARCADIS Euroconsult, 1998). The following need particular attention:

- Ponta Gea headland: erosive site of main importance; jeopardy and loss of houses.
- Seawall at Miramar: damaged seawall with risk of damage to road.
- Outlet sluice ("*Desaquadouro das Palmeiras*"):
 - a) Implementation of slide doors to control water movements and levels; improvement of the morphological situation (interrupted littoral drift);
 - b) Measures to correct downdrift erosion and risk of damage to road.
- Macuti Beach/Fatimar: progressive collapse of groynes.
- General maintenance & repairs of concrete groynes & constructions: urgent locations with backwash of groynes and undermining; at Beira Terrace repair of dislocated and damaged concrete slabs in slope that protects the beach wall along the riverfront.
- Dune management measures to reduce the loss of sand in landward direction.

Except for the protection of threatened houses at the NW side (the backside) of Ponta Gea, no emergency measures are being considered to stop the shifting of the coastline between Ponta Gea and "Praia Nova". These are considered as long-term measures (see *Paragraph 2.2.6*).

(b) *Outlet sluice ("*Desaquadouro das Palmeiras*")*

Regulation of the water flow by installation of slide doors and lifting gear for the outlet has a high priority. Conditions for proper operation are:

- lifting equipment must be operational at all times;
- operation must be in accordance with a detailed practice-based operation protocol;
- CMB staff and supervisors involved must be properly trained.

Meeting these conditions is constrained by:

- Sedimentation blocks the outlet. Maintenance excavation for sand nourishment and / or by-passing will have to be executed regularly (with heavy equipment). Sand should be used to nourish the downdrift beaches in order to mitigate the erosion in that area.
- Stagnant (polluted) water in the drain could become a threat for public health.
- Regular flushing, especially in the dry season, will help to reduce the above problems but will not solve these. Too much flushing might result in sedimentation inside the channel, as well as a continuation of loss of sand from the littoral system (as currently occurs).
- Keeping the outlet open to remove excessive sand in front of the gates by excavation on a regular basis, in combination with some flushing, the sand to be by-passed to the downdrift system and replenished at other locations along the coast.

(c) *Ponta Gea*

Erosion problems between Ponta Gea and Praia Nova are caused by severe downdrift erosion (as much as 1.5 m/yr), which appears to result from the reduced sand supply caused by the updrift groynes. Ponta Gea needs protection since it provides the foundation for the updrift coastline. Ponta Gea is a well defined headland where the shoreline meets the mouth of the Pungue River (*Figure 2.8*). It is a critical point with a complicated morphological situation. Erosion occurs from two sides:

- From the outer point eastward where erosion has been high in recent years, but erosion has been reduced due to the implementation of some emergency measures in 1993 (dumping of rubble to support the headland);
- From the river side, where houses are located; one house collapsed in recent years.



Figure 2.8 – The embattled headland at Punta Gea with rubble defence

Required is to build a headland-type of structure with short groynes at Ponta Gea to push the tidal currents seaward and to capture sand in the compartments between the groynes to protect the toe of the headland. The design is based on reinforcement of the existing situation with minimal modifications and optimal use of available materials from destroyed buildings and constructions in the town.

(d) Miramar Seawall

The seawall updrift of groyne no.13 has been undermined as a result of shortage of sand in the adjacent compartment. Stones and rubble that have been placed to protect the road are removed by wave action. Shortage of sand probably results from diversion of the littoral drift to the foreshore, which is caused by the underwater delta at the *Desaquadouro* at Palmeiras. In the corner where the seawall and groyne no.13 meet, the foundation of the seawall has been undermined and some 15 m has been destroyed. In total 50 m shows damage. It seems best to completely demolish and reconstruct the affected section in the long-term, with a deeper foundation level. Within the scope and budget of the project this is not feasible.

To protect the road from damage and avoid further damage to the seawall, a protected slope was recommended for the corner with maximum top elevation equal to the level of the top of the seawall. Slope with geotextile and stabilised with sand bags was recommended (*Figure 2.9*).

The gap between two elements at the root of groyne no.13 (near the road) should be filled with concrete to avoid spillage of sand; the same applies for the gaps between three elements of the seawall, near the point where it meets groyne no.13.

(e) Area downdrift of the Palmeiras outlet

It was observed that the erosion downdrift of groyne no.18 had almost reached the road. It was proposed to construct at this location a revetment starting with sand for levelling off the border of the road, followed by a geotextile filter and then several layers of rock gradually increasing in size. The toe of the revetment should be covered with sand to increase its lifetime. Also some sand nourishment was recommended for the adjacent downdrift groyne compartments. The sand is available from the bar at the foreshore or the accretion area updrift of the *dolos* groyne (no.19a) where regular sand mining has been taking place by the city. It is expected that sand removal updrift of groyne no.19a will not worsen the situation, provided that the sand is used for nourishment of the updrift or downdrift beaches.

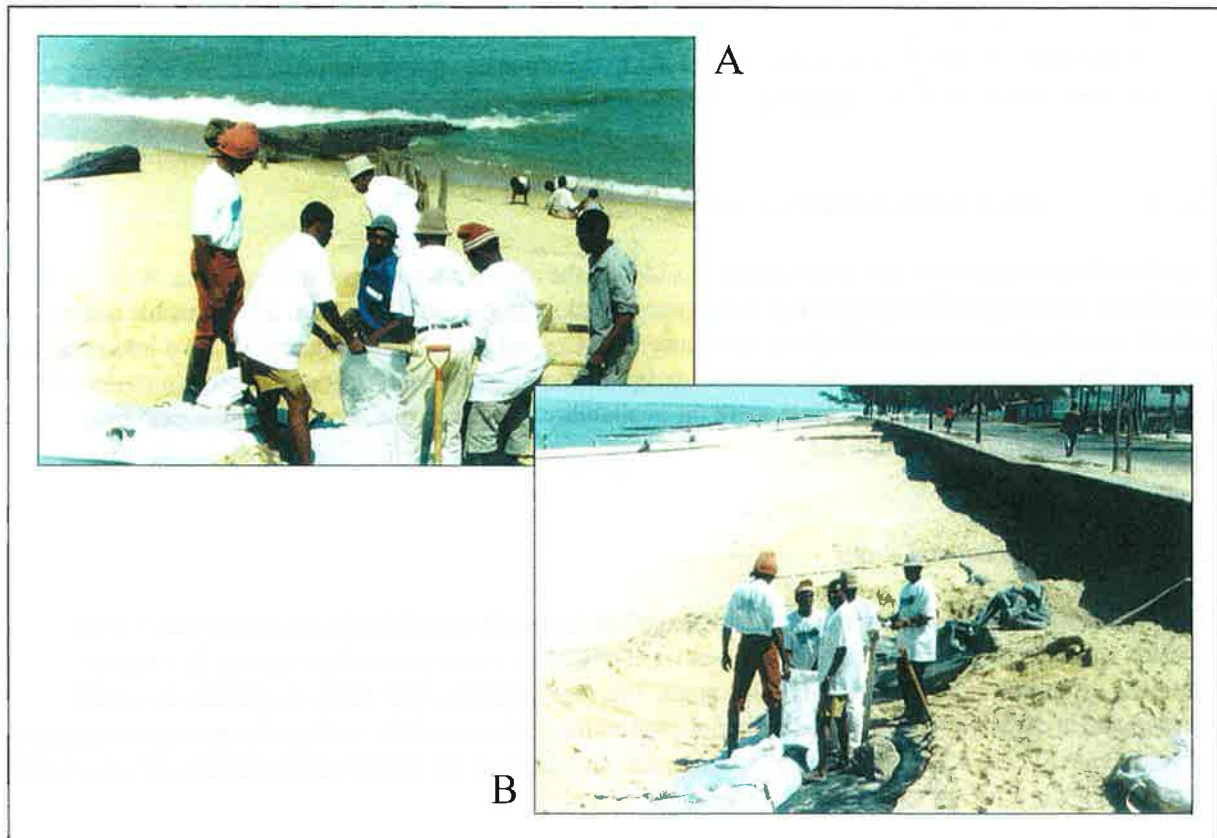


Figure 2.9 – Repairs to corner between groin (A) and road (B) at Miramar seawall site

Measures considered for the area downdrift of the outlet to avoid further erosion, consist of:

- sand by-passing and nourishment with trucks to downdrift of groyne no.18;
- some rearrangement of the stone protection and adding of rubble (or stones) to the riprap revetment at the downdrift side of the seawall (updrift of groyne no.19);
- increase of the level of the low (horizontal) section of groyne no.19 with a stone structure to reduce erosive effects of currents at the slope in toe compartment no.19;
- increase the level of groyne no.18b until the top of the old military bunker to increase the sand retaining capacity;
- repair of the longitudinal toe-protection wall in compartment between no.18b and no.19; rearrange / add stones.

(f) *Macuti Beach / Fatimar*

At this location the progressive deterioration of the protection system is visible. Backwash of downdrift groyne no.33 has caused loss of sand in compartment no.33, causing backwash and undermining the foundation of groyne no.34. The process has in a number of years destroyed both groynes and has now reached groyne no.36 that shows backwash of sand.

Obviously, the dunes have suffered from the erosion of the coastline and many *Casuarinas* were lost at this location. Recommended is:

- repair of damage and sand-leaks at the LWL and HWL;
- repair of groyne no.33 at LWL over approximately 15 m (concrete) and sand nourishment;

- groyne no.34 should be abandoned and a new groyne built along side of it from concrete;
- groyne no.35 shows major damage over the full length but still can be repaired. Existing pieces of concrete shall be incorporated in the concrete body to reduce the quantity of concrete that is needed;
- sand nourishment in compartments no.33, 34 and 35 in the foredune area.

2.2.4 Beach renourishment potential

Beach replenishment is a major intervention considering the required equipment and expertise. With the timeframe and budget of the project (i.e. Emergency Works component) this option is not feasible and is passed on to implementation of the long-term Integrated Coastal Zone Management plan. As a maintenance activity, beach recharge would not be feasible, except in combination with harbour dredging (now done by one old dredger). This possibility must await the availability of a pump dredger, which may have to be specially funded through foreign aid.

2.2.5 The coastal dune

Once the erosion process starts, the flora is damaged or destroyed and seldomly recovers (*Figure 2.10*). Erosion spots expand at locations, such as westward of Biques. Here, erosion has resulted in a almost complete disappearance of dunes over large areas. The degeneration of the dunes contributes to coastal erosion and is caused by uncontrolled activities such as those above and the cutting of trees and construction of settlements. These activities damage the ecosystem and decrease the natural sand retaining capacity which in turn results in a loss of sand by wind erosion.



Figure 2.10 – Dune system has been seriously eroded and narrowed

It should be considered to apply barriers against vehicle traffic at badly affected spots for which building materials may be used. The placement of simple windscreens from palm leaves and / or bamboo, and

plantation projects might be done in co-operation with local NGO's. Such windscreens must be accompanied by proper dune management and patrolling.

The brickwall between the dunes and the road is an effective barrier to reduce wind erosion as well as human activities. It is clearly visible that where there is no wall the erosion is much worse. Reconstruction of large sections is required.

Additional entrances should be made in the brickwall to facilitate beach visitation and reduce uncontrolled walking over the dunes. The passages should be made such that they pass over the level of the (future) dune crest. The passages can be bordered by "spiky plants" that do grow in the local dune environment.

Where sand is needed to rebuild dunes, the existence of accretion areas and exposed (at low tide) intertidal sand banks in front of the beach in certain places make small scale activities to reinforce dunes possible. A number of mitigating measures were considered. In summary, what should be considered for the urgent works, in order of priority, are the following:

- repair of the wall between coastal road and dune crest;
- construction of wind breaks in most critical areas (i.e. where most of the dune has disappeared);
- total exclusion of vehicles from the dunes and regulation of (recreational) activities by local authorities;
- total prohibition of sand mining (*Figure 2.11A*);
- replanting ground covering plants where needed;
- depositing sand in badly eroded locations (*Figure 2.11B*).

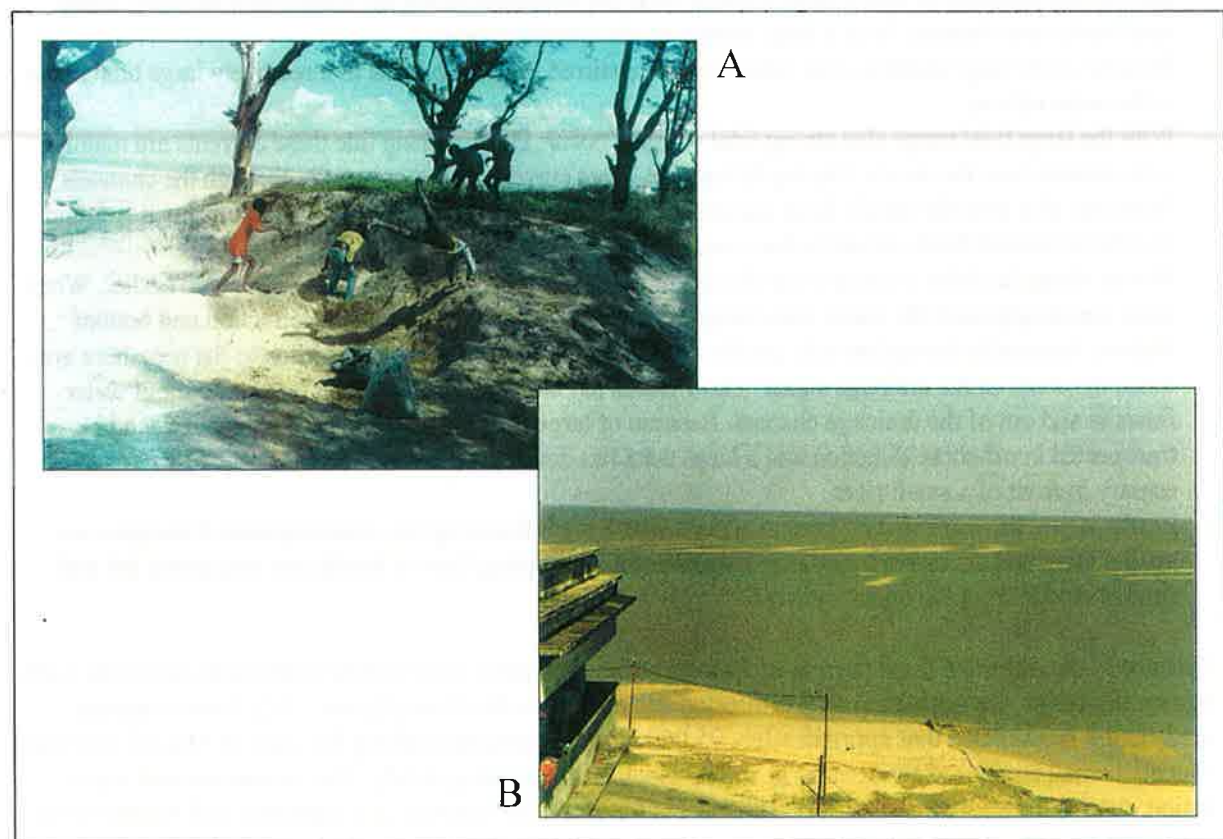


Figure 2.11 – Total prohibition of sand mining will help save dunes (A), but sand will have to be shifted to fill some now barren dunes (B)

These measures are simple but labour intensive, and not costly, but will require regular attention of the parties involved if they are to remain effective.

2.2.6 Long-term modelling study

In order to describe the existing and future coastal system at Beira, a morphological study has been performed by using computer modelling. For more details: see full study (Alkyon, 1998).

Before any realistic prediction about the future coastline can be made, the existing coastal system has to be studied; see "(a)" below. Second, critical areas in need of immediate action are identified and possible measures for improvement are given; see "(b)" below.

Through computer modelling and based on engineering experience, the impact of possible measures is estimated in a qualitative and quantitative way, see "(c)" below. In areas where computer modelling is not possible, like the drainage sluice "*Das Palmeiras*", the impact of measures is estimated.

(a) Existing coastal system

The coastal system at Beira can be characterised as follows:

- During large river discharges the Pungue River west of Beira also discharges a large amount of sediment into the sea. Because of this, a large shallow area has developed along the south coast of Beira. These sand banks and channels have a large impact on the coastal system;
- Because of the large shallow area, tidal waves are stirred up, which leads to a relatively large tidal range in the order of 6 m.
- With the large tidal range also strong tidal currents occur. During rising tide these currents are mainly concentrated over the shoals. During falling tide, large currents occur especially through the channels. However, also over the shoals large currents occur. From several studies and measurements it is found that the westward flood current is dominant.
- Waves along the Beira coast are sub-divided in two types, swell and wind waves, as noted earlier. When these waves approach the coast, wave height decreases due to wave breaking, refraction and bottom friction. Especially during low tide conditions, there is only small wave penetration to the nearshore area.
- Since the doors of the drainage sluice "*Das Palmeiras*" stopped functioning, a large amount of water flows in and out of the drainage channel. Because of large flow velocities a large amount of sand is transported in off-shore direction and a large delta has developed because the discharge functions as an estuary in front of a small river.
- Furthermore, there are several human actions which are influencing the coastal system. Examples are sand mining and excessive trampling. Because of the trampling there is hardly any vegetation left and sand is eroded from the dunes by wind.

Because of the dominant flood current and waves which are mostly approaching from south-eastern to north-eastern directions, the net littoral drift is directed into a western direction (*Figure 2.12*). From computer modelling it is estimated that approximately 95,000 m³/yr is transported along the coast of Macuti. At Ponta Macuti a small amount of sand settles at a spit, which is still growing slowly. Due to currents and wave action, sand is transported into the flood channel in front of Club Nautico. It is estimated that 90,000 m³/yr is then transported further in a western direction.

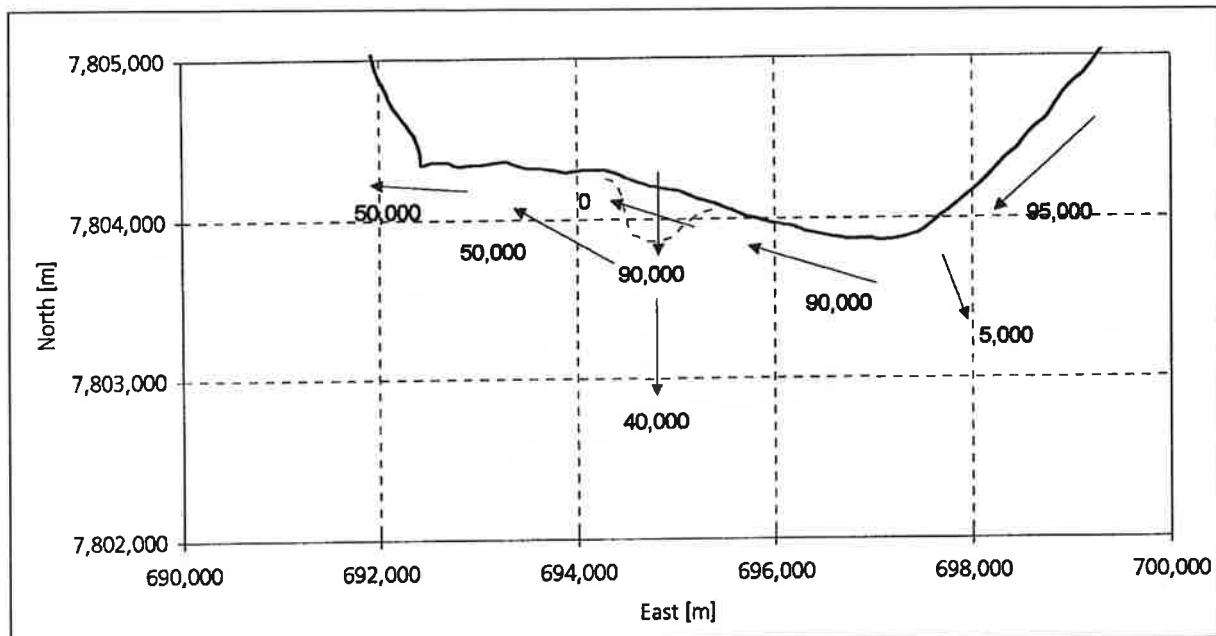


Figure 2.12 – Movement (littoral drift) of sand (in m³) along beach

At the drainage sluice, all transported sand from the east comes to the delta because of large flow velocities through the sluice during falling tide. Due to tidal currents and wave action a part of the sand is transported back in onshore direction. Computer modelling has shown that approximately 50,000 m³/yr is transported back in on-shore direction. This means that 40,000 m³/yr is lost from the coastal system. The amount of 50,000 m³/yr which is transported in on-shore direction is further transported into western direction and it finally ends up in the access channel of Beira Port.

(b) Critical areas and suggested measures

Along the Beira coast there are several locations where local conditions should not further deteriorate. These locations are:

- Structural erosion along the coastline of Macuti;
- Club Nautico, located too close to the sea;
- Loss of sand due to the delta in front of the drainage sluice;
- Coastal erosion in front of Hotel Miramar and damage to the sea wall;
- The "headland" of Ponta Gea;
- Erosion between Praia Nova and Ponta Gea.

Possible solutions are given below; more detailed solutions are given in Alkyon, 1998.

Along the coast of Macuti, structural erosion is caused by poorly functioning groynes. Between groynes no.32 and no.36 the coastline is developing to a coastline orientation similar to the one further north-east. If no action is taken, much erosion is expected to take place in the next 15 years. Therefore, groynes have to be reconstructed as soon as possible. A forecast of coastline development in the next 15 years, if nothing is done, is given in Figure 2.13. To prevent the most severe erosion to occur, groynes no.33 to no.36 are to be reconstructed by the project.

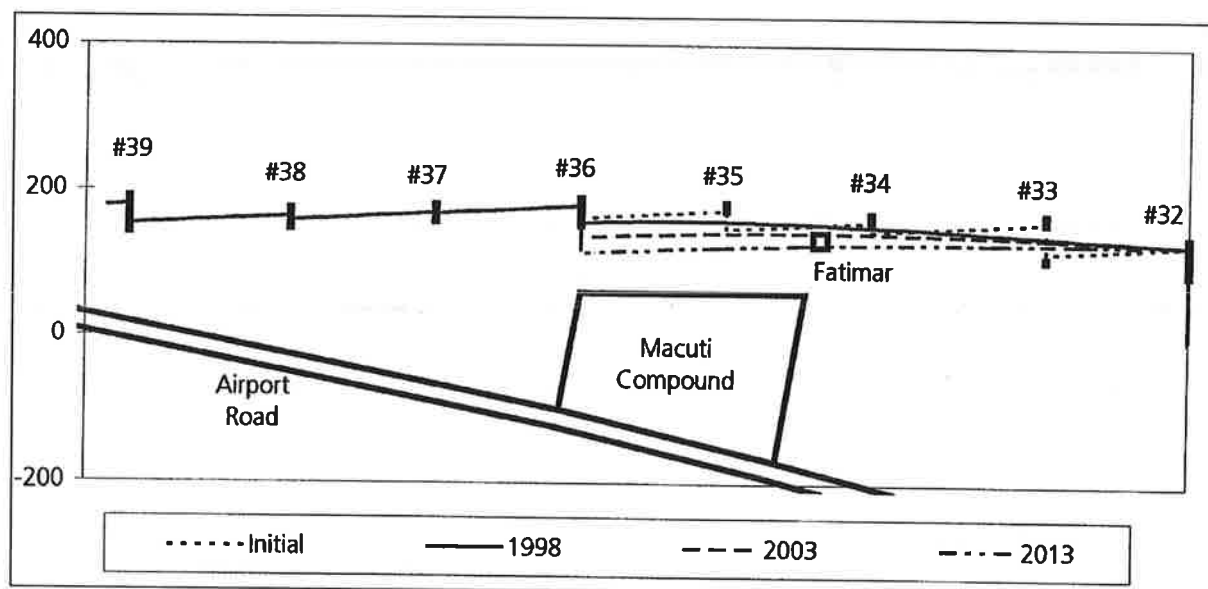


Figure 2.13 – Predicted changes in the beach at Macuti after groyne repairs are completed

Near Club Nautico the waterline has retreated in a way that now the club buildings are threatened. The groynes in front of premises are still in good condition, but these are too low to block enough sand. In order to improve the situation a number of groynes has to be raised in a way that they will block more sand. This will then lead to a wider beach.

Because of the non-functional drainage sluice a large amount of sand is lost in the off-shore direction. To achieve more by-pass of sand in the western direction, the doors of the sluice were restored by the Project. The delta will then decrease in size and especially during the dry season, when there is hardly any discharge through the sluice, most of the sand is transported along the coastline into a western direction instead of being transported to the delta.

From a morphological point of view it would be even more effective if the sluice is completely closed. All drainage water will then be drained through the Chiveve river. The littoral drift west of the sluice will then increase from 50,000 m³/yr to 90,000 m³/yr.

In front of Hotel Miramar, the high waterline has already reached the sea wall. In the corner at groyne no.13 the sea wall is damaged. Because the existing groynes along this coastline section are too low, the coastline will not restore itself, even if the littoral drift is increased after restoring the doors in the sluice. Groynes no.11, 11A and 12 have to be reconstructed in order to provide enough beach development in front of the sea wall.

The headland at Ponta Gea should be retained at all times. If the headland fails, the erosion just west of the headland will continue, which could even lead to damage to the city itself. The most suitable option for maintaining the headland is reconstruction of groyne no.3 and building a small dam in the western direction. This groyne will then force tidal currents further from the headland and the area west of the headland will be attacked less by currents.

The coastline between Praia Nova and Ponta Gea could be improved by placing hard structures. From a morphological point of view a long dam (ca 1 km) starting at Praia Nova and parallel to the access channel,

would be the most favourable option. This dam will then block most of the littoral drift from a eastern direction and strong tidal currents will be forced further off-shore.

(c) *Impact of measures along the coastline*

Measures as described above will effect the coastal system in a positive way. However, also some negative effects are to be expected. In the situation of 1998, the coastline of Macuti is eroding because of poorly functioning groynes. In order to restore the coastline, groynes no.33 to 36 were reconstructed by the Project. When groynes are reconstructed well, the littoral drift from the east will be blocked and there will be accretion updrift of the new groynes. The negative side effect is however, that the littoral drift is temporarily blocked, which means there will be erosion downdrift of the new constructed groynes. To avoid large damage from downdrift erosion, the following actions are needed:

- When reconstructing the groynes one by one, the littoral drift is blocked less compared to a situation where more than one groyne is reconstructed at the same time. The less the littoral drift is blocked, the smaller the downdrift erosion will be.
- The accretion updrift of the new groyne can be accelerated by nourishments. If the accretion of the coastline take a shorter period of time, also the time that the littoral drift is blocked will be smaller. This will then result in smaller downdrift erosion.
- The downdrift erosion can be decreased by nourishments downdrift of the new groyne. If the amount of sand which is blocked by the new groyne is compensated by nourishment, downdrift erosion will not take place.

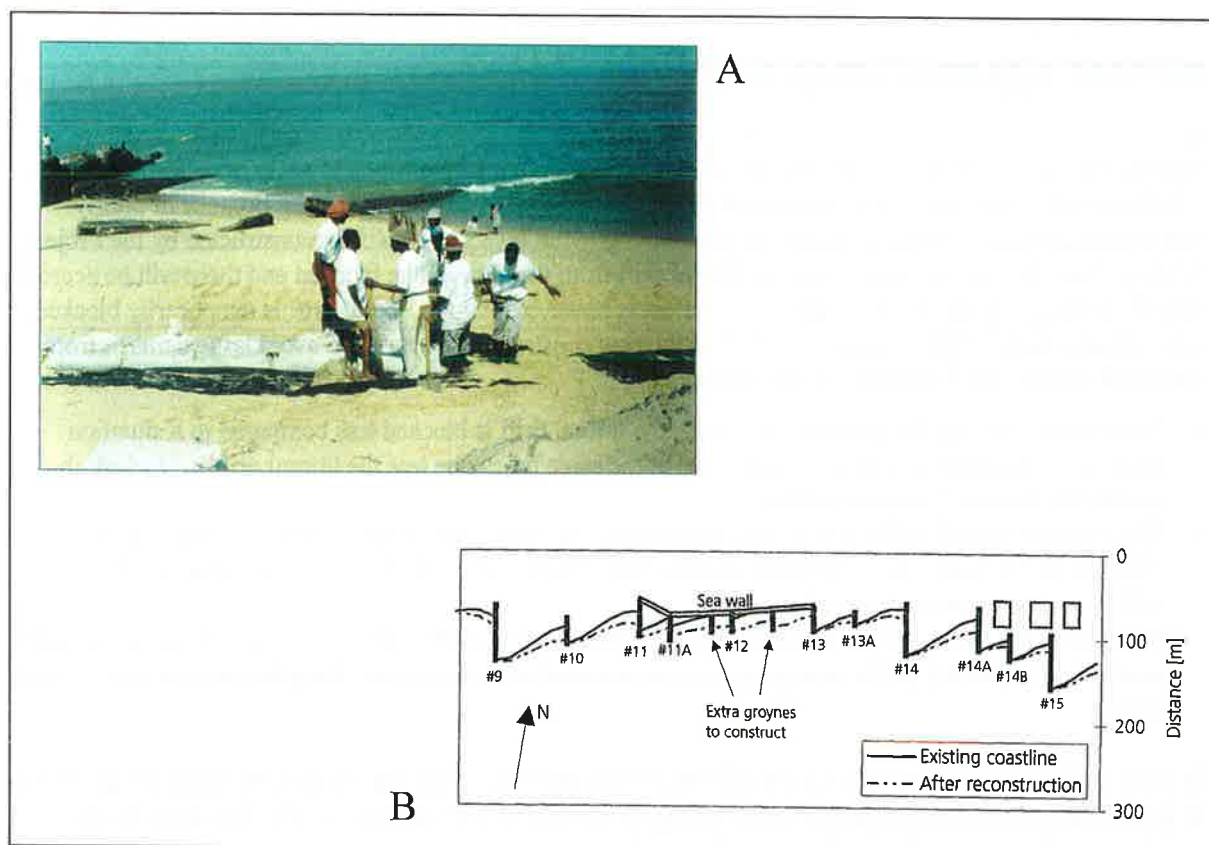
In front of Club Nautico the groynes are still functioning properly. They only have to be raised for about 1 m to give sufficient beach development. After raising the groynes it will take a relatively short time for the coastline to adjust. Large downdrift erosion is therefore not expected to occur.

If the doors in the drainage outlet “*Das Palmeiras*” are restored, more sand will be transported further west along the coastline instead of being transported to the delta because of large flow velocities through the sluice. The littoral drift west of the sluice will then be at least 60,000 to 70,000 m³/yr instead of 50,000 m³/yr in the existing situation. Because of this larger littoral drift the beach width will increase downdrift of all groynes. The only location where the beach width will not be sufficient, is the coastline section along the sea wall at Hotel Miramar.

From computer modelling it is concluded that a beach will be present along the full length of the sea wall if groynes no.11, 11A and 12 are replaced by 4 m high groynes (*Figure 2.14A*). From an economical point of view this is however not feasible. An alternative is to place more groynes with a smaller height along the coastline of Miramar. Computer modelling showed that 2 new constructed groynes in combination with raising groynes no.11A and 12 by 1 m could result in a beach along the full length of the seawall (see *Figure 2.14B*).

If the sluice would be closed completely, the littoral drift would increase to 90,000 m³/yr along the coastline west of the sluice. For the coastline reconstruction of groynes no.11, 11A and 12 with a height of 2 m would be sufficient for creating a beach along the full length of the sea wall.

Since it would take many years before the Chiveve river can be made ready for discharging all drainage water from the lowlands, closing the sluice will not be an option at this time. In this stage of the Project restoring the doors of the sluice is the most reasonable option.



Figs 2.14 – With repairs at Miramar completed (A), groynes raised one m., and additional groynes added the condition shown in (B) will be reached

With a long dam at Praia Nova, currents will be forced in off-shore direction. This leaves a shadow area updrift of the dam where there are no strong tidal currents. In this area there will be accretion and a spit will develop from Ponta Gea into the direction of the dam. When this spit has reached the dam a wetland area is created (see *Figure 2.15*). The spit then functions as a flexible defence which will always restore itself after damage. Because of the large area which has to be filled, it will take a long time before the coastline is stable. Until that time, the headland of Ponta Gea has to be maintained.

(d) Protection scheme

From a morphological point of view, the above-mentioned solutions will have a positive effect on the coastal development. Based on priorities a protection scheme should be defined in order to achieve a satisfying coastline development. It should however be noticed that some measures as described above cannot be executed independently of each other. Measures for the sluice are for example strongly related with needed measures along the beach wall at Hotel Miramar. This is described more in detail in the Project's full morphological study (Alkyon, 1998).

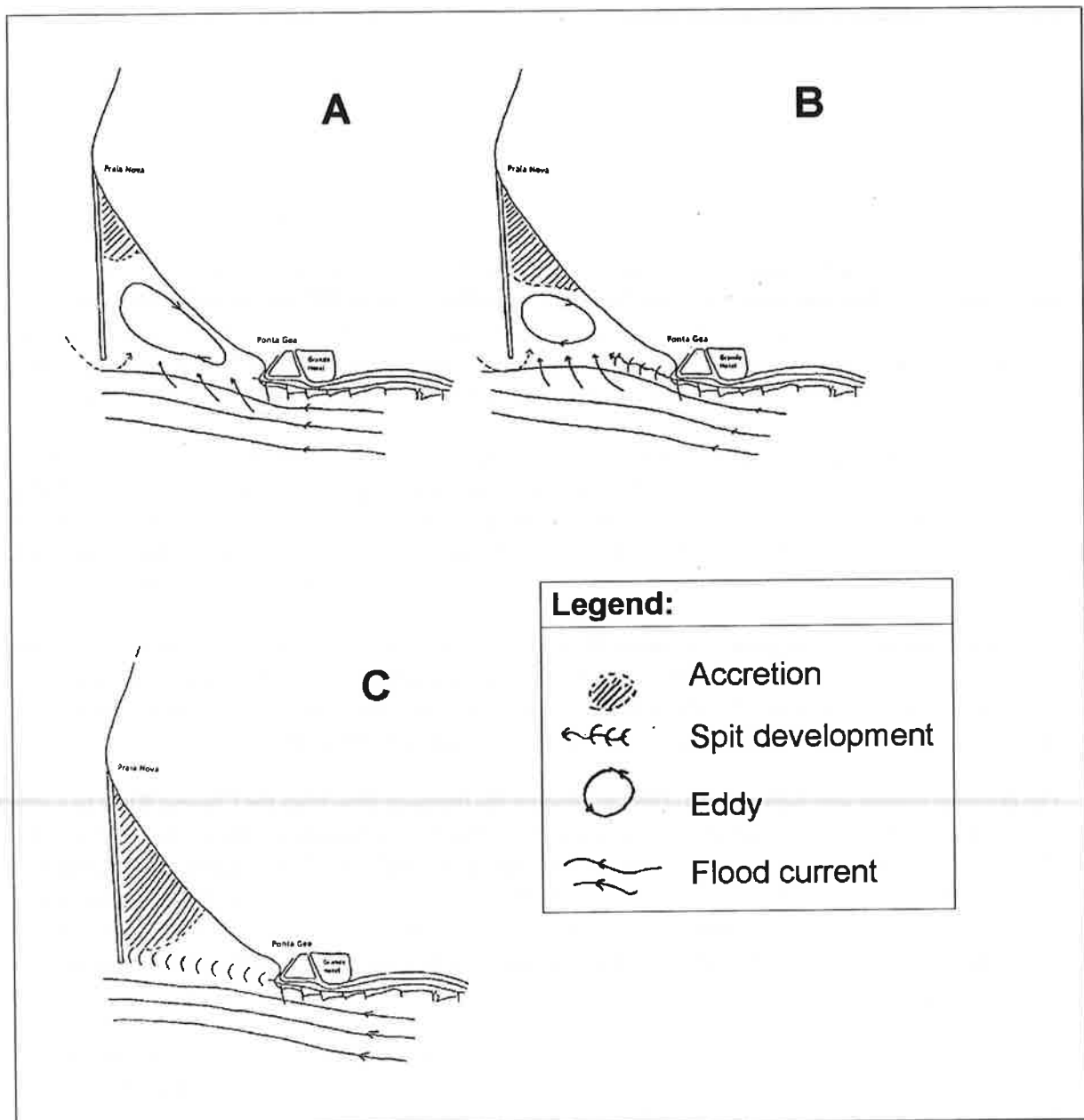


Figure 2.15 – Expected infilling of sediment if a long dam is built outwards from Praia Nova

2.2.7 Storm contingency programme

Because of the likelihood of major damage from future storm events, such as occurred during the 1993 and 1997 cyclones, a post-event rapid response plan should be created to assist CMB in both advance preparations (stockpiling materials, identifying equipment, assigning manpower, etc.) and in rapid response to beachfront damage in order to minimise the impacts of storms.

2.3 Urban Lowlands Sub-Zone

This section addresses the interior lowlands with riparian areas, marshlands, canals, fields and settlements (in total thousands of ha), all of which are connected to the sea via the *Desaquadouro*.

2.3.1 *Desaquadouro at Palmeiras*

Because the sluice rehabilitation is supported by the Project for the specific purpose of beachfront management, the sluice operational regime should be controlled by the ICZM-unit in such a way as to stabilise the beach/dune system. Yet this confers a wider responsibility upon the ICZM-unit to also operate the sluice in such a manner as to properly drain the lowlands, maintain water quality in the canals, prevent serious flooding of residences and agriculture fields, and reduce salt water intrusion.

The above are not simple tasks considering that there are many trade-offs among these functions and all cannot be optimised simultaneously. Therefore, the sluice gate operating protocols must benefit from dialogue and negotiation with stakeholders. Spontaneous settlements cover the lowlands from an elevation of 2 to 4 m CD, whilst the tide outside rises and falls between 1.5 and 6 m CD. Moreover, tides occasionally rise to 7 m CD, or 3 to 5 m above the elevation of the settlements. This creates a very serious flooding threat.

The sluice gates of the *Desaquadouro* control the water level in the whole area of the Secondary Urban Sub-Zone at a single point on the beach. The secondary water control structures are inoperative at present. Therefore, it is not possible to refine the drainage system and have separate programmes for the three different compartments of the Sub-Zone in order to assure maximum conditions.

The drainage system was built in 1961-1962 to shortcut the drainage flow from the Chiveve River to a direct ocean outlet (the Chiveve's mouth at the seaport was then closed). The system was then redesigned in 1985 (Prack, 1985), and rebuilt in 1986 with a maximum capacity outflow of 42.7 m/sec and a service area of about 2,400 ha. The concepts were: (1) fast drainage of housing areas; and (2) maintenance of appropriate water levels in agriculture areas (*Figure 2.16*). Three drainage zones were designated and internal control gates (sluices) were operated on two trunk canals so that separate water levels could be maintained in each zone.

The western zone was designated for housing, the centre zone for agriculture, and the eastern zone for housing with allowance for agriculture. This called for strategic use of the internal gates in co-ordination with the sluice gates at Palmeiras. But this ability was defunct in 1994.

With the drainage system completely disfunctional by 1994, all gates were left open to the free flow of water in and out with the tides. This not only left the area at the mercy of tidal flooding, it also created a hydraulic effect which was to build a large delta in front of the outlet which seriously blocked the sand flow (littoral drift) along the beach to the west resulting in major erosion. The current Project's goal was to rebuild the sluice gates in order to reduce this delta and stabilise the downdrift beach.

With the sluice operating again it will be necessary to repair the internal control structures and to remove silt from some canals to get the full effect of the system in balancing flood control, water level for agriculture, reduction of salt water intrusion, and improvement of sanitation.



The Project recommends investigation of a longer term plan, one that would promote long-term beach stability and eliminate the *Desaquadouro* and its troublesome sluice gates along with the delta which causes erosion to beaches to the west.

This new wide channel could be covered with a column supported concrete deck to provide surface area for development. It would be possible to create a new commercial waterfront facility here with integrated retail, entertainment, and/or residential space in the vacant area between the old bridge and the fishing port. Such development, by private sector investment, is realistic and may be necessary to fully support the Chiveve River revitalisation. Waterfront malls have been universally successful in ports around the world.

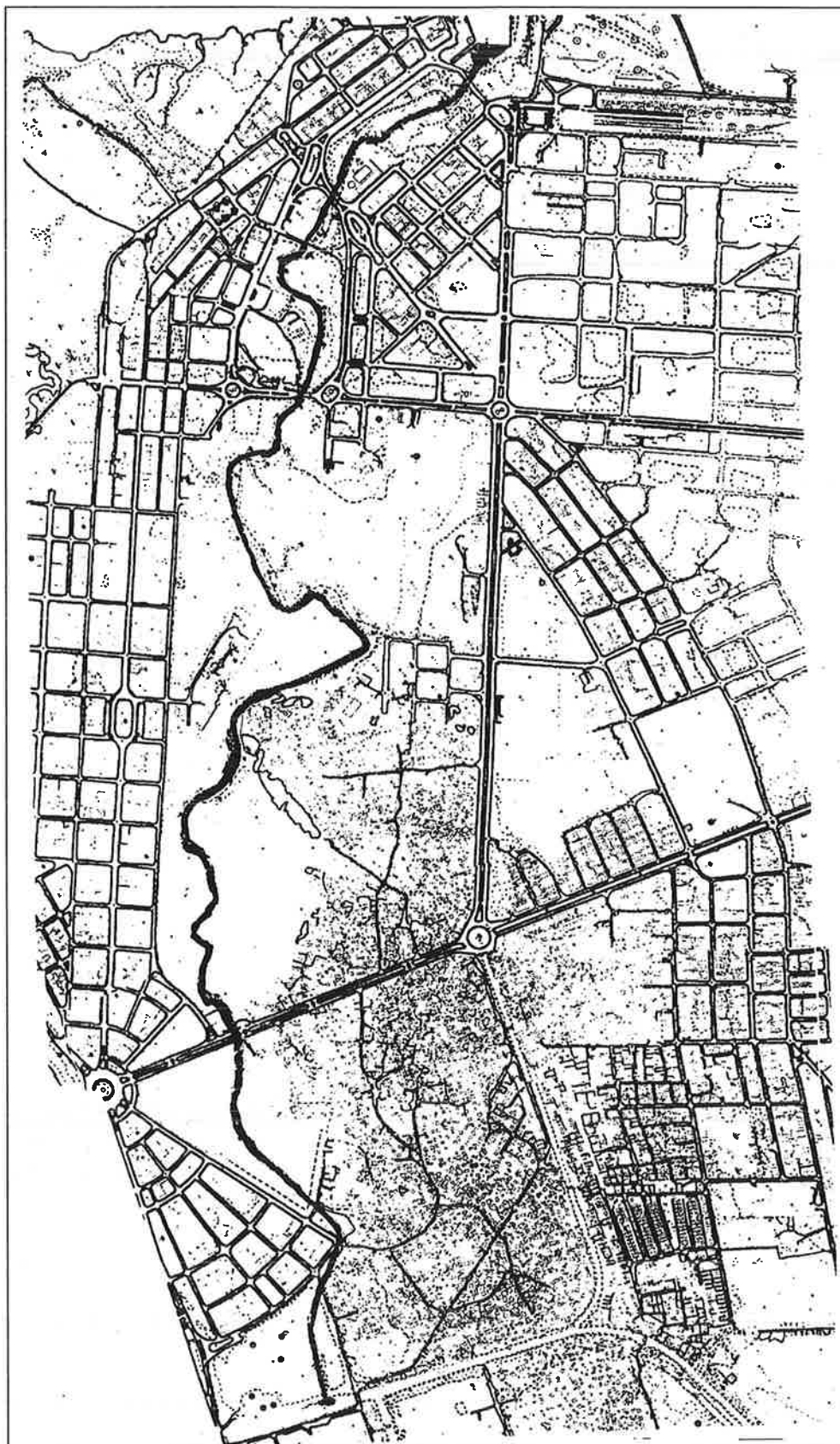


Figure 2.17 - Rerouting of the Chiveve

Redirecting drainage flow by reopening the Chiveve River mouth may reduce siltation in the fishing port by scouring and have many other benefits. However, the balance of siltation -- plus and minus -- needs to be carefully analysed as part of a detailed study to evaluate these costs and benefits of Chiveve revitalisation. Such a project would require excavating a new bed for the river, detouring around residences in the Palmeiras area, and two bridge crossings where it would flow under existing roads (*Figure 2.17*).

From a landscape and ecological point of view such a programme could be quite beneficial. Our ecological investigation (IUCN, 1998) concluded that the mangroves of the Chiveve River are an extremely valuable municipal asset that should be recognised for their landscape value, and water purification function. These mangroves provide a self-maintaining riverine park or green belt that would provide a valuable focus for restoration of the town centre and promenade.

Repairs to the drainage outlet at Palmeiras are a short-term measure only and not considered as the final solution to the problems caused by this system. Even, with optimum operation of the structure, beach erosion westward to Ponta Gea will be relieved but not solved. Problems will continue into the future; not only for the beach but for the lowlands drainage system.

"Maintenance friendly" and cost efficient options for the longer term are initially identified as:

- Abandonment of the sluice and rerouting of the drainage water via the Chiveve river system to detour the fishing port and enter the River Pungue at the harbour, requiring high investments and certain adjustments.
- Discharge of the drainage effluent via a buried pipe system to an offshore outfall in order to transport the flow from the sluice to deeper water, also expensive and not trouble free.

Neither of these eliminates the need for a water level control structure, or structures needed for hydraulic management of the drainage. And, of course, other options will be explored.

Some years ago DHV (1990) studied a number of options, with the conclusion that rebuilding the sluice followed by periodic sand removal (maintenance excavation) from the beach in front of the outlet might be the best solution for the beachfront from an economic point of view. Construction of the ocean outfall was estimated by DHV at USD 3.8 million (1990 price level). No estimate was given for the Chiveve River option by DHV. In order to evaluate this option an intensive hydraulic and topographic survey must be done along with engineering and socio-economic studies. Non-technical roadblocks and infeasibilities may exist.

2.4 Eastern Rural Sub-Zone

This Sub-Zone includes the coastal lands east of Estoril within the municipal boundaries of Beira, extending along the coast to Rio Maria and Savanne, including the beachfront, the dunes, the tidal waterways, mangroves, and the shorelands that lie seaward of the road to Savane.

Of particular significance in this sub-zone is the Rio Maria - Savane estuary complex (seashore, dunes, tidal creeks and marshes, sand and mud flats, and mangroves and associated vegetation) which is a sparsely populated area that supports a range of fishery and recreational activities. This saline and waterlogged area offers little scope for development. However, it holds tremendous opportunity for conservation and sustainable use of resources, both those in the estuary-wetland complex and others offshore that are dependent on it.

The sustainability of these resources will require the implementation of a range of management measures aiming at controlling activities in- and outside the estuarine complex (e.g. on air or water pollution, etc.). Such measures, as mentioned in the biodiversity discussion below (*Paragraph 2.9.1*), include designation as a sensitive area, specific conservation measures, environmental impact assessments, and a management programme with stakeholder participation.

2.5 Northern Rural Sub-Zone

This Sub-Zone includes the coastal lands north of the seaport that lie within the municipal boundaries of Beira, extending north along the Pungue River and including the beachfront, mangroves, all riparian areas, the lowlands that drain into the estuary, and adjacent shorelands extending inland to the Dondo Road.

The mangrove fringe should be protected as part of a shoreline "greenbelt" (see *Paragraph 2.9.1*). Blocked drainage channels should be reopened (e.g. at the railroad crossing and the Oliveira Bus Co. yard). The garbage dump should be relocated and converted to a modern landfill. Industrial, commercial, and other expansion into the area should be controlled. Sanitation should be improved.

2.6 Seaport Sub-Zone

This Sub-Zone includes the seaport complex including the area supporting seaport facilities extending from Beira Terrace to the oil terminal as well as the attendant railroad facilities, warehouses, and commercial and industrial facilities, and fisheries harbour (*Figure 2.18*).

The seaport complex, including CFM (the Port's parent organisation) and other operations, is a relatively autonomous area operating under national authority. As Beira's main economic asset, close co-ordination with city and provincial government programmes is essential. This is particularly important with increasing privatisation of port activities.

Access to the seaport by road and rail goes directly through Beira with many traffic and infrastructure implications. Access by sea requires an extensive, continuous, dredging programme with important implications for Beira. Expansion of the seaport involves land use questions with important implications to Beira.

As explained in *Paragraph 2.9.2*, the seaport has a high potential for environmental pollution which must be examined and any major sources corrected. However, no environmental assessment of the Port is available to look at details. Perhaps this can be done under MICOA's new laws which provide for retroactive assessments.

It should also be recognised that CFM owns many properties in or adjacent to the Primary Urban Sub-Zone and has responsibilities to the city for these.

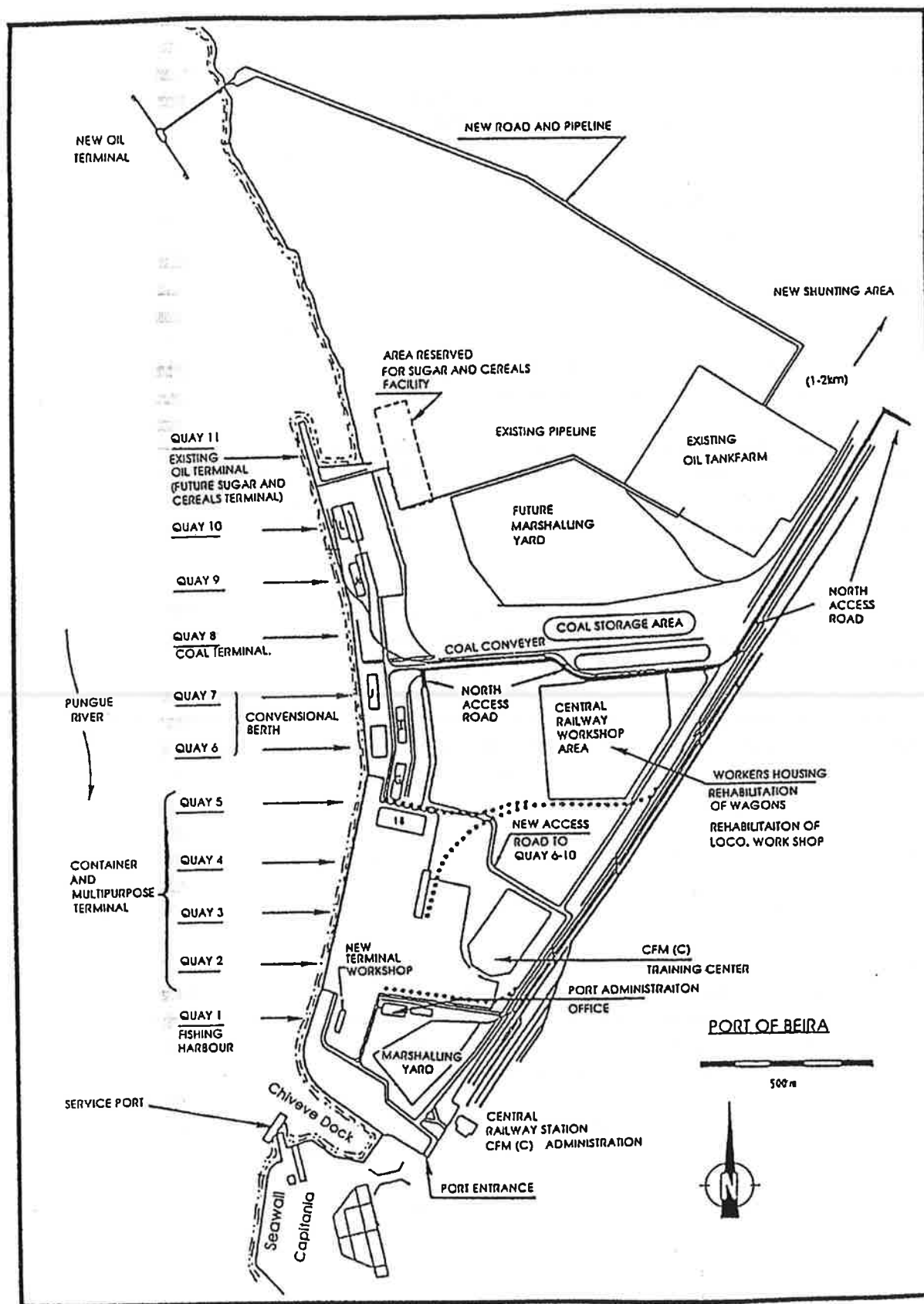


Figure 2.18 - Port layout

2.7 Urban Central Sub-Zone

This Sub-Zone includes what is often referred to as "cement city", the Beira city centre. While this Sub-Zone is not recommended for management as part of the coastal zone, its management does have a major influence through storm drainage and sewage, infrastructure, water use, expansion, economic attractions and pressures, and regulation of land use and constructions within the coastal zone. Therefore, any attempt at establishing an Integrated Coastal Zone Management plan for the Municipality of Beira must include co-ordinated action with initiatives of the city centre.

2.8 Extended Sub-Zone

This more loosely defined zone includes areas outside the above-mentioned zones, beyond the urban boundaries, that have a major influence on the coastal environment; e.g. agricultural and forestry lands, the Pungue riverway and water control- and diversion sites, inland settlements, etc.

The municipal water supply for Beira originates from an intake 82 river-km (RK) from Beira (about 50 straight km) that is shared with a sugarcane factory. Here, the water becomes saline and unpalatable during the dry season when river flow is low and ocean tides are high (spring flood tide). This situation has received considerable attention in the past (DNA, 1994 and 1995) and is now (1998) a concern of ARA-Centro (*Figure 2.19*).

Several alternatives have been suggested, i.e. build a high dam above the intake at Bue Marie (including flood mitigation); build a high dam below the intake; build a submerged dam below the intake; move the intake to RK 89, 91 or 94. But the matter is far from resolution.

In the meantime, near the headwaters, Mutari (Zimbabwe) wants to increase its consumption from the river. Also agriculture interests demand more water. And there is also a serious problem in trying to supply, in the future, 24,000 m³ per day to a proposed iron industry near the Savane River (Eastern Rural Sub-Zone)(Impacto, 1998).

Relevance to the Beira ICZM-Project is that any alteration of the quantity of flow or the hydro-period will have consequences on the ecology of the Pungue Estuary and possibly on beachfront stability. Also, upstream land uses may have strong effects on the downstream coastal zone.

Although the current Project did not analyse land uses in Sofala and Manica provinces, certain common used do effect the coastal zone. For example, agriculture has strong implications on coastal conservation. Land clearing and farming cause soil erosion which ends up in coastal waters. Applications of agro-chemicals without careful control cause pollutants to run down rivers to the sea and affect water quality, contribute towards the eutrophication of river and coastal waters, enter into food chains, and degrade ecosystems.

In addition, exploitation of forest lands for timber, farmland, plantations, and fuelwood is of concern. Deforestation reduces watershed protection, increases surface water runoff, increases soil erosion and desertification, contributes to siltation, and results in pollution of the coastal zone. Forest exploitation in watersheds which increases sediment loads of rivers entering the Pungue Estuary, must be strictly controlled. These matters require watershed-wide co-operation of authorities and involvement of and negotiation with stakeholders and agencies.

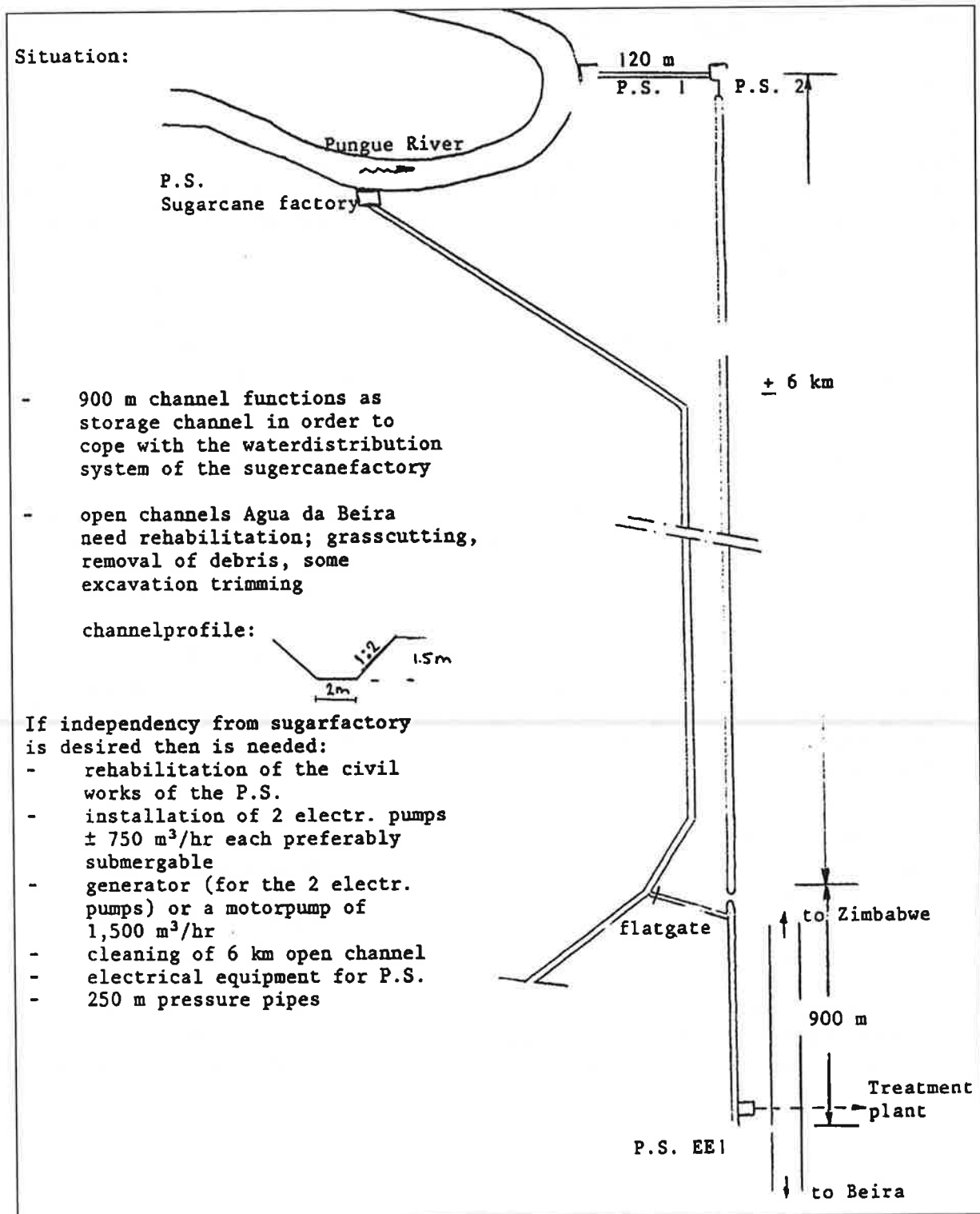


Figure 2.19 - Pungue inlet for water

2.9 Investigations

2.9.1 Environment

(a) *Biodiversity assets*

Biodiversity investigations for the Project were undertaken by IUCN (Salm, 1998) as summarised below with some additions and modifications. Identified as the principal biodiversity assets of the urban and rural coastal areas of Beira city, along with an assessment of local, national and regional conservation values include (see also *Table 2.1*):

- Mangroves of the Pungue River (local value moderate, national value low, regional value low).
- Mangroves of Rio Chiveve and Praia Nova (local value high, national value low, regional value low).
- Reed beds and seasonal wetlands between Ponta Gea and Praia Nova (local, national and regional values not yet known; reported to be important for migratory birds during wet season).
- Tidal creeks, mangroves, and associated habitats of the Rio Maria -Savane complex (local value high, national value moderate, regional value moderate).
- Primary dunes and associated vegetation (local value high, national value low, regional value low).

Outstanding assets of high conservation value from national or regional perspectives are not found around Beira, as might be expected for an urban setting. However, when viewed in a functional context, most assets are of high local value as is explained in the following paragraphs.

(b) *Mangroves of the Pungue River*

The role of mangroves in supporting fisheries production, especially in providing breeding and feeding grounds for shrimp and fish, is well documented in literature, along with the roles in accretion of land by trapping sediments, and stabilising shorelines. Mangroves also thrive in saltwater, turning the otherwise harsh saline environment into productive green areas. Consequently, all mangroves are likely to contribute to fisheries and shoreline stabilisation, and should therefore be conserved for these functions (*Figure 2.20*). Note that MICOA policy is for full protection of mangrove. Therefore, the following is recommended:

- Beira authorities formulate a green belt policy to provide total protection for mangroves close to the shoreline, including a strip at least 20 m back from the MHW line along all tidal water bodies (sea, river, estuary, tidal creek).
- All other mangroves should be carefully safeguarded against encroachment, draining, filling, pollution, and clear felling, and licenses for pole cutting and other removals should be strictly controlled and monitored. Management measures should include such incentives as preferential issuance of licenses for cutting to individuals who replant cut areas.
- The City, Maritima, MICOA, and/or other appropriate entities should conduct a dialogue among concerned authorities to discuss and agree on effective and sustainable enforcement mechanisms and responsibilities.

Biodiversity Assets	Conservation Issues	Management Opportunities	Expected Outcomes
Pungue River mangroves	Heavy cutting of poles and firewood	<ol style="list-style-type: none"> 1. Beira Municipality formulates green belt policy that includes total protection for all mangroves within 20-50 m of the water's edge. 2. The authority that licenses mangrove cutting includes green belt prohibitions with all permits. 	General protection of shorelines, fringing mangroves, and related fisheries production maintained for minimal management overheads
Rio Chiveve and Praia Nova mangroves	No major threats, but used as public latrine	<ol style="list-style-type: none"> 1. Chiveve River restoration and protection of its mangroves factored into Beira City Structure Plan. 2. Chiveve River mangroves gazetted as reserve. 	Attractive green open space focus for downtown Beira and promenade secured
Ponta Gea - Praia Nova reed beds and wetlands	Unconfirmed value for migratory birds Encroachment by market gardens Burning/cutting of reeds	<ol style="list-style-type: none"> 1. Assessment of value for migrant birds during wet season (November-March) 2. If warranted by this assessment, initiate process to define use and management options 	Confirmation of value for migratory birds and identification of use options
Tidal creeks, mangroves, and associated habitats of the Rio Maria - Savane complex	Heavy cutting of mangroves Unregulated harvest of clams, including many that are very small Erosion of estuary banks - not known if this natural or the result of mangrove cutting	<ol style="list-style-type: none"> 1. Rio Maria - Savane area from seashore to include all wetlands and areas of tidal influence designated a "sensitive area" in Beira City Structure Plan and gazetted as such. 2. EIA procedures requiring maximum detail be defined for all developments planned within 5 km of this sensitive area, with special attention to water and air pollution. 3. Management planning process initiated along the lines prescribed in Annex 1. 	Productive fisheries and related livelihoods maintained for the Rio Maria - Savane estuary complex
Primary dunes and associated vegetation	<p>Dune erosion and destruction of dune plants by:</p> <ul style="list-style-type: none"> • Trampling • Squatters and fishers • clearing for tourist and recreation sites • vehicle traffic <p>Sand mining</p> <p>Interference with natural dynamics by:</p> <ul style="list-style-type: none"> • encroachment by buildings <ul style="list-style-type: none"> • delta effect of desaguadouro outlet • deflection and loss of sand seawards by groynes <p>Collapse of beach and dune management structures:</p> <ul style="list-style-type: none"> • damaged groynes • retaining wall on inland side of dunes 	<ol style="list-style-type: none"> 1. Dunes stabilized by planting with a mix of creepers, grasses, herbs, and shrubs (starting with a pilot restoration activity for a damaged dune). 2. Dunes landscaped to control access and provide shade and beauty spots (starting with a pilot activity for a stable dune). 3. A nursery be established (or negotiated with the existing viveiras) that prepares stocks of dune plants for use on demand. 4. A sethack extending inland 100 m from the high water mark or that includes the entire dune and extends not less than 20 m behind it, and modified road access, be designated in the Beira City Structure Plan. 5. Additional signs prohibiting sand mining are posted along the dunes, the area patrolled, and mining prevented. 6. Alternative sand deposits are identified (channel dredgers, secondary dune system east of Estoril (near salt works) and made available at convenient location and sufficiently cheap prices to discourage purchase from illicit sources. 7. All derelict buildings and structures are removed from the dunes, and the dunes restored. 8. Setback policy is uniformly and universally enforced (see 4 above). 9. Construction standards defined and enforced for all beach facilities. 10. Rehabilitation and operation of desaguadouro as prescribed by Beira ICZM project. 11. Groyne design reviewed and modified as recommended by Beira ICZM project. 12. Repair damaged groynes following prescriptions of Beira ICZM project. 13. Retaining wall repaired, reinforced, or replaced as needed. 	<p>Stabilized and landscaped dune system incorporated into Beira City Structure Plan.</p> <p>Dune erosion controlled and dunes building up.</p> <p>Beach erosion controlled and beaches accreting.</p>

Table 2.1 - Summary of biodiversity conservation and management opportunities for rural and urban Beira

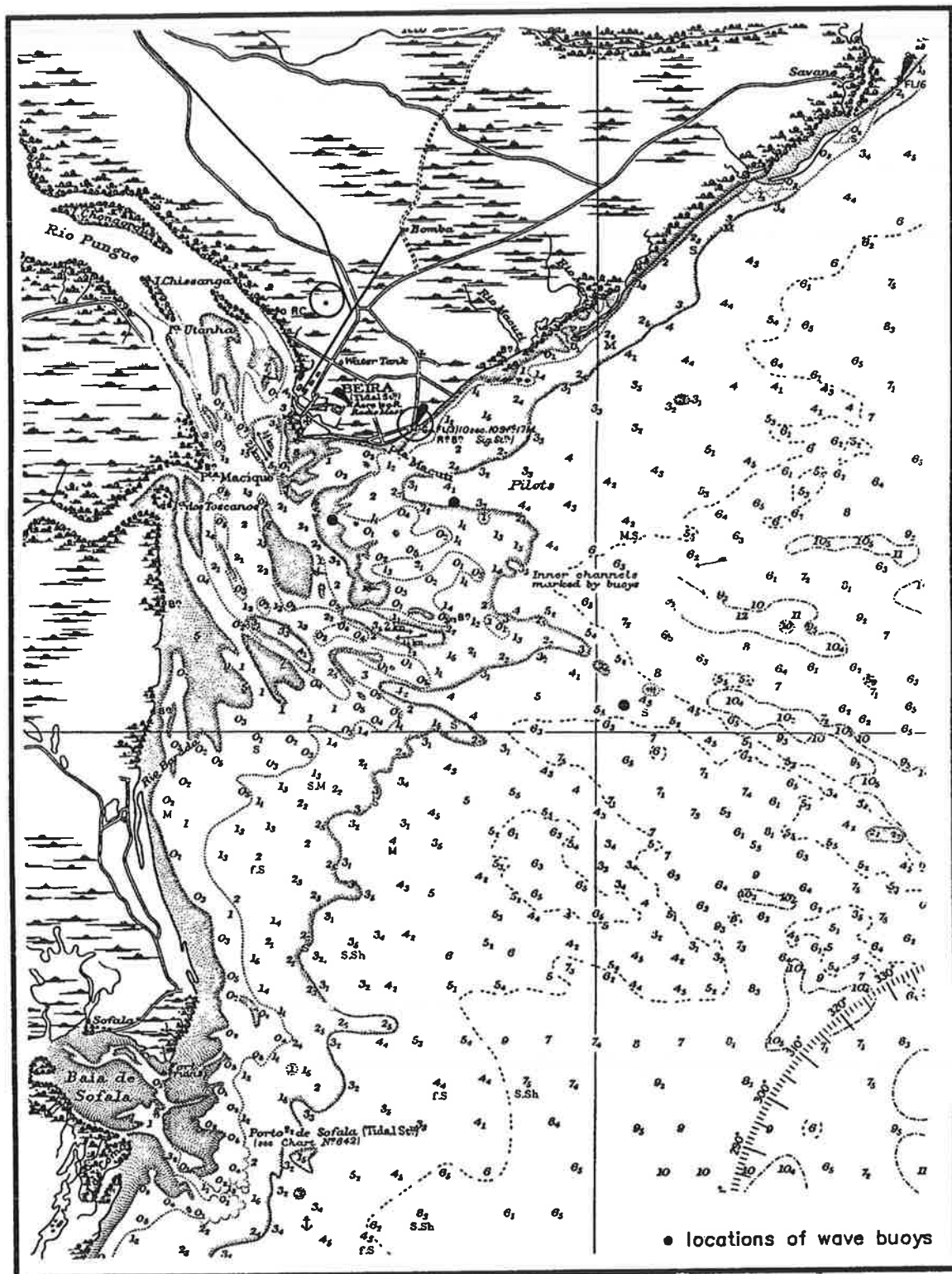


Figure 2.20 - Map of area from Buzi to Savane



Figure 2.21 – Erosion of shoreline from Punta Gea to Pria Nova from 1956 (A) to 1993 (B) with loss of mangrove (+ 100 ha)

(c) *Mangroves of Rio Chiveve and Praia Nova*

It is emphasised that the mangroves of the Chiveve River are an extremely valuable municipal asset that should be recognised for their landscape value and their water purification- and ecological functions. These mangroves provide a self-maintaining riverine park or green belt that would provide a valuable focus for restoration of the town centre and promenade. As part of the proposed mangrove green belt policy, the Praia Nova mangroves should be fully protected as both a green space in downtown Beira and for its possible shore stabilisation and fishery support roles. It is therefore strongly recommended that, as immediate measures:

- the Chiveve mangroves and restoration of the Chiveve River drainage system be included in the ICZM plan and in PROL's structural plan for Beira City; and
- the mangroves of the Chiveve River are declared a reserve to be managed by the Beira Municipality.

No replanting of former mangrove areas is proposed under the Project's emergency works but the feasibility of longer term efforts should be examined for the ICZM plan, in co-ordination with several entities (*Figure 2.21*). PROPECA (a Beira city agency) is initiating a mangrove rehabilitation project with NGO assistance. Other probable supportive entities are Amsterdam-Beira City Co-operation, NIZA (Netherlands Institute for Southern Africa), and the NGO KULIMA. However, such replanting projects need professional guidance.

Habitat changes in the former mangrove area between Ponta Gea and Praia Nova - with a lowering of salinity and nearly continuous flooding - exclude the possibility of mangrove regeneration, unless an open connection with the sea is constructed.

(d) *Reed beds and seasonal wetlands Ponta Gea to Praia Nova*

The mosaic of freshwater and brackish swamps, with reed beds, sedges, small pools and rice fields, is of importance to conservation and is an attractive habitat for birdlife, plants, amphibians and fish. Caution should be exercised in converting parts to mangrove (*Figure 2.22*). Before any conclusion can be made on this site, its conservation potential will need to be determined. It is recommended to conduct a survey during the wet season to determine the value of the site for migratory birds and to what extent these birds are dependent on this particular seasonal wetland.



Figure 2.22 – Low marsh area behind Wedding House at Ponta Gea

(e) *Tidal creek/mangrove habitats of the Rio Maria/Savane complex*

The Rio Maria/Savane estuary complex (seashore, dunes, tidal creeks and marshes, sand and mud flats, and mangroves and associated vegetation) is a sparsely populated area that supports a range of fishery activities. The saline and waterlogged area offers little scope for urban or industrial development. However, it holds outstanding opportunity for conservation and sustainable use of resources, both those in the estuary-wetland complex and others off-shore that depend on it, along with some controlled recreation and tourism use.

The sustainability of these resources will require the implementation of a range of management measures aimed at controlling activities directly in the estuarine complex and others outside that could affect the area (e.g. air or water pollution). As immediate first steps, it is recommended that:

- the seashore, wetlands, creeks, and areas of tidal influence from Rio Maria to Savane be designated a sensitive area and as such be fully protected and identified in both the ICZM and City Structure plans;
- this designation be formally gazetted;
- detailed Environmental Impact Assessment (EIA) procedures be defined for all commercial and industrial developments planned within 5 km of this sensitive area with special attention afforded to water and air pollution;
- a detailed participatory consultative process be initiated to investigate management options and formulate practical and effective management prescriptions for the area.

(f) *Primary dunes and associated vegetation*

Beira's dune system is critical for the continued protection of the coastline and as a defence against serious sea water flooding of Beira residential areas and farm lands (and consequent salinisation) or direct loss of property into the sea as has already happened at a few sites in urban Beira (*Figure 2.23*).



Figure 2.23 - House collapsed into sea at Punta Gea from erosion

The avifauna is not very diverse, and there are no waders and few terns. The most common bird species are the introduced Rufous Sparrow *Passer motitensis*, Red Bishop *Euplectes orix* and Pied Crow *Corvus albus*. Little Egret *Egretta garzetta* are locally common, for example near the Palmeiras outlet of the drainage channel.

Conservation of the dunes and the associated vegetation is very important. However, it should be acknowledged that this dune system falls into an altered and artificial urban environment. So, the conservation emphasis should be on preserving the functional and aesthetic roles of this system, rather than on nature conservation in the pure sense. As a consequence, any planting and landscaping activities should be designed to achieve maximum sand binding, dune stabilisation, aesthetic-, recreational-, and access control functions using the best species for these purposes. Common nature conservation principles would restrict to plant as much as possible indigenous species.

It is recommended therefore, that the mix of species used for dune stabilisation be based on the following criteria:

- stocks are readily available, easily transportable, and suitable for propagation through cuttings (likely to be indigenous species);
- species are known pioneers of, or fully adapted to, unstable beach environments (likely to be indigenous species);
- effectiveness as a barrier to access (likely to be a mixture of indigenous and exotic, thorny species);
- aesthetic (decorative and shade) value (likely to be a mix of indigenous and exotic species).

It is further recommended that:

- the dune system be incorporated into the city Structure Plan as a landscape feature; with protection and restoration; zoning for access; mandatory setbacks (existing 100 m inland from HWL, or inclusive of all dunes to at least 20 m inland from the back of dune); all of the above to be in line with current setbacks and other legal protections (City, Maratima, MICOA, etc);
- all sections of non-essential informal road running along the inland margin of the dunes be closed and allow vehicle access on a limited number of roads orientated normal to the dune system (rather than parallel and continuous behind it);
- a pilot dune restoration be attempted for an area of damaged dune, and that this be carefully monitored, evaluated, and refined to serve as a model approach for future restoration activities;
- dune landscaping be included in the pilot dune study at a stable dune area for aesthetic and access control purposes (boardwalk), and that this be monitored, evaluated, and refined to serve as a model for future landscaping activities;
- CMB make an agreement with a Viveiras (plant nursery) to establish a stock of suitable plants for City and private people requiring these for dune restoration purposes;
- wherever CMB intervenes to rebuild a beach or dune, the reclaimed area is immediately planted with appropriate vegetation;
- landowners benefiting from dune restoration be required to maintain dune vegetation;
- all derelict structures be removed and the dunes at these points restored;
- the retaining wall on the inland side of the dune system be repaired throughout its length.

2.9.2 Pollution and health

(a) General condition

Beira has many of the environmental health problems of urban areas found everywhere, but its location on low lying delta lands adjacent to the sea create special problems. Water surrounds the city and it has

been convenient to dispose of liquid wastes directly into the Pungue Estuary or to the open seacoast without treatment. Unfortunately, Beira has no regular water quality monitoring programme to detect specific problems.

Garbage is dumped at very low sites where leachates can easily run off into the water. The main city disposal area at Dama is not a proper landfill, it is dump with no real protection against leaching into groundwater and the estuary.

Because the majority of people have no sanitary facilities, excrement is widely scattered around the fringes of the city. Also, the wastes from thousands of persons in the spontaneous settlements (in the marshlands adjacent to the formal part of the city) go directly into the drainage canals and are carried out to sea or into the groundwater which leaches into the canals and into the many wells used for water supply (only 30% of the urban population is connected to the formal water supply).

The result of these conditions is frequent epidemics of malaria, cholera, and other water-related diseases. For example, the outbreak of cholera in January 1998 that caused the death of more than 600 persons, is directly traceable to water-related sanitation problems. It is said that severe obstruction of the drainage system, with large areas below high tide levels "makes for a perfect breeding home for mosquitoes ... as a result, malaria is the most frequently diagnosed disease in hospitals" (*Conselho*, 1996).

(b) *Sewers and storm drains*

The formal parts of the city have a sewerage collection service. This system is in poor condition and malfunctions regularly because one or more of the 15 force pump set-ups fail or parts of the system collapse or become clogged. When it is operational it disposes untreated sewerage directly to the Pungue Estuary north of the seaport. When not functioning it disposes much of the sewage directly to the drainage canal at Palmeiras, via an overflow outlet, this sewage then goes directly out to sea via the *Desaquadouro* where it pollutes the beaches (DHV, 1998).

The storm drain system consists of open (ditches) and closed (street drains, pipes) parts. Discharge is directed via the open canal system or to five outlets at the beach or the estuary. The latter are almost totally clogged with beach sand and their outlet units non-functional. It may be assumed that stormwater run-off is highly polluted because of human waste scattered over the landscape.

(c) *Other sources*

Some industrial wastes are generated at facilities north of the seaport, in the general area of Munhava, which drain toward the estuary. The seaport itself is a major potential source of pollution from shore facilities, cargo transfers, and ship wastes (toilets, garbage, bilge pumpings, chemical spills, etc). E.g. in 1997 dangerous cargos were landed 98 times, mostly industrial chemicals (CHAEM, 1998).

(d) *Relevance to coastal zone management*

Several of the designated coastal Sub-Zones (see *Paragraph 2.1*) are involved with the pollution problems mentioned above and which need attention by relevant city and provincial agencies. The ICZM-unit should co-ordinate with and assist such agencies to reduce environmental pollution affecting coastal waters.

Of most concern to the ICZM-unit will be control of the drainage system servicing thousands of hectares which discharges via the *Desaquadouro* at Palmeiras. With the sluices back in operation, the potential for control of water levels in this extensive area is in the hands of the sluice operator.

2.9.3 Institutional analysis (SWOT)

Coastal management activities are currently the concern of various Government agencies, each with their specific mandates, interests and focus of activities. The main official responsibility for the protection and management of the Beira coastal zone rests with the Municipal Council of Beira (CMB), which has created a specialist organisation (the Division of Coastal Protection) for beachfront management, including mangrove forests (*Figure 2.24*). This Division has limited (advisory) authority concerning coastal development. More power for approval of works to be executed at the coast lies with the provincial organisation Maritima, which answers directly to the Governor of the Province of Sofala.

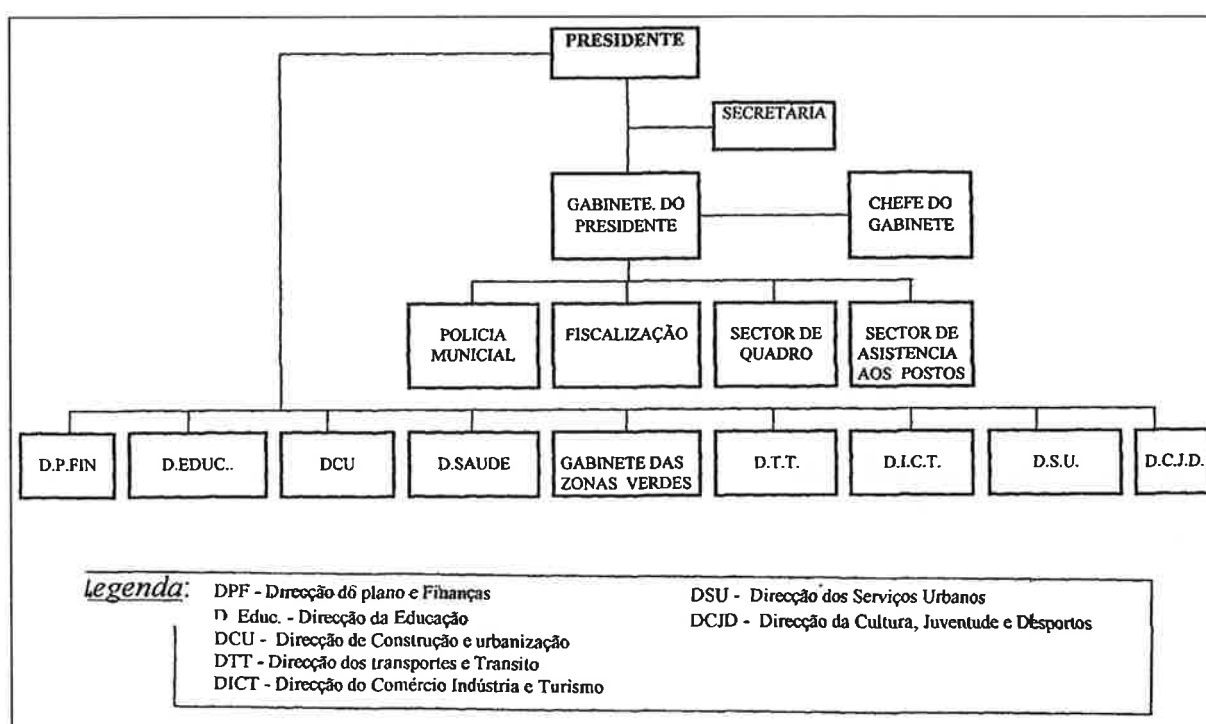


Figure 2.24 – Organization of the Conselho Municipal da Beira

In addition, the Beira harbour authorities answer to Government at national level, where all decisions are made including safeguarding the harbour's accessibility. Other agencies involved with coastal zone management are those responsible for regulating water supply in the Pungue River, those concerned with land-use practices in coastal areas, research institutes, and the agriculture communities confronted with the adverse effects of erosion, salinisation and floods.

To better understand the responsibilities of and relations between agencies and how these affect coastal management, a SWOT (strengths and weaknesses) survey was conducted of provincial and city agencies. A preliminary letter of inquiry was sent to each agency identified for the survey which included a multipart questionnaire (11 parts) which was to be the basis of a follow-up interview. Appointments were made and interviews were conducted with the agency representatives at their offices.

The most useful results were an identification of agency's problems, which are given below according to the percentage identifying problem categories:

Problem	Percent of agencies
Inadequate budget	82
Inadequate transport	82
Lack of equipment and materials	73
Inadequate staff	45
Lack of communication facilities	45
Lack of equipment maintenance	27
Inadequate computer facilities	27
Failure of interagency communication	18

In addition, the eleven agencies interviewed reported they were in regular communication and interaction with about eight other agencies (the statistical average was 7.7 agencies). Only two agencies reported insufficient inter-agency communication. This suggested that on the whole communication between agencies is not working too badly, as one would expect with a small bureaucracy in close physical proximity. But there is a sense that this communication is not really solving the problems of integration of programmes of the various agencies and is not breaking down agency competition, a problem that can only be solved by action of the highest authorities.

From review of the other institutional problems mentioned above, it appears that the city is operating its system with too little support to the agencies. The inadequacies identified are not unique to bureaucracies but in the Beira/Sofala situation it appears that insufficient support being given to most agencies is truly weakening the effectiveness of government institutions. This is particularly evident in the area of transport (82% reported inadequacy) because agency staff cannot get to the places they must go to do their jobs. For example, the staff of the agency that controls building must depend upon the developer for transport to the sites for inspection.

One of the agencies most weakened by inadequate support is the Office of Coastal Protection (OCP). This office has very little support from the city and no annual budget allocation to work with. It is dependent on such foreign aid funds as it can get for most expenses.

As an integrated coastal zone management programme is a goal of the city, the OCP must be strengthened in authority, manpower and equipment so that it can really protect coastal resources. This suggests both empowerment of OCP and a realignment of agency responsibilities whereby OCP acquires more autonomy.

The difficulties of achieving the above are augmented by the general weakness of the CMB and of municipal governments in general in Mozambique. In a 1996 study of the city's governmental status (CMB, 1996), the following were reported: (1) poor organisation, lack of funds, non co-ordinated growth, poor service and weak capacity for intervention, all leading to dissatisfaction and low morale of citizens; (2) lack of autonomy and finance denying autonomy and making the city dependent on provincial and central governments.

3 CONSTRUCTION OF EMERGENCY WORKS

3.1 Introduction

The Emergency Works component of the Project included direct input by a variety of experts from ARCADIS Euroconsult, supported by the Dutch firms ARCADIS Bouw/Infra and Alkyon, the Portuguese firm Profabril (with offices in Maputo), the Beira based firm Context Lda, and the International Union for Conservation of Nature (IUCN). The counterpart agency was the Office of Coastal Protection of the Municipal Council of Beira (CMB).

Based upon initial surveys, led by ARCADIS Infra-Bouw, a number of priority emergency works were identified by the Project in co-ordination with the Coastal Protection Unit of CMB.

The works were classified as those which were within the capacity of the Maintenance Brigade of CMB to execute and those which were beyond capacity of the Brigade and which would require the services of more specialised contracting organisations.

The design of the emergency works and their prioritisation was done by ARCADIS Infra-Bouw. The designs were based upon international standards for sea defence systems. One important innovation was the use of lateral gabion units (along the downdrift side of the groynes) to prevent damaging scouring of the sand underneath the groynes which would cause the groynes to subside, crack and collapse.

This chapter describes the works which were carried out both by the contractors (two firms) and CMB as part of the Emergency Works. Works commenced in 1998 and were completed in February 1999.

3.2 Background

As noted in *Chapter 1*, much of the city is built on primary dunefields, especially the eastern half, where there is a broad ridge. A major road runs along the entire coast, often close to the dune crest. Coastal erosion became a problem after the coastal road was hardened and fixed in place and many houses, restaurants, holiday cottages, and campgrounds were constructed along the roadway. All are threatened by erosion and several have already been destroyed by the sea. In an attempt to stabilise the beachfront, sea defences were installed starting in 1930s. The present system of groynes was constructed in the 1950s and 1960s.

In the years of unrest - up to the peace agreement of 1992 - these coastal protection works fell into disrepair, as little maintenance was carried out except for some emergency repairs, e.g., those of 1989-1990. As a result, beach erosion occurs at a rate of 1 m per year (in the 1982-1993 period). Major disruption of the beachfront occurs during sea storms, including cyclones.

The situation is further worsened by damage caused by recreational 4WD-vehicles driving over the dunes, sand excavation, and trampling by the public. Rising sea level (due to global climate change) is also believed to contribute to erosional force, as well as reduction of inland sand supply due to diversion of river flows. Coastal erosion at Beira is not new; it has been reported already 500 years ago. In his recent book ("A History of Mozambique"), Malyn Newitt explains the difficulties of living in the delta of the Punque River:

In the early sixteenth century it was estimated that there were 10,000 people living around the Bay of Sofala and that there were at least two villages apart from the main town. But the sands shift and are impermanent. As fast as the rivers deposit their silt, the sea gnaws at the dunes and during the high equinoctial tides invades the land in all directions. The villages and larger towns have frequently to be rebuilt, and their locations change.

In addition to the erosion problem, large parts of Beira are located in lowlands that are highly susceptible to flooding in the rainy season. In the past this was ameliorated by means of a constructed drainage canal system that drained excess water to the sea. The water exited through a water level control structure (the "Desaquadouro"). However, the lift gates controlling inflow (during high tides) and outflow (during heavy rains) became non-functional (around 1993) and as a result, the incidence of flooding seriously increased. Also, there was saline water intrusion, which affected both crops and drinking water supplies. Both flooding and saline intrusion have added to health problems related to poor sanitation and water-borne diseases.

Even so, these problems are minor compared to what may occur if the protective coastal dunes are breached because of erosion, as urban flooding could then take on calamitous proportions during major storm events.

In order to alleviate these problems, the Municipal Council of Beira sought support from various donor agencies and partners, including NIZA (Netherlands Institute for South Africa) and the cities of Amsterdam and Gothenburg (which have "twin city" agreements with the city of Beira). Investigatory missions were carried out in 1994-96 and a number of emergency measures were proposed, but this did not result in re-constructions.

In 1997 the Royal Netherlands Embassy in Maputo agreed to finance a programme of emergency works to stabilise the beachfront in co-ordination with Beira city, as a partnership arrangement whereby the main works would be completed by specialised contractors and other works would be done by CMB.

Prioritisation of the particular works that could be accomplished under the budget was a most difficult matter. Also, constructing civil works under difficult conditions (strong current, waves) was most challenging. A map of beach areas and groyne locations and their numbers for the 7 km of Beira's beachfront between Macuti and Ponta Gêa is provided in *Figure 2.3*.

3.3 Tendering and selection of works

The works identified were the rehabilitation of the existing lift gates of the *Desaquadouro* at Palmeiras, re-construction of groyne no.34, extensive repairs to existing groynes no.33, 35 and 36, and repairs to other groynes along with extensive repairs to the headland at Ponta Gêa (*Figures 3.1 and 3.2*).

The works were split into two separate packages (i.e. A and B) for tendering purposes due to the different nature of the tasks involved in the execution of each package. Tender procedures were initiated and beginning on 18 May 1998. A number of locally and regionally based contractors were requested to submit expressions of interest (EoI) in tendering for the Project works by 25 May 1998. The EoI was to include details of the contractor's qualifications for undertaking the works. EoI's were received from the following eight contractors: OPCA, CETA, TAMEGA ECO, FABIÃO, COTAM, HUGHS and RUMDEL.



Figure 3.1 – Consultant engineer, contractor, and Coastal Protection Unit Director examine damaged groyne scheduled for repair



Figure 3.2 – Repair work to Groyne 33 being examined by Project Engineer

The qualifications of the contractors were assessed and this assessment formed the basis for the selection of contractors who be invited to tender for either package.

Package A - The *Desaquadouro* Outlet at Palmeiras

The work consisted of the rehabilitation of the existing sluice gates in Palmeiras in accordance with the original design.

Following receipt of tenders the lowest tender was submitted by Hughs Engineering in the amount of USD 99,715. In subsequent negotiations the final contract amount was agreed at USD 92,368 which was within the budgetary allowance.

Package B - Marine Works and Groynes

The rehabilitation of the Macuti beach groyne system was identified as being a particularly high priority. Groyne no.34 required complete re-construction while a number of other groynes were in need of urgent repair in order to avoid further deterioration. Also included were a list of optional items in connection with the repair of Ponta Gea headland.

Following receipt of tenders the lowest tender was submitted by Rumdel in the amount of USD 566,630. At the time it was necessary to revise the scope of work and remove the optional items for Ponta Gea due to budget constraints with the final agreed contract amount being USD 250,972.

Subsequently, the overall budget was increased by an additional USD 240,000 by the Embassy which enabled the repair of the Ponta Gea headland

3.4 Contracted works

The two selected contractors successfully completed the works in February 1999: (Package A) Hughs Engineering from Mutare, Zimbabwe for the rehabilitation of the *Desaquadouro* at Palmeiras and (Package B) Rumdel Construction from Richards Bay, South Africa for the re-construction of groyne no.34 as well as repairs to groynes no.33, 35 and 36 and miscellaneous groyne repairs and stabilisation of the Ponta Gea headland.

3.4.1 *Desaquadouro*

The works at the Palmeiras *Desaquadouro* (Package A) consisted of the rehabilitation, re-construction and installation of all elements and services required in order to make the lift gates operational and return the *Desaquadouro* to a state of full function. A general plan section of the *Desaquadouro* outlet system is provided in *Figure 3.3*.

The work consisted in a number of different sections and phases which are described below.

(a) *Beachfront canal openings*

The *Desaquadouro* outlet is protected on the seaside by a number of wave barriers which protect the lift gates of the control structure from the direct impact of wave action and pounding by heavy floating objects. There are six openings in all. The outer two openings on either side are fitted with timber and concrete stop logs which are fixed in concrete guide slots lined with steel channel.

The work to be carried out consisted in the removal of the existing stoplogs, steel profiles, cleaning the guide slots and the re-installation of new wave barriers (*Figures 3.4 and 3.5*). Fully closed timber and

concrete panels were fitted on the two outermost openings, while half closed panels were fitted to the inward openings. The centre openings were left open.

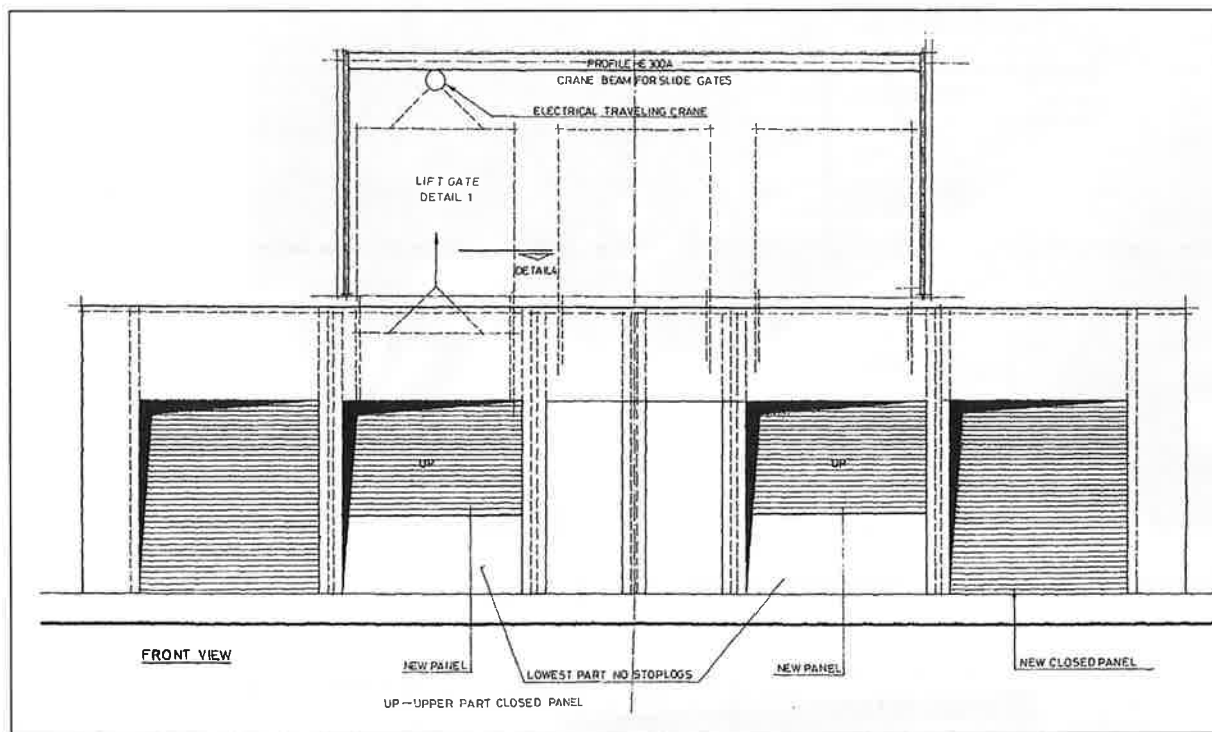


Figure 3.3 – General plan section of the desaquadouro lift gate system

(b) Vertical lift gates

The flow of water at the *Desaquadouro* outlet is controlled by vertical lift gates. The lift gates are raised or lowered into their respective openings as required by the particular tidal or flood conditions. There are three openings for the lift gates; however, only two gates were left and actually in position before works commenced.

The work carried out consisted in the removal of the existing gates and lifting structure in addition to a general cleaning of the service building, cleaning and generally repairing the existing guide slots for the gates, installation of three new timber panelled, metal framed lift gates, installation of the crane support structure, installation of one 10-tonne electric travelling crane, installation of one 10-tonne hand driven mechanical crane and a new electrical installation for light and power.

Much of the work was carried out off-site. The metalwork for the crane support structure and the framing to the lift gates was fabricated and sent for galvanising to Harare (Zimbabwe) before assembly on-site. In addition, all galvanised metalwork was painted with a special marine paint system. Most of the work was completed by end-December 1998, with the exception of the supply and installation of the electrical crane. This necessitated the temporary installation of an additional mechanical crane by the contractor. The electrical crane was finally installed in early-February 1999.



Figure 3.4 – Wave barrier wells at the Palmeiras desaquadouro



Figure 3.5 – Hughs construction crew removing old stoplogs from the Palmeiras desaquadouro

(c) Gratings

Protection of the lift gates from clogging and impact by heavy floating objects is also required on the landside openings of the *Desaquadouro*. This is provided by five new large metal gratings, none of which existed at the time the works commenced. As with the other metalwork items, the gratings were prefabricated, galvanised and painted off-site before installation.

Large metal hand rakes were also provided to facilitate the cleaning of the gratings which require constant attention, particularly when there are heavy rains and large volumes of water and debris are running toward the outlet.

(d) *Timber*

Timber was supplied locally for the stoplogs and the lift gates. There were a number of difficulties in establishing a species suitable for the purpose due to the qualities required and the short timeframe of the Project. "Messinda" wood was eventually settled upon due to its density ($>1,200 \text{ kg/m}^3$). There were however difficulties in procuring correct size and quantities which led to some delays in completion of the works. Even then it was not possible to fully dry the timber used due to the constraints imposed by the Project timeframe.

(e) *Operation*

Day-to-day operation of the *Desaquadouro* outlet became an issue immediately upon installation of the lift gates. The importance of the correct operation of the outlet was highlighted by heavy rain experienced throughout December and January which necessitated close attention in order to reduce possible flooding in the low-lying areas served by the outlet. Operatives from CMB were involved in the operation of the outlet under the supervision of the Project's Engineer. There is a need for continuing supervision of the lift gate operation by CMB to ensure proper functioning.

(f) *Programme summary*

Works commenced on 29 August 1998, following signing of the contract on 15 August 1998 with completion expected by 27 October 1998. Delays were experienced due to problems in the procurement of timber, difficulties in importing the fabricated metalwork and the electrical crane and in meeting the requirements of the paint specifications. The work was completed on 23 December 1998 with the exception of the electrical crane installation which was completed in February 1999, permitting handing-over of the outlet to the CMB on 19 February 1999, following a period of testing and commissioning of the installation.

3.4.2 New groyne

A new groyne was constructed by Rumdel (Package B) at the site of old groyne no.34 which had been undermined and collapsed, thereby threatening the failure of the entire groyne system in the Macuti beach area.

(a) *General description*

At the time of the pre-construction survey, it was decided that an existing concrete base which had been previously cast in place by the *Conselho Municipal* was to provide a suitable base for the groyne thus providing a small saving in the cost of the foundation. All other elements were to be executed as originally specified.

The new groyne structure consists of a foundation base on top of which was cast a trapezoidal-shaped mass concrete groyne with a total length of 75 m. The new groyne is 2 m high, 1.5 m wide at the base and 0.6 m wide at the top. At the head of the groyne an underscour protection element was placed consisting of three rock filled gabion mattresses 6 m x 2 m x 0.3 m thick. In addition the groyne length was extended inland by a further 15 m in order to connect with the currently eroding dune on the landside by means of a retaining wall constructed from a double row of driven timber poles tied with galvanised steel wire and infilled with cement stabilised sand bags to the same height as the concrete groyne.

The timber pole and cement stabilised sand bag retaining wall extension was the first element constructed in order to protect the new concrete work from possible erosion and undermining at the dune end. Once the existing base was prepared concreting commenced on the trapezoidal groyne structure.

(b) Problems experienced

Work on the new groyne was progressing well with about 30% of the concrete work complete in early-October 1998. On 3 and 4 October a combination of spring high tides and strong seas resulted in the loss of 4 m of dune width with serious erosion of the beach on the downstream side and undermining of the completed groyne works. These conditions repeated later on in October, during November and in early-December with a total of over 7 m of dune width being eroded, though beach conditions did improve between the crises. The onset of these crises slowed the works considerably, particularly during October when most of the contractor's inputs were made to execute remedial works in order to protect the work already completed.

The unusually high tides were associated with spot thermal heating of the waters of the Madagascar Straights which likely raised sea level anomalously due to thermal expansion of regional waters (data from USA/NOAA satellites).

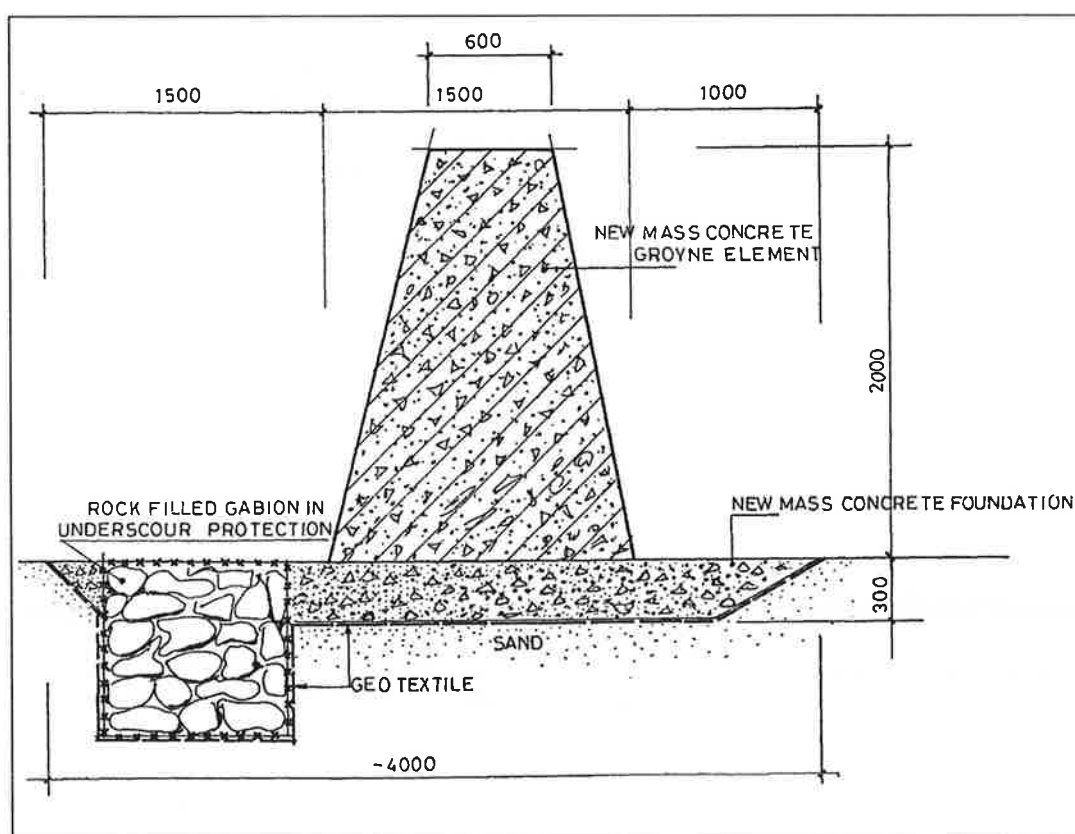


Figure 3.6 – A section of the completed Groyne 34 showing the installation of the gabions for underscour protection.

(c) *Measures taken*

Much of Rumdel's efforts went to securing the stability of the work already executed. To this end, geotextile backed gabion cages were placed below the shoulder of the foundation on the downdrift side. With further underscoring and undermining experienced in October and November it also became necessary to concrete in the gabion cages to insure the effectiveness of the underscour protection.

The result of these counter measures was to secure the stability of the groyne in conditions where serious erosion and undermining would otherwise have occurred as indicated by the additional erosion of the dune on the downstream side over the period. The success of these measures allowed the groyne to function on the upstream side with an immediate build up of sand, once conditions improved.

A section of the completed groyne no.34 showing the installation of the underscour protection is given in *Figure 3.6*.

3.4.3 Repair of existing groynes

(a) *Groynes no. 33, 35 and 36*

These groynes required extensive rehabilitation in order to maintain their structural integrity. Rehabilitation by Rumdel consisted mainly of cleaning out, breaking back to a good foundation and reconcreting sections on the groynes which had become stressed or had failed completely.



Figure 3.7 – Placing the mass concrete shoulder on the downdrift side of Groyne 33 (photo by Luis Renne)

Groyne no.33 was being undermined at the HWL due to the absence of a foundation slab for a length of 20 m which was rectified by excavating and placing a 1 x 0.75 m mass concrete shoulder on the downdrift side and backfilling as well as filling in gaps and sealing cracks (*Figures 3.7 and 3.8*).



Figure 3.8 – Groyne repair involved considerable hand labor – the Project Engineer inspects work of the Rumdel construction crew

Groyne no.35 required rehabilitation and repair similar to that done for groyne no.33. The height of groyne no.36 was raised by 0.5 m at the landward end for a distance of 7 m to become fully effective.

The length of groyne no. 35 and 36 was extended inland by 15 m, as with groyne no.34, in order to connect with the eroding dune on the landside by means of a retaining wall constructed from a double row of driven timber poles tied with galvanised steel wire and infilled with cement stabilised sand bags to the same height as the concrete groyne.

During construction some problems were experienced with current undermining along certain sections of groyne no.33. An experimental 4 m long rock-filled gabion was installed in order to control the undermining action. This measure proved to be successful and as a result a total of 30 m of geotextile backed gabion cage was placed in underscour protection for groyne no.33. A section of the completed groyne no.33 showing the installation of the underscour protection is provided in *Figure 3.10*.

As an additional measure, a gap in groyne no.32 was filled with mass concrete which greatly added to its effectiveness in promoting the inter-groyne build-up of sand.

(b) Groynes 11a, 12, 13, 14, 17 and 18b

While these works were listed in the original programme, funds shortage (due mainly to the necessity to carry out remedial work on groyne no.34) required that they be deferred and transferred to the works programme of the CMB Maintenance Brigade.

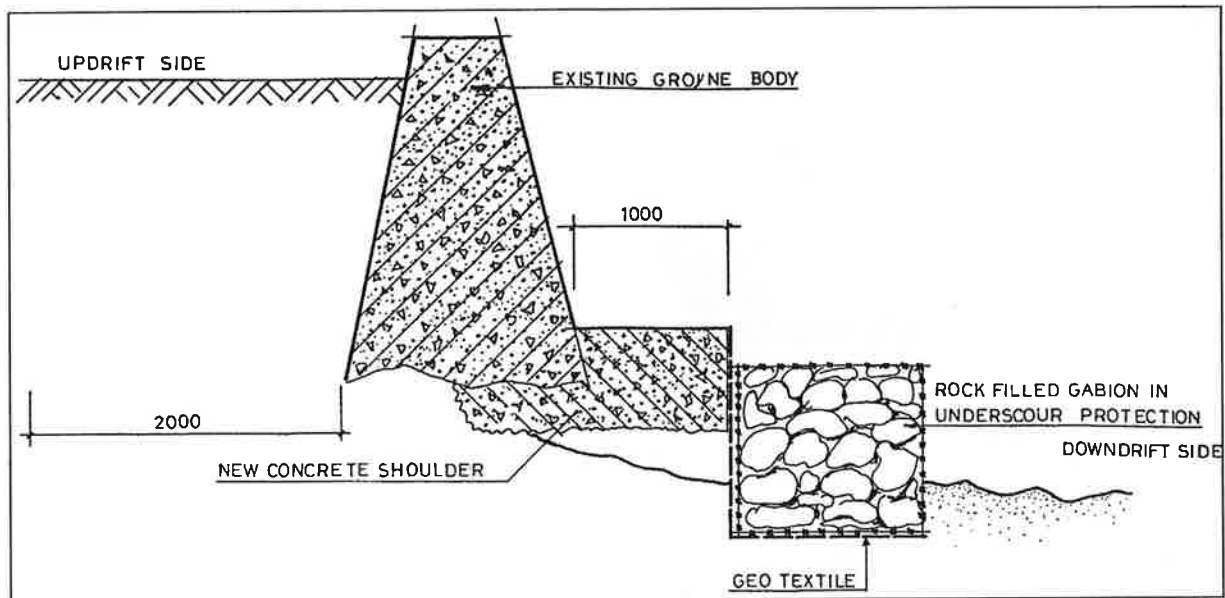


Figure 3.9 – Section of the completed Groyne 33 showing the installation of the underscour protection using gabions

3.4.4 Ponta Gêa

Further works originally designated as "optional" and not included in the original contract programme were approved for execution on 21 September 1998, following supplementary funding. These works generally consisted in the construction of two rubble groynes, a retaining wall in geotextile backed gabion cages, slope and toe protection to the eroded headland at Ponta Gêa as well as other miscellaneous repairs to walls and groynes.

A general plan of Ponta Gêa headland and the works executed is provided in *Figure 3.11*.

A great deal of the work consisted of the supply and placement of approximately 900 m³ of stone and rubble in groynes and gap filling to existing protection.

An alteration to the original design was the construction of a gabion cage retaining structure in front of the threatened houses instead of the originally proposed pole and bag construction which proved not to be feasible due to the heavy erosion which had been experienced.

Toe protection in the form of a single row of gabion cages has also been placed in position running from the retaining structure to the so called short rubble groyne.

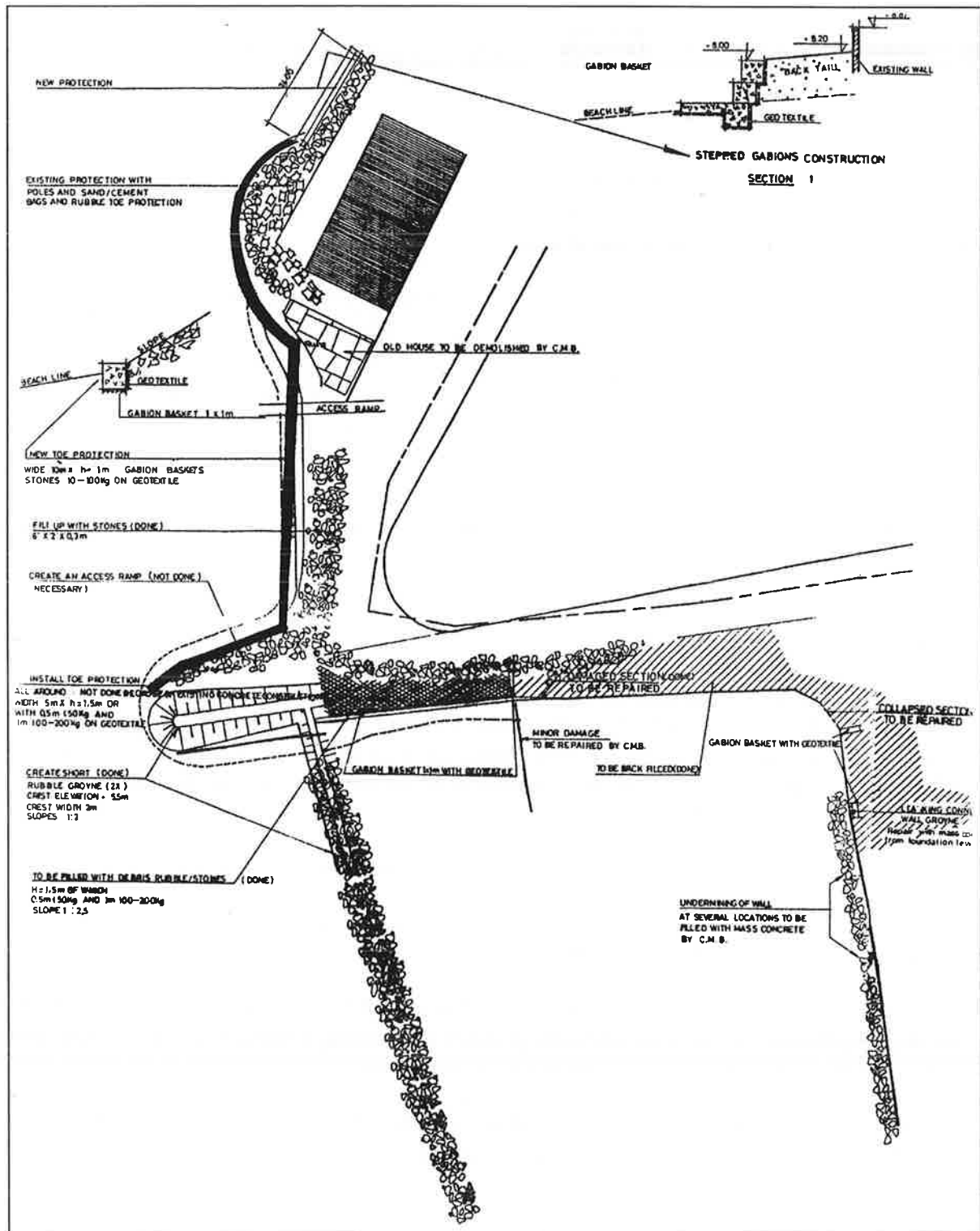


Figure 3.10 – General plan of Ponta Gêa headland and the works executed by Rumdel

3.4.5 Palmeiras

A small surplus remained in the budget for Package B which allowed the installation of a small retaining structure of similar construction to that installed in Ponta Gêa, in order to protect the main road along the seaside next to the *Desaquadouro* at Palmeiras. However, this work is considered as temporary and not sufficient to protect the road in the long term, requiring that CMB install further protection.

3.4.6 Programme summary

The construction of new groyne no.34 and the repair of groynes no.33, 35 and 36 were delayed due to the effect of high tides and stormy weather conditions in early-October 1998. The need to carry out counter measures to protect groyne no.34 was particularly significant as the contractor's resources were concentrated on carrying out this additional work which caused a one-month delay to the overall programme.

Groynes no.34, 35 and 36 were handed-over to CMB on 15 December 1998. Groyne no.33 and the additional works on groyne no.32 were not actually completed until end-January 1999; delay was mainly due to difficulties in procuring and importing the plastic coated gabion cages required for the underscour protection for groyne no.33 and the authorisation of the toe protection and gabion retaining wall works in Ponta Gea.

The contractor was issued with an instruction for the execution of optional items in Ponta Gea on 21 September 1998. Because of the difficulties being experienced on groyne no.34, the time taken for importing sufficient quantities of stone, the need to clarify a number of technical matters regarding the execution of the rubble groynes, and the protection to the houses and problems with the importation of the plastic coated gabion cages, work did not begin until December 1998. However, despite the Christmas and New Year break sufficient progress was made during December and January which allowed completion and handing-over to CMB on 5 February 1999.

3.5 Works by Conselho Municipal de Beira

In addition to the works which were identified as requiring the attention of specialist contractors, there were important items identified by the Consultant as suitable for execution by the Maintenance Brigade of CMB.

Labour and equipment were provided by CMB while funds from the Emergency Works Project were provided to assist with materials, fuel, and supplies as well as technical assistance provided by the locally-based Site Engineer.

3.5.1 Miramar

Repair works were required to the seawall at Miramar consisting in the construction of a protected slope with sand and cement stabilised bags at a diagonal between the seawall and groyne no.13. The resulting triangular area was infilled with sand up to the level of the retaining wall and the seawall (*Figure 3.11*).



Figure 3.11 – Works underway by the Conselho Municipal to protect seawall at Miramar under supervision by project Engineers

As part of the Miramar operation, repairs were also carried out to the body of groyne no.13 including concreting and gap filling. The concrete block wall between the dune and the road was rebuilt for a length of 10 m and the stormwater drains in the seawall which had previously been concreted in, were reopened. The sidewalk was also repaired for a length of 50 m.

The work was slow to get going and suffered a number of setbacks during execution including bad weather and unavailability of equipment at crucial stages, largely because the Maintenance Brigade was engaged in road repairs. Progress was also hampered by the Municipal Elections in end-June. Nevertheless, progress was made despite the difficulties of the management of the Maintenance Brigade and works were completed by end-September 1998.

3.5.2 Other works

Work commenced on repairs to groyne no.4 and the adjoining seawall in Ponta Gêa in July mainly on demolitions (*Figure 3.12*). A number of gaps were filled and quantities of stone were moved and placed on the downstream side. Due to lack of heavy jack hammers and other demolition equipment it was decided to transfer CMB operations to the seawall repairs at Miramar.

Following completion of works by contractor Hughs at the *Desaquadouro*, CMB carried out miscellaneous repairs to the gatehouse building including filling of cracks to the walls and pavements as well as preparation for painting. It is anticipated that the gatehouse building will be painted in due course by CMB with paint supplied by the Project.



Figure 3.12 – Demolition work at Groyne 4 and adjoining seawall in Ponta Gêa by the Conselho Municipal's Road Brigade

3.6 Commentary

It is still too early to comment on the effectiveness of the works carried out; an accurate assessment will probably require six to twelve months after turnover (i.e. August 1999 to January 2000).

3.6.1 Evaluation of contracted works

Wide acceptance was achieved on set priorities and expenditure on the works executed. The contracted works have generally been successful to date in achieving the goals that were set in consideration of budget constraints.

(a) *Desaquadouro at Palmeiras*

It is too early to conclude what will be the long-term impact of the rehabilitation of the *Desaquadouro* at Palmeiras because much depends on management and operation. However, the rehabilitation work carried out by the Project will enable CMB to pursue its selected strategy as long as it remains committed to continuing maintenance of outlet lift gates and equipment. To assist CMB in the maintenance programme, the Project provided tools, special clothing, painting supplies, and lubricants.

(b) *New groyne and groyne repairs*

There are encouraging signs such as the build-up of sand along the repaired groynes while there are also worrying signs of continuing undermining of the existing unprotected groynes.

Provision of underscour protection through the use of geotextile-backed gabion cages at the shoulder on the downdrift side has proved its effectiveness and merits consideration for inclusion in future construction or rehabilitation programmes.

(c) *Ponta Gea Headland*

The Project's contribution towards stabilising the situation at Ponta Gea headland was welcomed by residents in the immediate vicinity and the city in general. All parties involved in the Project have expressed particular satisfaction with the work executed by the Project in Ponta Gea. However, once again the importance of participation by the CMB to motivate residents and prevent theft of the plastic coated wire used to construct the installed gabion cages is essential.

3.6.2 Evaluation of *Conselho* works

The work by the *Conselho* at Miramar and groyne no.4 has made a valuable contribution to the programme. It highlights the potential of existing capacity and the need for it to be properly managed so that it can continue to make an effective contribution to coastal protection.

3.6.3 Lessons learned

A longer timeframe is necessary in order to assess the impact of works executed.

CMB can play an important role in coastal protection but attention needs to be given to appropriate management procedures which will facilitate a timely and effective response to existing and potential problems in the coastal protection system. This requires important institutional changes to assure continuing, non-episodic maintenance of sea defences.

There is a continuing role for private contractors to play in providing support to the Coastal Protection Unit in executing both large and small items of work where CMB itself does not possess the appropriate capacity.

On future projects consideration needs to be given to the use of geotextile-backed gabions for the reduction of underscour of groynes. The extensive use of geotextile-backed gabion cages in the Project points the way for future rehabilitation and coastal protection work. Given an adequate supply of cages and imported stone, the technology can be applied quickly and, perhaps more importantly, it is well within the capacity of locally available skills to execute, either CMB or local contractors.

There is a risk that the wire from the gabion cages will be subject to theft and this situation needs to be closely controlled by the CMB, not only through policing but also through public information and education.

Future work should be scheduled during non-stormy weather periods.

4 INTEGRATED COASTAL ZONE MANAGEMENT STRATEGY PLAN

During implementation of the Project it became clear that because of the complexity of local site conditions, the existing institutional setting, and the limited manpower and time available, it would not be possible to complete the full process of ICZM planning for Beira's coastal zone. What was possible to complete was the compilation, with full participation of stakeholders, of a so-called ICZM Strategy Plan. The current chapter presents this Strategy Plan.

In the opinion of the Consultant, next steps towards actual implementation of a still to be prepared ICZM Action (or Master) Plan for Beira's coastal zone include preparation of policy documents, preparation of regulations and obtaining government approval for these, further institutional strengthening, and design of a detailed ICZM Action (or Master) Plan. It is estimated that these additional post-Project activities require a period of 2 years and technical assistance input.

4.1 Background

4.1.1 Introduction

Beira city has a serious problem with erosion of its coastline. Unless strong and continuous counter measures are taken, roads, houses and commercial buildings will be attacked and damaged by the sea. Although much of the focus has been given in the past, and in the current Project, on coastal defence, integrated programmes for coastal management are required. In this context, aspects such as human settlement, infrastructure, drainage and flooding, sanitation (sewage, solid waste disposal), port management, coastal fisheries and tourism, and the impacts of various development options should be addressed as well.

The Consultant has assisted Beira in the preparation of a strategy for management of its coastal zone through the collection, analysis and interpretation of relevant data, facilitation of discussions in working groups of government officers and stakeholders, preparation of discussion drafts of planning frameworks, and preparation of the current Integrated Coastal Zone Management (ICZM) Strategy Plan. It is essential that further detailing and refining of this strategy into a final plan is to be done after review by the Beira government. It is the role of the Consultant to facilitate the ICZM plan formulation process, but ownership of the final product (the plan) is to reside with the Beira city government, as without this sense of ownership, full implementation is unlikely to occur.

The type of ICZM recommended for Beira is termed a "Situation Management" programme (as opposed to a national programme) because it is so strongly targeted on a particular situation (Clark, 1998), in this case geographic specific.

4.1.2 The planning process

Strategy planning is an essential step in the process of developing an ICZM programme because here the strategy for management is worked out. As the initial planning step, strategy planning considers problems and opportunities regarding resources, coastal protection, economic development activities, environmental health, and social needs in the coastal area and devises a strategy to accomplish the ICZM objectives. It also sets priorities for action. The Strategy Plan is the next to last step in the ICZM planning process, the last step is preparation of an ICZM Action Plan.

Strategy planning explores options and develops an *optimum strategy* for an ICZM management programme. It examines the facts, suggests possible solutions, and proposes legal and institutional arrangements. The Strategy Plan lays the foundation for the future legislation or executive order needed to authorise the ICZM programme.

This Strategy Plan: (1) addresses the issues; (2) assigns responsibility for the programme to a particular agency; (3) recommends the funding necessary for programme development; (4) states the purposes and objectives of the ICZM programme; (5) recommends a method for co-ordination and collaboration among the various governmental agencies and private interests involved; and (6) outlines the elements of the Action Plan.

The Strategy Plan is to facilitate decision making on: (1) the merits of a comprehensive integrated coastal programme, and (2) on the need for a long-term ICZM Action Plan. The latter explores every aspect of needs and opportunities for management of the coast, i.e. beach and dune protection, control on coastal building, environmental conservation, and facilitation of sound economic development (tourism, recreation, etc.). It helps to formulate policies, determine management authorities and responsibilities, a management structure, interagency co-ordination, budgets, and community participation and awareness approaches (see *Annex 8* for a outline for the ICZM Action Plan).

4.1.3 Methodology

The Project applied the standard ICZM planning approach, involving preliminary investigations, data collection, issue analysis, dialogue, negotiation, and draft writing; necessary to enable government to define problems, understand options and proceed to authorise, organise, and administer a specific ICZM strategy and, later on, to formulate an Action Plan.

An essential role in the process was set aside for the "technical working groups" consisting of members of an informal advisory body established by the city, the coastal management "Forum". Ten workshops were held, each of which addressed a particular subject (see *Annex 5*) in a general progression toward the Strategy Plan. Decisions were made by consensus. Participants were mostly from government offices (city and province) but some non-governmental stakeholders also participated. Average attendance at the workshops was 14 persons.

The Forum advised on various approaches to ICZM and guided the ICZM planning. Two Forum meetings were held, one before the ten workshops commenced and one after the last one was held (*Annex 5*). The first Forum meeting focussed on the scope of the programme, the second meeting was meant to gain overall consensus on the results of the ten workshops and to evaluate the draft ICZM Strategy Plan.

4.1.4 Definition of Coastal Zone

It is important to clearly define the boundaries of the Coastal Zone in order to focus the ICZM planning effort and to fit the overall "Structure Plan" of the city. In the urban context, much of the land area is already committed to settlement, industry, commerce and infrastructure. Also urban management practices are already in place (environmental programmes have greater scope in rural settings). These factors greatly limit the scope of the proposed ICZM programme and affect its boundaries.

The Coastal Zone has both inland and oceanward boundaries. There is no single standard for placement of these boundaries in ICZM programmes. Location depends on the issues the ICZM programme is supposed to address. All such programmes must include the shoreline and parts of the sea and the land, but basically, the beach is the core of the Coastal Zone. The aim is to include all priority issues within an identified Coastal Zone. In the urban context, the narrower the Coastal Zone is defined, the clearer is the scope of the ICZM programme. On the other hand, the broader it is, the more complicated the programme becomes.

The Coastal Zone of Beira is so varied in terms of land use and conservation values, that for management it was necessary to divide the Coastal Zone in Sub-Zones, segments that have similar properties. For example, coastal management issues for the seaport are different from those for rural Rio Maria or Savane. In applying zoning, it is important that zones, as much as possible:

- represent relatively homogeneous areas delineated by natural features of the coastal environment and the density and type of uses of the built-up environment;
- are in compliance with jurisdictional and administrative categories of the city and provincial government;
- reflect the priority Coastal Zone issues defined by government and stakeholders.

The Beira Coastal Zone and its Sub-Zones, as suggested by the technical working groups, is shown in *Table 4.1* and *Figures 4.1* and *4.2*. The Sub-Zones vary in the level of attention each Sub-Zone requires from an ICZM programme; e.g., from direct management by the ICZM agency's authority to broad collaborative efforts to involve other agencies. A further refinement of the zones is to be done in the ICZM Action Plan.

1. Urban Seacoast Subzone	
The Urban Primary Zone, or Core Zone, extending from Estoril to Praia Nova would include:	
1) <u>the area of the beachfront</u> (from MLW to the inner edge of the primary dune, often marked by the major coastal roadway) and including the dunes, beach, and any mangrove wetlands adjacent to the shoreline; and	
2) <u>the area of the immediate shorelands</u> extending from the primary dune to the first major roadway, if not included in (1).	
The above are inclusive of any built upon or developed lands, any internal waterways, any vacant lands, any disturbed lands, and any natural lands, whether in public or private ownership or use.	
2. Urban Lowlands Subzone	
<u>The interior lowlands</u> , composed of all riparian areas, and all wetlands, rivers, creeks and their banks and other drainages that surround the urban area and that flow to the sea.	
3. Eastern Rural Subzone	
<u>The coastal lands east of Estoril</u> within the municipal boundaries of Beira, extending along the coast to Rio Maria and Savanne, including the beachfront and shorelands.	
4. Northern Rural Subzone	
<u>The coastal lands north of the Seaport</u> that lie within the municipal boundaries of Beira, extending north along the Pungue River including the beachfront and shorelands, all riparian areas, and the lowlands that drain into the estuary.	
5. Seaport Subzone	
<u>The Port complex</u> including the area supporting seaport facilities extending from Beira Terrace to the oil terminal.	
6. Urban Center Subzone	
<u>The Beira City Center</u> including the main developed area of the City.	
7. Extended Subzone	
<u>The Zone of Influence</u> , areas outside the above zones, including areas that have a major influence on the coastal environment; e.g., agricultural and forestry lands, the Pungue riverway and water control and diversion sites, inland settlements, etc.	

Table 4.1 – Subzones for integrated Coastal Zone Management

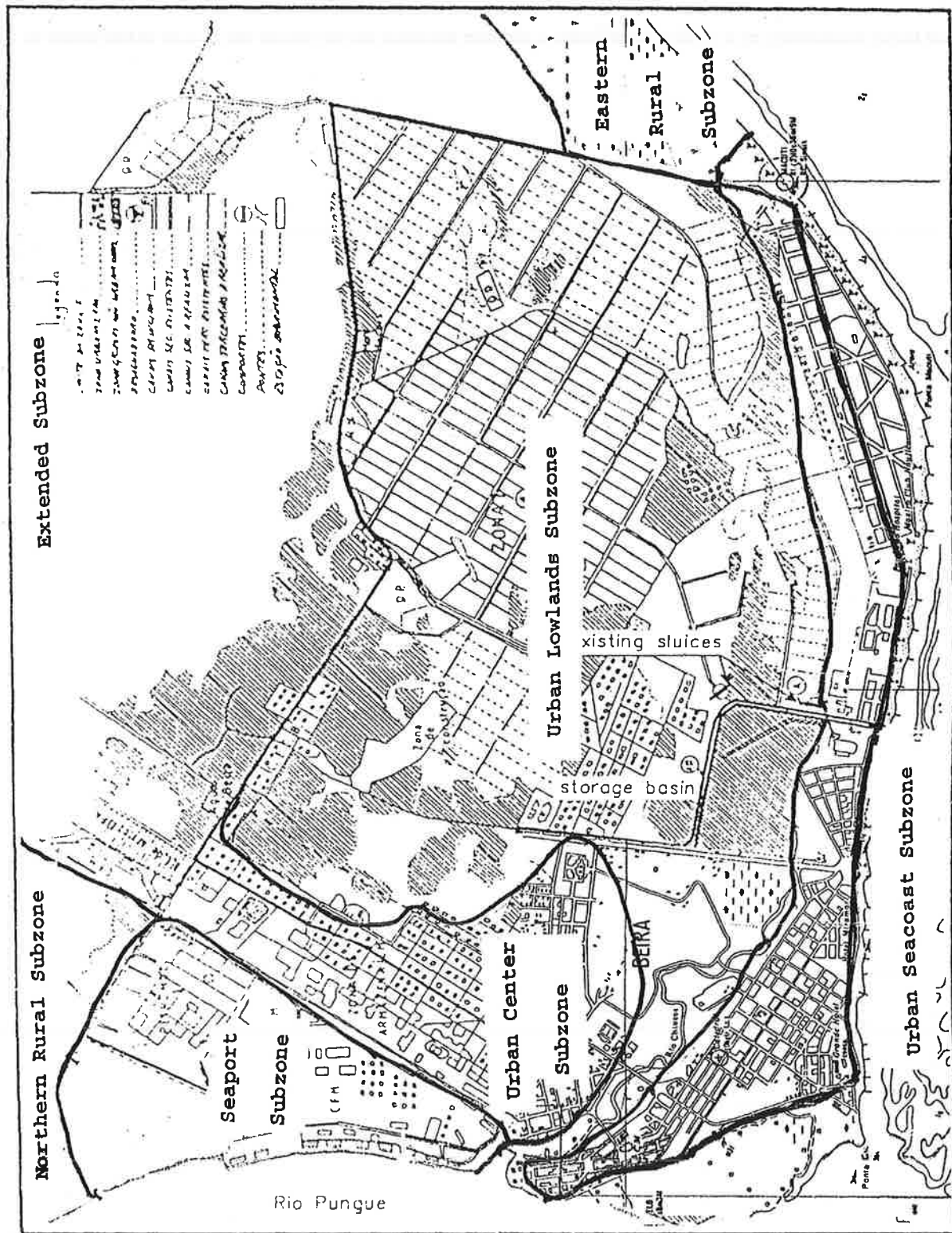


Figure 4.1 – Large scale of central area

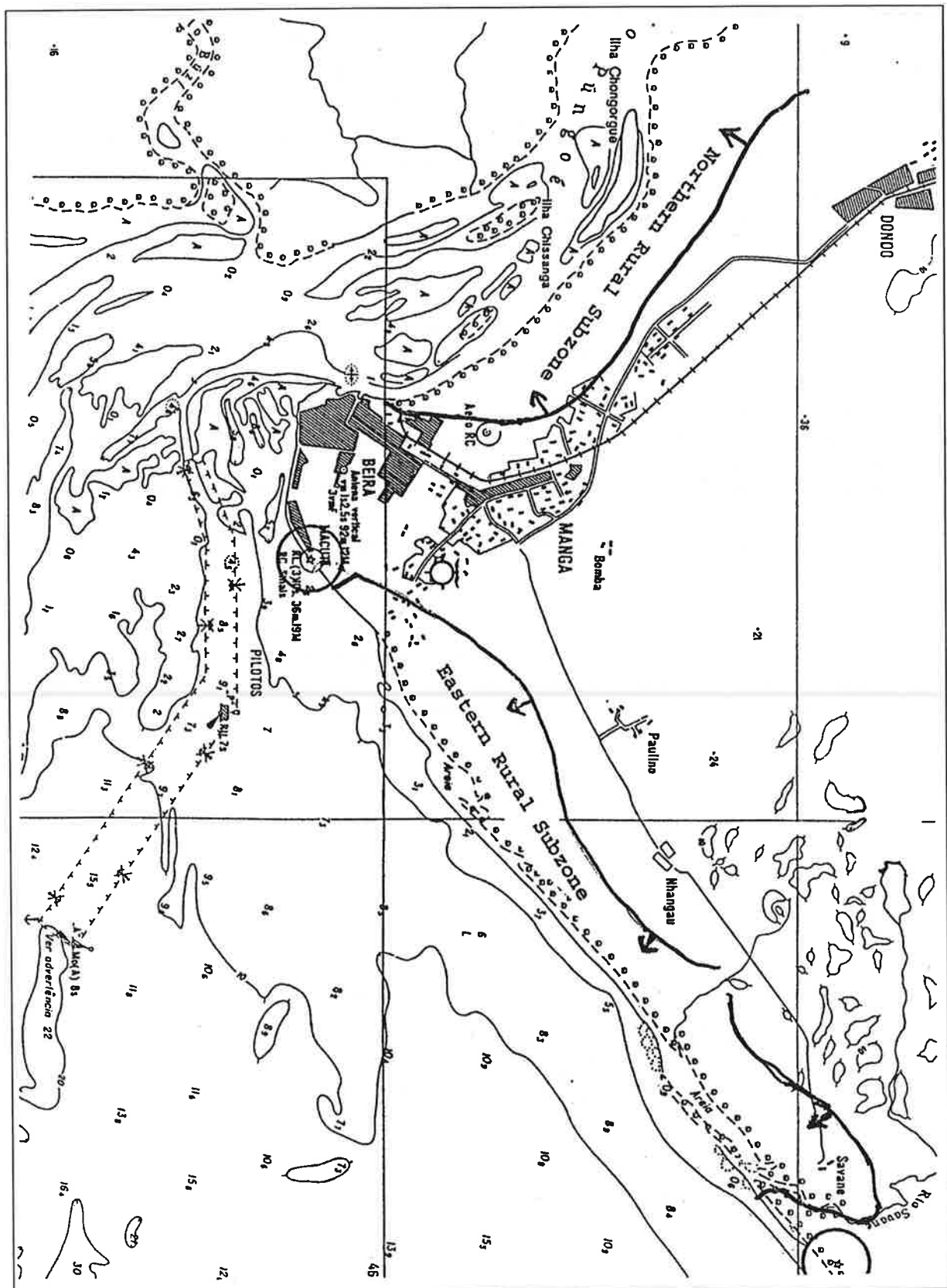


Figure 4.2 - Map of whole area

4.1.5 Coastal issues

ICZM is a problem solving process and requires clear insight in the problems it is to solve (Clark, 1998). The following concepts were used:

- (1) In a programme of Integrated Coastal Zone Management, the protection issues and conflicts must first be identified before management strategies can be formulated and specific counter-measures proposed.
- (2) This identification, known as "issues analysis", is the most critical aspect of the strategy formulation. Issues analysis is the anchor point for the ICZM programme, clarifying:
 - goals and objectives;
 - priority management needs;
 - identification of participants in the planning process;
 - identification of information needs;
 - the institutional arrangements needed;
 - uses to be permitted or prohibited.
- (3) Because ICZM is an issue-driven process, the nature of the particular issues will dictate the type of programme to be created.
- (4) Each issue should be evaluated for the extent of disturbance or loss that it addresses and the consequences of not resolving it.
- (5) Finally, priorities should be established to decide which issues should be addressed first in the ICZM programme.

The approach to issue identification was to first list the problems through discussions with stakeholders at special ICZM technical workshops (*Table 4.2*). After listing and evaluation, these problems were converted into issues. After further discussion, the issues were then listed by priority order, to help decide how and when the issues are to be resolved in the ICZM programme. Issues were listed by Sub-Zone (*Table 4.3*).

- Malfunction of the drainage system, particularly the Palmeiras sluice, but also the internal water control structures and the drainage at Dama/Munhava
- Erosion of the beachfront caused by diversion of sand from desaguadouro outflow
- Malfunction of the anti-erosion system of groynes and breakwalls
- Lack of control on human wastes in the drainage
- Flooding of the settlements in the lowlands,
- Destruction of the dunes by human activity including 4-wheelers
- Cutting of mangrove and other trees,
- Activities of artisanal fishermen on the beach ,
- Touristic/residential developments along the beachfront and lack of controls for same,
- Mining of beach sand,
- Degradation of the natural drainage system flowing to the harbor area, including impaction of the Chiveze River flowway,
- Water pollution from various sources
- General degradation of biodiversity and lack of conservation, most apparent for mangroves, tidal creeks, etc.
- Lack of public awareness of human caused coastal problems,
- Impacts of the Port, siltation, pollution, dredging
- Endangerment of the Beira water supply system by salination,
- Soil erosion from Pungue watershed and pollution from agrochemicals and other sources,
- Very poor enforcement of protection laws
- Insufficient funding and staffing of CMB agencies
- Need for continuing source of revenue for maintenance of coastal protection facilities
- Need for advancement of skills of agency staffs, and
- Need for effective liaison among various agencies.

Table 4.2 – Coastal Zone Problems Identified by Working Groups

<p>1. Urban Seacoast Subzone</p> <ul style="list-style-type: none"> - Prevent erosion - Control sand removal - Protect against cyclones - Control foot traffic on dunes - Stop vehicle traffic in dunes - Restore and stabilize the dunes - Control fishermen - Stop tree cutting - Control construction near beach - Improve dune landscape and habitat values - Sustain scenic values of coast - Protect mangroves and other wetlands <p>2. Urban Lowlands Subzone</p> <ul style="list-style-type: none"> - Drainage system needs total overhaul - Control flooding -- strategy needed - Improve sanitation/control pollution - Maintain water level (canals and ground water) - Proper disposal of garbage and other solid wastes - Control settlements - Open blocked canal in Munhava - Chiveve River needs management <p>3. Eastern Rural Subzone</p> <ul style="list-style-type: none"> - Damage to mangrove/tidal creek ecosystem - control of industrial development - displacement of communities <p>4. Northern Rural Subzone</p> <ul style="list-style-type: none"> - Prevent erosion at Dama - restore blocked drainages - improve garbage dump - protect mangroves <p>5. Seaport Subzone</p> <ul style="list-style-type: none"> - Reduce pollution (from City, river, and Port) - Coordinate Port expansion and activities with City - Remove stranded ships - Provide sand commercially <p>6. Urban Center Subzone</p> <ul style="list-style-type: none"> - Reduce pollution (from City, river, and Port) - Control development in low areas - Protect Chiveve River <p>7. Extended Subzone</p> <ul style="list-style-type: none"> - Reduce soil erosion and siltation - Control water use, intrusion of salt up Pungue River - Control pollution <p>Administration</p> <ul style="list-style-type: none"> - Improve enforcement of laws - Improve City maintenance of infrastructure - Organize a special patrol for beachfront - Civic education needed (sand removal, other) - Monitoring: periodic inventory of beach sand - Improve coastal defense work

Table 4.3 – Coastal Issues Listed by Subzone

4.1.6 Representation

(a) Participation

In order to develop a balanced ICZM Strategy Plan, the planning process started with the identification and involvement of government agencies and community stakeholders' interest in the Coastal Zone who could identify development options for human settlement and commerce, needs for infrastructure (roads, shipping lanes, railway), water supplies, sanitation (sewage, solid waste disposal), drainage and flooding, port management, coastal fisheries and tourism.

The list of categories of interests follows:

- Water suppliers;
- Infrastructure interests;
- Maritime administration of the province (Maritima);
- Port (operations, dredgers, INAHINA, EMODRAGA);
- Physical planning (both city and province);
- Sanitation;
- Communities/neighbourhoods;
- Public liaison officers;
- Municipal police;
- Beachfront residents/resort operators;
- Commercial interests;
- Industry;
- Tourism (city and province);
- Transport;
- Central and government and provincial officials (MICOA, MARITIMA);
- Fishermen;
- Collaborators (e.g., PROL).

The planning process was successful in having participation at the technical workshops from most stakeholder groups. But some groups, like fishermen, were in-sufficiently organised to provide representation. Moreover, the Beira community does not have a tradition of active NGOs involvement in this sort of participative approaches.

<p>STABILIZE BEACHFRONT -- Maintain and improve coastal defenses</p> <p>PROTECT DUNE SYSTEM -- Restore and maintain; control access</p> <p>MANAGE COASTAL AND LOWLANDS DEVELOPMENT -- Encourage good economic development and prohibit bad development (that infringes on dunes, etc)</p> <p>IMPROVE MANAGEMENT OF DRAINAGE -- Operate desaguadouro optimally, control occupation of lowlands (<4m), fix inner control structures, clean channels -- encourage closing of desaguadouro & opening Chiveve.</p> <p>PROTECT ENVIRONMENT -- Control pollution, protect mangrove systems and other natural resources, improve environmental health</p> <p>ENHANCE LANDSCAPE QUALITY -- Promote landscape quality and city beautification</p> <p>ENHANCE PUBLIC AWARENESS -- Improve use of media and other approaches to enhance public awareness of coastal needs</p> <p>ENCOURAGE SELF SUFFICIENCY -- Improve ability of Beirans to manage their own affairs and support necessary public programs</p> <p>CREATE AND FULFILL CZM MASTER PLAN -- Create a Master Plan for the coast and provide the resources necessary to implement it.</p> <p>ESTABLISH HIGH LEVEL COASTAL AUTHORITY -- Elevate the present Office of Coastal Protection to a higher level Coastal Authority.</p>

Table 4.4 – Ten goals for Beira: A Vision Statement

PROBLEMS	INSTITUTIONS														National/ Province						
	CMB								D.C.U.												
	BARRIOS	PROPECA	D.S.U.	DICT	ZONES V	FISCILZ	POLICIA	CHAEM	CADASTRAL	SANITATION	CSTL. PROTE	ESTRAD	TECH	MICOA		CFM	EMODRAGA	MARITIMI	DROPH	DNA/ARA	CCOM. TOUR
Terras baixas	X				X				X	X	X							X			
- Drainage system needs total overhaul	X				X					X	X										
- Control flooding -- strategy needed	X	X	X		X			X		X	X			X						X	
- Improve sanitation/Control pollution	X				X			X		X	X										
- Maintain water level (canals and ground water)	X				X					X	X							X			
- Proper disposal of garbage and other solid wastes	X	X	X		X					X	X		X							X	
- Control settlement	X		X		X					X	X										
Shoreline																					
- Prevent erosion																					
- Control sand removal	X		X						X	X	X			X		X	X				
- Protect against cyclones			X					X		X	X									X	
- Control foot traffic on dunes					X				X	X	X										
- Stop vehicle traffic in dunes					X				X	X	X			X							
- Restore and stabilize the dunes	X		X							X	X		X							X	
- Control fishermen	X		X		X				X	X	X						X			X	
- Stop tree cutting	X	X	X		X					X	X			X						X	
- Control construction near beach	X		X						X		X		X							X	
Harbor and Estuary																					
- Reduce siltation											X				X						
- Control intrusion of salt up Pungue River										X	X				X		X	X			
- Reduce pollution (from City, River, and Port)										X	X			X	X		X	X			
- Coordinate Port activities	X									X	X		X		X		X				
Environment																					
- Improve dune habitat		X	X								X				X					X	
- Protect and Restore mangroves	X										X			X	X						
- Conserve birdlife in pantanos (Punta Gea to Pria Nova)	X			X							X			X	X						
- Control pollution	X	X	X	X				X		X	X			X	X					X	
- Sustain scenic values of coast		X		X				X		X	X		X	X	X					X	
Administration																					
- Improve enforcement of laws	X	X	X	X				X	X		X		X	X	X		X			X	
- Improve City maintenance of infrastructure	X	X	X	X				X	X		X		X	X	X						

(b) *Vision statement*

Toward the end of the series of technical workshops a "Vision Statement" was created (*Table 4.4*). The purpose of this statement was to provide guidance and to set long-term goals for the ICZM programme. The statement may need revision and refinement prior to preparation of the ICZM Action Plan, since it is to reflect ICZM needs given in previous studies on the Mozambique Coastal Zone (Massinga, 1996; Gove, 1996; Shah *et.al.*, 1997; NORAD, 1992).

4.1.7 Options for development

Development scenarios and land use management aspects of ICZM planning are closely related to urban planning activities. In order to improve efficiency of ICZM planning, collaboration with the PROL project (Beira Structure Plan) has been arranged. The PROL mandate is a comprehensive one-year urban planning activity for Beira resulting in a Structure Plan. To avoid duplication and maximise efficiency, the current Project shared information with PROL and *vice versa*, particularly for subjects for which technical expertise was engaged, such as for sanitation, water resources, urban lowland drainage, infrastructure, social conditions, urban mapping (GIS), flood potential, and general urban growth (development). In addition, effort was made to agree on management requirements for the Coastal Zone where both projects have interests. ICZM will become one of the "Action Plans" under the broad Structure Plan for Beira.

4.1.8 Present jurisdiction and institutional capacities

Interests of agencies involved with the Coastal Zone are shown in *Table 4.5*. Responsibilities of these agencies are sometimes unclear and need further investigation and analysis. In the limited time available, the Project Team was unable to further analyse the institutional capacity involved with the Coastal Zone. A detailed assessment of proposed interventions as regard to requirements for manpower, staff training, etc. is to be done in the process of preparation of the ICZM Action Plan.

Better protection of the coastline will require strengthening of the Office of Coastal Protection of CMB, improving co-ordination and co-operation with various other agencies involved with the Coastal Zone, and transferring authority from other agencies to the coastal authority. Establishment of an interagency co-ordinating committee is needed to ensure effective participation of numerous government agencies at various levels.

4.1.9 Existing coastal management activities

The government is involved with management of the Coastal Zone at three levels, i.e. city, province, and central level. The most significant organisations involved with the Coastal Zone are listed below. Most organisations have direct authority, but some play only an advisory role.

(a) *Conselho Municipal Beira*

- *Gabinete de Protecção Costeira*: the coastal protection office advises on coastal development and projects, does surveys, manages protection works projects, co-ordinates coastal affairs;
- *Planeamento Física e Cadasto*: responsible for land use approval (licenses land entitlement) and physical planning matters; rules based on pre-independence schemes;
- *Fiscalização*: enforces rules involving illegal occupation and activities and levies fines;

- *Departamento Técnico*: reviews and approves building plans and creates spot programmes, encourages a 50 m setback;
- *Departamento de Estradas e Pontes*: responsible for maintenance of streets and bridges;
- *Departamento de Águas e Saneamento*: in charge of sewers and drainage;
- *Industria e Turismo*: licenses commercial operators;
- *Aguas da Beira*: provides water supply to Beira;
- *Zonas Verdes*: responsible for agriculture;
- *Gabinete de Gestão Ambiental*: responsible for environment.

(b) *Province of Sofala*

- *Maritima (Administração Marítima da Sofala)*: mandated to control land use 100 m shoreward from mid-tide level and constructions 100 m into sea (e.g. piers), licenses boat operators, fishermen and conducts enforcement;
- *Industria e Turismo*: licenses commercial operators;
- *MICOA (Ministry for Co-ordination of Environment)*: co-ordinates environmental matters, including Central government CZM policy initiative;
- *CHAEM (Centro de Higiene Ambiental)*: inspects water and food quality and does required health checks (e.g., drive license).

(c) *Central Government*

- *ARA Centro (Administração Regional de Águas de Centro)*: regional agency for a national undertaking to improve and maintain water supplies;
- *CFM (Portos e Camiños de Ferro de Moçambique)*: as agency responsible for national ports and railroads, controls the Beira seaport;
- *EMODRAGA*: responsible for navigation dredging in the country.

4.2 ICZM programme: administration

4.2.1 **Goals and objectives**

ICZM programmes are developed around specific objectives generated in a participatory process involving government and community stakeholders. But the final definition of goals must be made at the highest level of government. These goals form the background against which more detailed policies, planning schemes and management plans are prepared. The broad goals of an ICZM programme for Beira would include the following:

- (1) to recognise that the Coastal Zone is threatened by sea force and that this zone provides the basis for tourism, recreation, artisanal fishing, shipping, coastal housing and commercial sites;
- (2) to provide a central administrative mechanism for management of the Coastal Zone that unifies the efforts of appropriate government agencies and that incorporates the interests of all sectors and stakeholders towards effective conservation and protection of the coastal zone; and
- (3) to engage in such programmes as are necessary to restore and sustain the security of coastal defences and conservation of coastal resources and to direct the benefits thereof to all residents.

The immediate and specific objectives for an ICZM programme are to protect the coast, to promote safe and environmentally-sound economic development, to streamline the development review process, and to resolve the priority issues identified by technical workshops (see also *Table 4.4*).

4.2.2 Criteria for ICZM

In order to meet goals and to resolve priority issues, an ICZM programme should be structured and an Action Plan created so as to:

- (1) have a firm policy base which recognises that the Coastal Zone will deteriorate unless concerted and unified action is taken to conserve it;
- (2) fit within the *modus operandi* of the existing governmental system;
- (3) influence private and public actions in the "Zone of Influence" that affects the Coastal Zone (in this case mostly the catchment of the Pungue and the surrounding sea);
- (4) reorient the direction of independent agency actions that affect the Coastal Zone toward a unified and focused approach involving: land use, permit issuance, planning, licensing, conservation and resource management, environmental monitoring, waste disposal, sea defences, EIA process, enforcement, storm hazards, infrastructure arrangements and other related processes;
- (5) review and amend existing laws, regulations, codes, and agency mandates in order to facilitate an ICZM inter-agency partnership for reducing ambiguity, amending legislation, strengthening guidelines, filling gaps, and minimising duplication;
- (6) increase awareness of the importance of Coastal Zone protection and conservation needs at all levels of society and government;
- (7) prepare and implement clear and unambiguous standards and guidelines;
- (8) streamline the review and decision process on development initiatives and applications and increase the transparency of the decision making process affecting the Coastal Zone;
- (9) encourage extensive participation of stakeholders, communities, civic groups, NGOs, economic sectors, and other public interests;
- (10) empower rural communities both by careful delegation of responsibility to local leadership and by provision of technical and other assistance to them; and
- (11) provide sufficient authority, manpower, and funds to accomplish the tasks necessary to make the ICZM programme successful.

4.2.3 Institutional arrangements

Experience in other countries shows that the above can be done through different institutional approaches. Each creates a similar high profile ICZM management and co-ordinating unit but each has a different institutional identity. Three options are shown below as examples:

- (1) Establishment of a semi-autonomous Coastal Zone management authority placed within an existing government agency and having direct independent statutory power, including project review and permit issuance.
- (2) Establishment of a new high level Coastal Zone co-ordinating entity, which by statute is given sufficient authority and wherewithal to ensure that all agencies and sectors conform to ICZM rules, procedures, standards and guidelines.
- (3) Expansion of the role of an appropriate existing agency by statute to give it the necessary mandate, authority, and wherewithal to implement the ICZM programme.

Any of the three institutional approaches above could feasibly be employed. But because of the great resource value and jeopardy of the Beira Coastal Zone and the present ambiguities of authority, it would be advisable to choose an approach that affords the highest level of autonomy to the ICZM Unit.

It must be recognised that the *Conselho* Municipal and Assembly have limits to their authority that are imposed by higher levels of government; therefore, the city's autonomy is itself restricted and cannot

exceed certain limits. Accordingly, a Beira ICZM programme must not exceed the limits of its authority and must be accepted by the relevant provincial and central government offices.

4.2.4 Conferral of authority

It is proposed that the *Conselho Municipal* and the Assembly create a semi-autonomous Coastal Directorate that reports directly to the Mayor according to the above reasoning and to the explanations given below. There should be no need to set up a new bureaucracy for a modest size ICZM programme for Beira, if the present Office of Coastal Protection is upgraded to the Directorate level.

The ICZM programme proposed must have clear and definite authority and influence in the various Sub-Zones defined above. The ICZM programme must also have sufficient financial means, adequate staff, and uncompromising political support in order to successfully carry out its responsibilities.

The Coastal Directorate must have influence on ministries and agencies involved, e.g. Finance, Agriculture, Sanitation, Economic Planning, Commerce, Tourism, Forestry and Transportation. But, the greater the number of agencies and sectors involved, the greater is the potential for conflict.

Provincial and local governments have to share authority. Also central government should support the Coastal Protection Directorate which would actually manage the ICZM programme. This type of arrangement is called "collaborative management" or "co-management".

Two main alternatives are given *Figure 4.3*. Alternate A creates an autonomous authority with full power over the Coastal Zone while Alternate B suggests to create a co-ordinating authority which guides the activities of other agencies. Because of the special situation of Beira, a mixture of these two is proposed whereby a Directorate of Coastal Protection is created which has certain autonomous powers and certain co-ordinative powers.

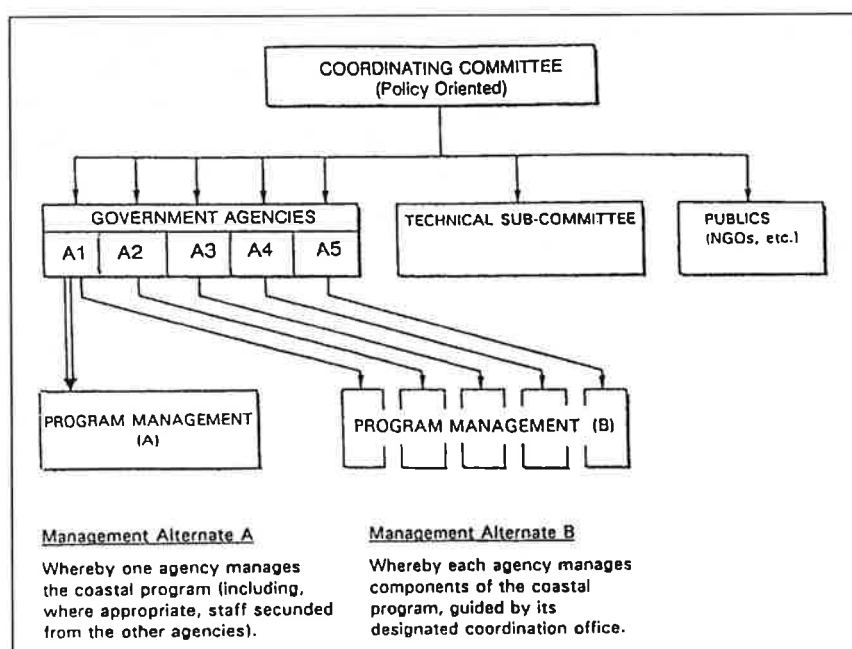


Figure 4.3 – General Model for CZM Administration

4.2.5 Authority in the different zones

(a) Urban Seacoast Sub-Zone

The Directorate of Coastal Protection should be given full responsibility for construction and maintenance of coastal protection works and for conserving the coastal sand dune system. In order to accomplish its mission the Directorate must have an adequate budget to cover manpower, equipment, and material and the authority to negotiate with international aid donors for assistance.

The Directorate of Coastal Protection should have primary authority to regulate development and any other uses that can affect the coastal environment. This implies a transparent system of permit letting to be operated by the ICZM programme for all public and private sector activities within the Primary Zone. This to be controlled by specific guidelines and standards, including environmental controls. This will require co-ordination with several city offices and negotiating jurisdictional matters with other governmental entities, e.g. particularly *MARITIMA*, and will require transfer of some authority from other agencies to the Coastal Authority. It will also require effective participation by various stakeholder interests.

A most challenging matter is sharing responsibility for coastal defences between the public and private sectors. Question to be answered include:

- In constructing and repairing particular defence works, how much should the city pay and how much should beachfront owners pay?
- Why should the city alone have to protect individual properties?
- Shouldn't the owners have to pay a fair share of the costs?

Every protection project will have some public as well as private benefit. Therefore a sharing mechanism seems appropriate, with different ratios of private/public cost for each particular type of project depending upon circumstances. This needs further study.

(b) Urban Lowlands Sub-Zone

The Coastal Directorate should have effective authority to control water flows via the *Desaquadouro* and land uses that affect the coastal environment via drainage, flooding, water levels and water quality. This will require the Coastal Directorate to operate the restored sluice gates of the *Desaquadouro* and co-ordinate jurisdictional matters with various governmental entities involved in managing the urban lowlands (*Figure 4.4*). It should be noted that 63% of the occupied lowlands lie below 4 m (Palmer Assoc, 1998) and are subject to flooding from the sea (which often rises to 7 m) and rain run-off, both of which will be controlled with the restored sluice gates.

Co-ordination is needed with the Sanitation Department (*Departamento de Águas e Saneamento*), which has been responsible in the past for drainage of the lowlands areas, in order to co-ordinate the operation of the *Desaquadouro*. The gates must be raised and lowered according to protocols that meet main requirements: beach stability; prevention of floods, septic condition of the canals, and salt water intrusion; and that maintain appropriate ground water levels (see Prack, 1985).

Also environmental and landscape values of the Chiveve River corridor need to be maintained and improved. This is particularly important in anticipating the reopening of the Chiveve as the major drainage of the 2,500 ha of lowlands comprising the Secondary Sub-Zone.



Figure 4.4 - The Desaquadouro at Palmeiras and channel

(c) *Eastern Rural Sub-Zone*

It is recommended that the Coastal Directorate be given primary authority over the mangrove/tidal creeks system that extends from Rio Maria to Savane (*Figure 4.5*), particularly with reference to any building or land use initiatives that could degrade the resource value of this system. Authority would be exercised from extreme LWL to the CD+4.0 m elevation contour on the land.



Figure 4.5 – Mangrove / Tidal Creek complex; Eastern Subzone

Dune and beach protection should also be a primary responsibility of the Coastal Directorate which should also attend to any pollution from industrial developments or other factors from outside the coastal boundary that affect the coast. Close co-ordination with various responsible agencies is necessary.

(d) Northern Rural Sub-Zone

It is recommended that the Coastal Directorate be given primary authority over the lowlands and tidal creeks along the Pungue Estuary. Authority would be exercised from extreme LWL to the CD+4.0 m elevation contour on the land. Close co-ordination is required with other responsible agencies, including *MARITIMA*.

(e) Seaport Sub-Zone

The Coastal Directorate needs to co-ordinate closely with CFM, the central government agency that manages the seaport, which should itself be responsible for controlling any adverse impacts such as pollution (*Figure 4.6*).



Figure 4.6 - The Beira Seaport on the Pungue Estuary

(f) Urban Centre Sub-Zone

The Coastal Authority needs to co-ordinate closely with other CMB authorities that manage various aspects of the centre city and who are responsible for controlling any impacts to coastal areas. Such impacts may be identified in the Structure Plan now being developed for Beira.

(g) Extended Sub-Zone

The Coastal Authority should negotiate with external authorities (village, city, provincial, central) in the interest of preventing siltation, pollution, and salt water intrusion. While the ICZM programme will have no direct authority in the Extended Sub-Zone, it should attempt to influence entities that do have such authority. This could be done by establishment of a formal interactive committee of coastal and inland authorities as an extension activity of the Coastal Zone Forum.

As an example of the need for extended influence, dams along the Pungue could lead to lower dry season discharges, encouraging saline water intrusion further upriver (*Figure 4.7*) and could result in smaller amounts of sand being transported to the coast. The latter is likely to disrupt sediment balances and may have already exacerbated coastal erosion. Optimising the use of water resources of the Pungue will require assessments, discussions and compromises in a larger, basin-wide context. This would be outside the direct mandate of the Coastal Directorate and would therefore require involvement of, and mediation with relevant authorities. At present this matter is being studied extensively by the regional water agency ARA Centro.

4.2.6 Organisational structure

The Coastal Directorate would report directly to the Mayor as a semi-autonomous agency. To conduct its activities efficiently, it would need ample manpower, equipment, materials, authority and an adequate annual budget. The Coastal Directorate would also need the authority to negotiate for foreign aid funding to assist with coastal management.

The Coastal Directorate would be controlled by policy decisions of the Assembly and administrative control by the Mayor's Office. Its programme would be guided by the Coastal Forum and its Technical Committees. The Forum could establish a small Steering Committee to review major decisions of the Coastal Directorate and serve as an appeals board, particularly involving approval or disapproval of applications for permits to build in the Seacoast-, Eastern-, and Western Sub-Zones or development that would otherwise impact on the resources of these Sub-Zones. The Coastal Directorate would control and operate the *Desaquadouro* with its own manpower and equipment and co-ordinate with other agencies involved with water management in the Lowlands Sub-Zone. The Coastal Directorate would be empowered to co-ordinate with and secure the co-operation of agencies and stakeholders of the Seaport, Urban Centre, and Extended Sub-Zones.

4.2.7 Training

Three levels of ICZM training of CMB and provincial employees are proposed: (1) routine on-the-job training, (2) local seminars, demonstrations, workshops and short courses, and (3) out-of-residence study tours and short courses. A programme of inviting visiting specialists and already posted consultants with expertise in particular technical areas should be encouraged.

The training strategy should be geared towards supporting the implementation of the ICZM Action Plan and, as such, would include: ICZM planning principles, Environmental Impact Assessment, technical training and monitoring capacities, appropriate computer skills, operation of the sluice gates at the *Desaquadouro*, maintenance of the implemented emergency works, and rapid storm response (RSR), along with other training needs as identified in co-operation with the relevant agencies.

4.2.8 Immediate and long-term targets

Development of an ICZM programme is a time-consuming process requiring a step-by-step approach. The recommended steps for ICZM planning and implementation are as follows:

- (1) Creation of a Strategy Plan for ICZM (reflected in the current Chapter).
- (2) Formulation of the policy background including a clear set of goals and directions for ICZM.

- (3) Passage of enabling orders or legislative statutes authorising reorganisation and establishment of a Coastal Directorate, Forum, and the ICZM programme.
- (4) Staffing and organising the ICZM unit and establishing both technical and policy advisory bodies.
- (5) Creation of an ICZM Action Plan for the coast.
- (6) Implementation of the Action Plan, step-by-step.

This Project has provided the Strategy Plan (Step 1). Steps 2 to 5 may require a period of about two years. Not all work has to wait for Step 6, on the contrary. Several activities can be done during initial stages, particularly those being urgent, non-controversial, and that receive immediate donor support. Recommended highest priority actions are discussed in *Paragraph 4.4*.

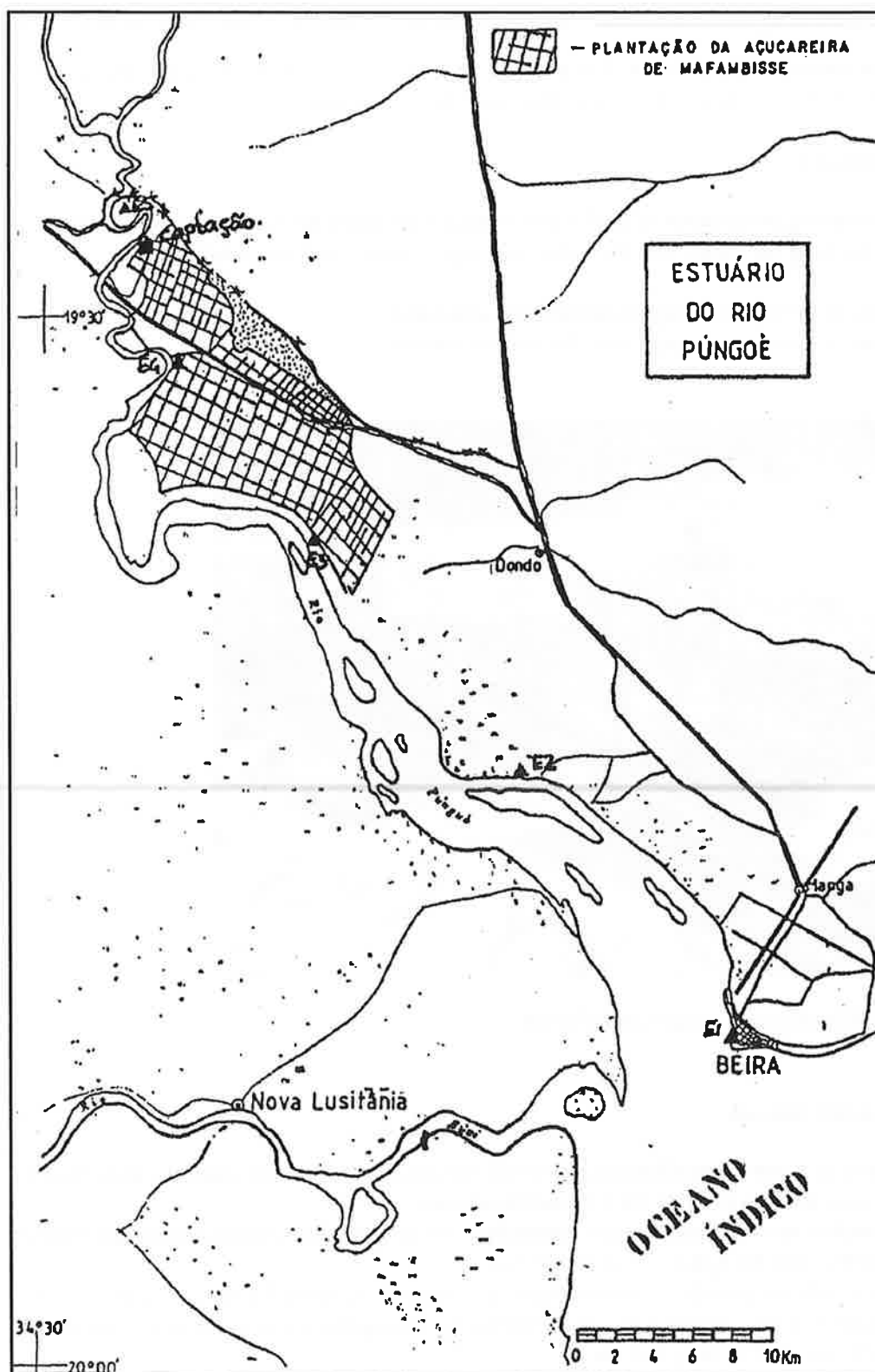


Figure 4.7 - The Water Supply Intake for Beira

4.3 ICZM programme: activities

The following is an outline of suggested ICZM activities to be undertaken by the Coastal Directorate with the assistance of other agencies and stakeholders and donor assistance.

4.3.1 Awareness

- (a) Conduct a continuing programme of public awareness of the needs for coastal protection and conservation utilising the public media, posters and signs, shows, and presentations to stakeholders.
- (b) Conduct a special awareness programme for dune protection.
- (c) Conduct a special awareness programme for decision makers.



Figure 4.8 – Safe: Development setback from beach

4.3.2 Land use control

- (a) Organise a system of permit application and review for development in the Coastal Zone (*Figures 4.8 and 4.9*) to be administered by the Coastal Directorate.
- (b) Organise a simple Environmental Impact Assessment (EIA) system for permit application reviews that is compatible with the system used by *MICOA*.
- (c) Prepare a set of official guidelines and standards for use by the Coastal Directorate and others to guide development in the Coastal Zone, in co-operation with agencies and stakeholders and in agreement with use priority designations.
- (d) Discourage all building within 40 m of the inland toe of the dune (note: the *Conselho's* Technical Department now applies a 50 m setback from waterline).
- (e) Restrict industry with significant negative impact on Coastal Zone ecosystems.
- (f) Avoid developments that require relocation of communities or have other significant negative social impacts.

- (g) Prohibit further settlement in areas with elevations less than CD+3.5 m .
- (h) Ensure that coastal developments are compatible with the Structure Plan (to be completed in 1999).



Figure 4.9 – Unsafe: buildings too close to Beach

4.3.3 Dune maintenance

- (a) Repair and maintain the dune system, including closing of blowouts, replanting, installation of windscreens and building of safe accessways such as boardwalks (*Figure 4.10*).
- (b) Reduce access by planting of spiny plants (e.g. cactus, Euphorbiaceae sp.) by roadblocks and by signs (see *Annex 4*).
- (c) Repair the retaining wall along beach from Club Nautico to Ponta Gea (*Figure 4.11*).
- (d) Prohibit sand mining in dunes or beach and arrange for alternative sand sources (e.g., from EMODRAGA).(*Figure 4.12*).
- (e) Prohibit all vehicular traffic on dunes or beach, also tree cutting, removal of vegetation, trash dumping, camping and fishermen trampling on dunes or placing equipment there.
- (f) Organise a special Beach Patrol assigned to the Coastal Authority for enforcement of dune management rules (need uniforms or identification badge).
- (g) Arrange alternative latrine services.
- (h) Dismantle derelict structures and encourage appropriate landscaping of dunes to create coastal scenic corridor.



Figure 4.10 – Major dune blowout; sand and vegetation gone



Figure 4.11 – Path through broken section of wall, dune gone



Figure 4.12 – Path through dune for carrying sand away

4.3.4 Shore protection

- (a) Implement a long-term plan for construction of shore defences recommended by the Project as given in *Annex 3* (see *Figure 4.13*) which, if not done, could result in very substantial damage (and expensive repairs) and serious social and economic losses if the shore defences fail in high water storms or cyclones.
- (b) Conduct a continuous programme of repair of structures using the workforce and equipment of the Coastal Directorate to protect Beira's present investment (USD 10,000,000) in coastal protection structures.
- (c) Prepare a Readiness and Rapid Storm Response plan to reduce cyclone damage, including storm strike prediction.
- (d) Conduct periodic monitoring, measurements of changes in sand volume on beach and dunes.



Figure 4.13 - Ponta Gêa -- Trouble spot for shore protection

4.3.5 *Desaquadouro* operation

- (a) Maintain the sluice gates in top condition.
- (b) Equip the system with the necessary appliances including water level gauges and a backup power supply source.
- (c) Prepare protocols for operation of gates in respect of needs to prevent flooding, maintain water levels, prevent salt water intrusion, and maintain healthful condition of waters.
- (d) Remove sand blockage at outlet as needed; deposit appropriately downdrift.
- (e) Repair internal water control structures of drainage system for agriculture, rehabilitate drainage channels, and conduct a regular maintenance programme.

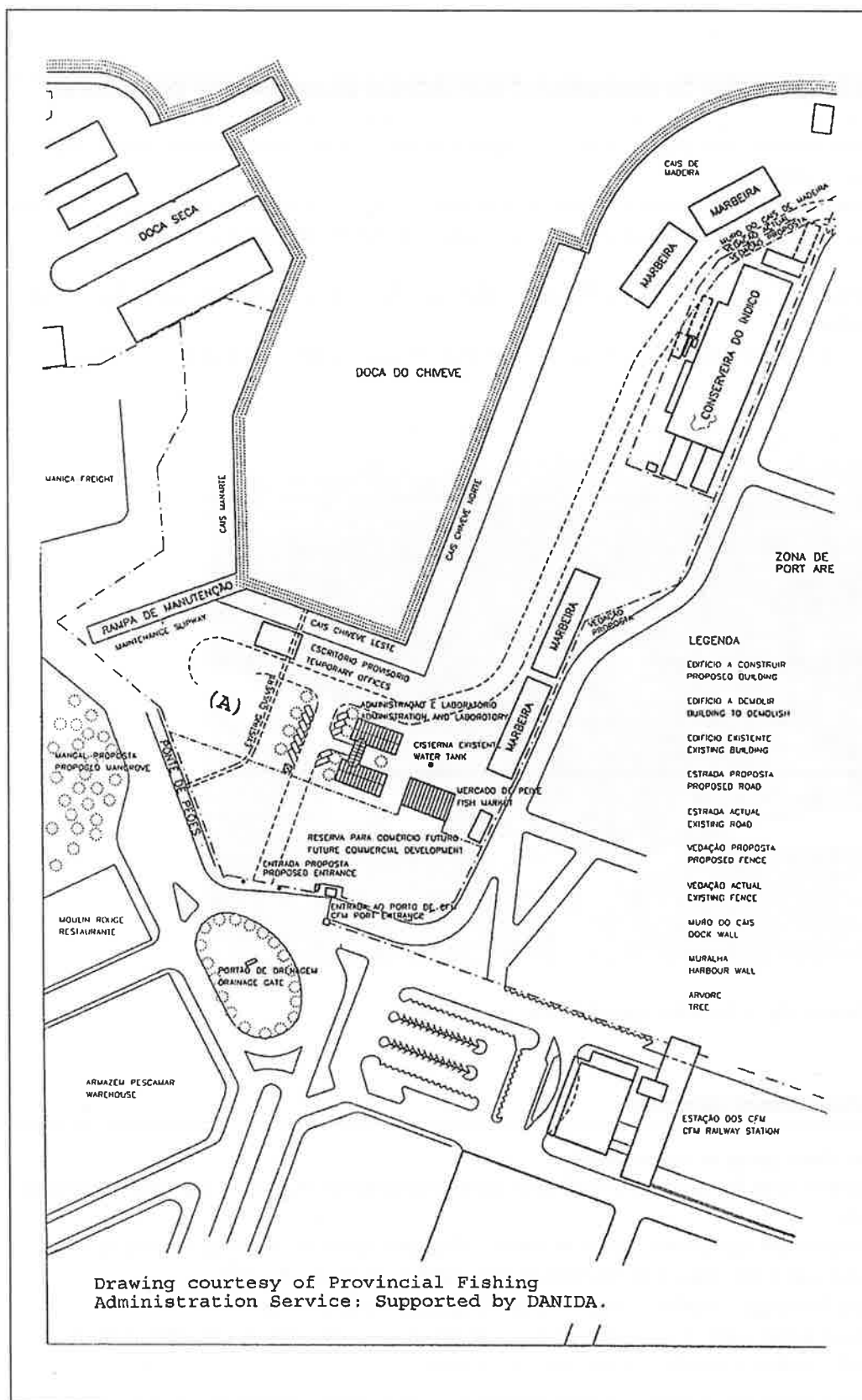


Figure 4.14 - Present Constricted Outlet of Rio Chiveve (A)

4.3.6 Drainage alternative

- (a) Explore the feasibility of rerouting drainage through the original Chiveve River channel and the benefits to environment and the city landscape and encouragement of potential commercial development (see *Figures 2.17* and *Figures 4.14* and *4.15*).
- (b) Explore feasibility of other drainage alternatives for lowlands.
- (c) Clear blockages in drainage channels at Dama/Munhava.

4.3.7 Environmental management

- (a) Protect all mangrove stands and devise protocols for cutting in certain places where sustainable, including replanting; organise local committees for management guidance.
- (b) Restrict all development in the Eastern, Northern, Seacoast, and Lowland Sub-Zones that would negatively affect the mangrove ecosystem, including tidal creeks and salinas.
- (c) For all areas believed to be important habitats, create Preserves (no-use zones) and study these to learn what their future should be; e.g. the low marsh north of Ponta Gea (*Figure 4.16*).
- (d) Co-ordinate with appropriate agencies to reduce water pollution from sewers, storm runoff, industry, and ships at seaport.
- (e) Conduct regular monitoring of environmental water quality.
- (f) Improve sanitary facilities to prevent widespread deposit of faeces in the Coastal Zone.
- (g) Improve disposal of solid wastes and upgrade the dump at Dama.



Figure 4.15 - The channel of the Rio Chiveve in Beira town

4.3.8 Pungue Estuary

- (a) Co-ordinate with appropriate agencies to prevent salt water intrusion; e.g. upriver to the water supply intake.
- (b) Co-ordinate with appropriate agencies to reduce soil erosion in the Pungue catchment, to reduce siltation of the Pungue Estuary.



Figure 4.16 – Low marsh wetlands near Ponta Gêa

4.3.9 Seaport

- (a) Co-ordinate with CFM (national railroad and ports) authorities to ensure that expansions do not have negative Coastal Zone effects.
- (b) Co-ordinate with CFM authorities to ensure that pollution is controlled from ships and port operation.
- (c) Negotiate with EMODRAGA to obtain sand for sale for construction uses as a substitute for beach/dune sand.
- (d) Remove abandoned ships except those serving as default groynes which prevent beach erosion.
- (e) Conduct an Environmental Impact Assessment of the Port.

4.3.10 Priority uses

In accordance with the above and for general land use guidance, priority use guidelines were summarised and considered during the Working Group sessions. Results are given in *Annex 6*. The land use programme of the Coastal Directorate will integrate with and support the Structure Plan for Beira.

4.3.11 Administration

- (a) Establish a Coastal Directorate, with full authority for the Coastal Zone, which would work in collaboration with provincial agencies such as MICOA and Maritima.
- (b) Organise co-ordination among agencies with Coastal Zone interests.
- (c) Collaborate with relevant agencies to improve sanitation, water supply, drainage, wastewater management, and solid waste removal and supporting infrastructure in the Coastal Zone.
- (d) Improve enforcement of rules for coastal protection.
- (e) Organise a system for cost recovery for coastal protection works (fees, taxes, fines, sales, contributions, etc.)

4.3.12 Action Plan

- (a) Obtain authorisation and funding for creation of an ICZM Action Plan to incorporate all the above actions.
- (b) Prepare the ICZM Action Plan (see *Annex 8*) and ensure that it follows and is compatible with the Structure Plan for the city and is integrated with relevant elements of it.

4.4 Immediate actions to be taken

It is not necessary to wait for completion of the Action Plan to commence already with some essential actions listed above. These can be accomplished before and during preparation of the ICZM Action Plan. The following list presents the actions that should be taken at the earliest possible time. These actions have been formulated during the series of Technical Workshops and are supported by consensus of Forum members. It is assumed that the *Conselho* will prepare an ICZM Action Plan and that additional needed management actions listed in *Paragraph 4.3* will be included in this plan.

4.4.1 Low-budget management actions

(a) *Management action: stop illegal activities*

The sand dunes are an integral part of the beach system and must be protected if erosion of beaches is to be prevented. Sand removal from the beach and dunes of Beira is illegal and is punishable by fines. The agency responsible for stopping sand removal and for levying fines is *Fiscalização*, which has done little so far about stopping illegal sand removal. This agency is autonomous and reports directly to the Mayor; therefore, the Mayor should direct *Fiscalização* to take full responsibility to end this illegal activity and to regularly patrol dunes and beaches.

It is unclear which agency should control other dune abusers, such as 4WDs and dirtbikes. Damage is also being done by foot traffic, by removal of vegetation, trash dumping, etc. It appears that new rules will have to be devised to protect the dune system and clear responsibility for enforcement assigned.

Costs: This administrative action should not require additional funds.

(b) *Management Action: complete urgent protection works*

The *Conselho* has been conducting urgent beach works as part of the "Emergency Works" component of the current Project (*Chapter 3*). These works are complementary to those being done by commercial contractors. The *Conselho's* works are an essential part of the entire Emergency Works programme,

the programme must be completed so that no essential works are left unfinished. The present strategy requires the *Conselho* to undertake works at Ponta Gea and near Miramar and Palmeiras.

Costs: About USD 15,000 of Dutch aid have already been spent to supply materials and equipment to the *Conselho*. Remaining works will require another USD 20,000 from Dutch aid (the final amount depends upon specific allocation of works and availability of funds).

(c) *Management Action: operation of the Desaquadouro*

New sluice gates and stoplogs have been installed in the water control structure (*Desaquadouro*) at Palmeiras by the current Project, in order to control drainage and stop damage to the beach done by the delta in front of the now uncontrolled drainage canal. Correct operation of the new sluice gates will reduce salt water flooding of 2,500 ha of lowlands which are heavily encroached upon by poor people. Correct operation will also free the sand trapped in the delta and stop the diversion and loss of large amounts of beach sand to offshore bars, thus protecting the Palmeiras, Miramar and Ponta Gea beaches.

The most recent set of operating instructions is from 1986, a new operating protocol is needed. The protocol should reflect current conditions. Rainwater should be discharged and salt water should be blocked (at high tides) except when the canals need flushing during the dry season for sanitation.

Correct operation of the sluice gates requires that: (1) operating personnel (4 persons) from the *Conselho* be carefully selected and supervised; (2) personnel be given thorough training before the *Desaquadouro* is handed over to the *Conselho* for operation; (3) an efficient and continuous programme of maintenance be conducted; (4) essential spare parts, lubricants, and tools be available; and (5) heavy equipment (bulldozer, or etc.) be available to remove sand that blocks the outlet of the sluice gates.

It is recommended that the Coastal Protection Office (or Directorate) takes over operation of the sluice and command of the personnel so that all requirements to protect the beaches are fulfilled as advised by the current Project.

Costs: It is expected that: (1) personnel will be provided through the pool of existing employees of the *Conselho*; (2) training will be provided by the Contractor (Hughes) who will also provide Operation Manuals for all installed equipment; (3) operation protocols will be revised by the *Conselho*, (4) initial supply of maintenance materials will be provided by the Emergency Works Project (USD 2,000); and (5) costs for use of heavy equipment will be incurred by the *Conselho*.

(d) *Management Action: monitor the beach*

In order to analyse the effects of the Project, it will be necessary to monitor the beach and dunes and measure the volume of sand gained or lost. This will include the situation during normal periods and the situation following major high water and storm events. Measurements should include beach profiles and calculated amounts of sand. Priority should be given to the critical areas of the beach. The information should be used to plan for urgent maintenance and restoration needs.

Costs: It is expected that the *Conselho* will do the monitoring with its own skilled personnel and under its existing budget.

(e) *Management Action: moratorium on coastal construction*

In order to protect the beach/dune system, it is necessary to control building in the Coastal Zone. This should be done consistently and systematically, following guidelines that must still be prepared. Such

guidelines are to modify existing development controls exercised by the *Conselho*, particularly as regards setbacks from the beach. Until these guidelines are prepared, no permits should be issued for development in the Coastal Sub-Zones.

Costs: The moratorium is a simple administrative response by present staff of *Conselho* with no cost implications. However, the development of guidelines and standards could be included in a possible future donor-funded ICZM Action Plan project.

4.4.2 More costly actions

The following important management actions require significant funding.

(a) *Management Action: maintenance of beach works*

Coastal protection works require continuous maintenance. Failing to do so will result in damage, the repair of which can be very expensive. Therefore, the *Conselho* must conduct a continuous programme of repair of structures using its workforce and equipment to strengthen and repair groynes, seawalls, and "toe protection" as needed, as well as respond to major storm events. This is a full-time programme which must be conducted during every month of the year. It requires manpower, heavy equipment (and repairs), hand tools, stockpiles of materials, and fuel on a continuous basis.

Costs: Annual cost for the *Conselho's* coastal protection maintenance programme would be about USD 75,000 (exclusive manpower and equipment). Start-up costs for heavy equipment (tipper truck, loader, mixer, spare parts), setting up a storage yard, etc. would be about USD 100,000.

(b) *Management Action: restoration of dunes*

Restoration of the dune system from Macuti to Ponta Gea is essential. The loss of sand through wind action contributes to beach erosion and can only be stopped if the dunes are repaired by regrading, replanting and conservation efforts. Walkways for foot traffic must be built, the dune wall restored, the dune covered with low plantings, vehicle entrance places closed off with roadblocks, damaging footpaths blocked with spiny plants, and the controls described in *Paragraph 4.4.1* and *4.4.2* enforced. Old, existing structures should be demolished. The objective would be to create a strong dune system which would also be a scenic corridor along the coast. This is a major undertaking for the *Conselho* which will be expensive and which was not part of the Project.

A first step for the *Conselho*, which would not be too expensive, would be to install roadblocks and signs to stop vehicle abuse in key places. A second step would be a small pilot project (150-200 m) to learn how best to do restoration including: filling and regrading, test planting of ground cover and prickly plants, walkways, benches, wall rebuilding, and landscaping. The third step, far larger in scale, would be to complete the restoration of the entire 7 km dune system (based on the pilot results). The entire marginal wall would be rehabilitated, blowouts repaired, barren areas planted, crossovers (walkways) built, signs installed, and benches and landscaping completed. All steps require that dune protection rules are formulated and enforced. The result would be a strong and attractive dune system that would enhance the scenic corridor along Beira's coast.

Costs: The *Conselho* could implement the whole programme if sufficient support were available from the *Conselho* and from donor sources. However, certain parts could be contracted out and some consultant help may be desirable. The costs will depend upon how much the *Conselho* itself can do.

Support for steps 1 and 2 would be approximately USD 20,000 if done by the *Conselho*. Step 3 could cost from USD 65,000 to USD 200,000 depending how much the *Conselho* does.

(c) *Alternative drainage system*

The beachfront of Beira will not be stabilised permanently until an alternative to the present drainage outlet at Palmeiras is eliminated. Construction of this *Desaquadouro* as a substitute for the natural drainage via the Chiveve river has proved to be not successful and should be corrected. There have been studies for possible alternatives (including a culvert to the sea and a new outlet at Estoril) but the restoration of the Chiveve river as the main outlet is recommended. This would require: (1) widening and cleaning of the Chiveve channel; (2) building two bridges; (3) installing a sluice to control water level; and (4) reopening the mouth of the Chiveve at the fishing boat harbour. A feasibility study is needed. Restoration of the Chiveve would have additional benefits such as:

- (1) the flow through the channel would reduce stagnation and pollution;
- (2) the riverway would become a scenic attraction of which Beira could be proud: a green corridor through the city;
- (3) biodiversity would be improved;
- (4) silt would be scoured out of the fishing boat harbour during high flows;
- (5) opportunity for waterfront commercial development would be provided.

Issue (5) is particularly important because it could attract private investment to share the costs of the restoration project. The property involved (controlled by CFM) is in the centre of a high value area that needs total redevelopment and can become a centre of waterfront retail trade and hospitality services with great economic benefit. This area extending from the Manica building to the roundabout by the RR station with entrance from the boulevard is the prime area for commercial waterfront development in Beira's future (see *Annex 9*).

A feasibility study is necessary. A consultancy would be required consisting of specialists in several subjects: hydraulics, engineering, socio-economics, investment, biodiversity, etc.

Costs: A feasibility study for restoration of the Chiveve river could be completed in one year and would cost around USD 350,000.

4.4.3 Administrative actions

(a) *Institutional development*

As a result of analyses and discussions in the various technical workshops and the final Forum, a strategy has evolved to raise the level of the Office of Coastal Protection (temporary) to a permanent and autonomous Department or Directorate. This would require some reorganisation in the *Conselho*, some shifting of responsibilities, and some redirection of resources to give such Department or Directorate more strength to manage the vital coastal zone of Beira. It is believed that such change would be beneficial because the permanent body would have at its disposal the needed manpower, equipment, materials and authority to conduct a continuing campaign to protect the shores of Beira.

In addition an advisory body with wide representation from government and community interests is considered necessary. This body could be a formalised version of the existing Beira Coastal Management Forum. The Forum would provide advice, assist in resolving conflicts, and provide opportunity for discussion and argument on aspects of coastal management, and serve as the major

community participation mechanism. Core members would be appointed by the Mayor but any citizen could attend meetings and express views.

In order to examine the feasibility of this strategy more closely and to investigate details involved, it will be necessary to commence an "Institutional Development" survey and feasibility study. This should be done as soon as possible. It is recommended that an Institutional Development initiative be closely co-ordinated with related activities of the Gothenburg institutional project and the PROL project on developing the Structure Plan for Beira.

While much of the institutional background can be drawn from investigations completed by the present Project and while the *Conselho* staff can contribute much, it would be useful to commission a consultancy of two specialists in coastal zone institutional arrangements to work with the *Conselho* on this; one specialist to cover institutional aspects, the other legal/legislative aspects.

Costs: The cost for a one-month consultancy would be about USD 40-45,000. It is recommended that the *Conselho* request donor support for such consultancy

(b) ICZM Action Plan development

An outline for the ICZM Action Plan for Beira is presented as *Annex 8*. It is important that the Action Plan follows and is compatible with the Structure Plan for the city and that it incorporates all elements that affect the Coastal Zone. It is estimated that two years will be required for completion of the Action Plan. The city would need to engage several specialists for this work, one a full time Team Leader.

Costs: It is expected that a donor would support this project and that its total cost would be a maximum of USD 350,000.

(c) General donor support

Other aspects of the ICZM programme for which the *Conselho* might wish to request donor support in the near future include the following:

- A public awareness programme to support coastal management;
- A training programme for coastal zone managers;
- Cost sharing; exploration of opportunities to support ICZM activity via taxes, sales, contributions, fees, etc.;
- Nature protection; exploration of natural areas in the Beira municipality to determine the feasibility of creating nature reserves.

Costs: Approximate costs for the above support would be respectively USD 65,000; USD 80,000; USD 50,000; and USD 40,000.

ANNEX 1. TASK ALLOCATION AND TIMING IN PROJECT-WEEKS (1-26)**A. Forum Development**

- Stakeholder identification 4,5
- Review composition and mandates of parties involved 5,6
- SWOT for institutions of parties 7,8
- Overview of community organisations 6,9
- Action by CMB to formalise Forum by decree 5
- Draft plan to strengthen Forum 10,12
- Forum meeting to review/modify plan 2,15,23
- Finalise plan to strengthen Forum 15,16

B. Issues and user conflicts analysis

- First identification of issues 3,4
- Issues Working Group meeting to refine issues 12
- Finalise and prioritise ICZM issues listing 13

C. Institutions

- Definition of lines of communication/co-ordination 6,7,9
- Definition of limitations of responsibility, gaps 10,11
- Review of finance stream to agencies 11
- Examination roles national/provincial agencies & NGOs 12
- Institutional Working Group meeting to refine above 13
- Examine needs for institutional adjustments 14,15
- Proposal for alternative institutional frameworks 14,15
- Needs for capacity building (training and restructure) 15
- Proposal for staff training needs and strategy 15
- Collateral (on-the-job) training activity 1-26
- Finalise institutional options with adjustments 17

D. Development options

- Review of Coastal Zone development issues 18
- Examination of needs to strengthen physical planning 19
- Examine needs to strengthen development controls 19
- Examine economic aspects of development scenarios 20
- Physical Planning/Development Group, refine above 21
- Finalise development/physical plan options for ICZM 22

F. Water management and infrastructure

- Review of water resources issues (e.g., Pungue R.) 14,15
- Review of drainage, sanitation, and water quality 16,18
- Review of wastewater discharge (human, industrial) 17
- Review of Port impacts and needs 17
- Review of infrastructure needs for Coastal Zone 20,21
- Water and Infrastructure Working Group; refine above 22
- Finalise CZM water and infrastructure options 23

G. Habitats

- Field study on dune and mangrove/wetlands habitats 1,2
- Review of Coastal Zone habitat/biodiversity problems 17
- Develop preliminary coastal ecosystem strategy 18
- Biodiversity/Habitats Working Group meeting to refine 18
- Finalise CZM conservation options 21

H. Beachfront management

- Conduct geomorphology, dune, and engineering studies 1-8
- Analysis for short vs long term needs and solutions 4-8
- Examine priorities, options, and costs 17,18
- Beachfront Management Working Group; refine above 21
- Finalise CZM plan for beachfront management 20,21

I. Beach erosion emergency works

- Field study of engineering solutions 1-4
- Preliminary proposal for emergency works 5-8
- Integration with ICZM framework 14,15
- Emergency Works Working Group; refine above 4
- Final plan for emergency works, select contractors 8-12
- Implement emergency works: sub-contractors and CMB 6-26

J. ICZM Plan for Beira

- Analyse all elements above for ICZM strategy 10,15-20
- Assess effectiveness of emergency works 23
- ICZM Working Group meeting to examine needs and options 11
- Propose component on public awareness and involvement 11
- Propose conflict resolution methodology 12
- Propose strategy for vert/ horiz integration 12,13
- Alternative options for ICZM organisation and plan 15,16
- Propose budget, timing, cost recovery 17,18
- Examine possible external support sources 23
- ICZM Working Group meeting; select/prioritise options 18
- Prepare preliminary ICZM strategy 21
- Institutional framework for ICZM 20-24
- Informal CZM Core Group meeting to draft ICZM strategy 22
- Preparation of final ICZM Strategy Plan 22-26

ANNEX 2. RURAL CONSULTATIVE PROCESS

A potential approach for management planning of the Rio Maria - Savane wetland complex is to implement a thorough stakeholder analysis, including socio-economic surveys to determine:

- (1) Levels of use and dependency on the natural resources of the wetland system by different sectors of the communities (young, old, men, women);
- (2) The organisational structure of the communities (leadership, committees, associations, co-operatives) that are relevant to governance and resource harvest and marketing.

Management issues and options for their resolution would operate through a fully consultative process with users (identified in step 1), concerned government authorities, and others from the private sector (farmers, tourism operators, etc.) who would discuss and agree on: management modalities (partnerships, delegated components, approaches); boundaries of the management area; zones for different activities, including levels of protection; and roles (who in government, community, or private sector does what when).

The process would suggest institutional framework and requirements to support area management (community responsibilities, government policies, and local, municipal, and national legislation).

Synthesise the above into a draft management plan for discussion, revision as appropriate, and agreement by all stakeholders.

(Source: IUCN, 1998)

ANNEX 3. MEDIUM AND LONG-TERM COASTAL PROTECTION WORKS

After completion of the Emergency Works by the Project, further important activities for the medium and long-term should be undertaken. These activities are based on the results of the Project's geomorphological study (Alkyon, 1998). These activities are listed below (* = high priority).

1. Raising of groynes

1.1 Twelve groynes to be raised one meter, 30 meters long:

- Numbers 6, 7, 8, 11*, 11A*, 12*, 21, 22, 23, 25A*, 26*, 27*.

Est cost: 12x USD 25,000 = USD 300,000

1.2. Other groynes to be raised

- No. 27A*, 1.5m, 30m long
- No. 18A*, 1m, 40m long

Est cost: 2x USD 35,000 = USD 70,000

2. New constructions

- Two new groynes at Miramar*, 2m high, 90m long

Est cost: 2 x USD 170,000 = USD 340,000

- One long groyne at Ponta Gea, crest @ CD+7m, 200m long

Est cost: USD 1.5 million

- Alternate to above, 1 km dam, crest @ CD+7m, Pria Nova to Ponta Gea, parallel to channel of Pungue

Est cost: USD 5.0 million

3. Repair revetment

- Necessary repairs to revetment at Beira Terrace

Est cost: USD 250,000

Note: It is important to determine the ratio of private to public investment in each project. Where the benefit is largely to an individual property owner, that owner should pay a higher share of the costs of the work.

ANNEX 4. DUNE PLANTS

Suggested plants for different dune faces and purposes

Dune Zone	Plant types	Use prescriptions
Upper beach and seaward slope of dunes	Mixed assemblage of the creeper <i>Ipomoea pes-caprae</i> ; grasses <i>Sporobolus virginicus</i> , <i>Cynodon dactylon</i> , and related species; sedges <i>Cyperus</i> species; and locally abundant herbs and shrubs	Offlimits area strictly protected for dune stabilization
Dune crest	Mixed assemblage of grasses, creepers, and shrubs, with <i>Casuarina</i> trees for shade in designated recreation areas, decorative species (<i>Pandanus</i>), and access controlled by <i>Hyphaene</i> palm, <i>Opuntia</i> cactus (prickly pear), and yucca	Generally offlimits dune binding area with access limited to few designated sites
Inland slope of dune	Mixed assemblage of grasses, herbs, shrubs, trees (<i>Hibiscus tiliaceous</i> , <i>Terminalia catappa</i> , <i>Casuarina</i>), and access controlled by <i>Hyphaene</i> palm, <i>Opuntia</i> cactus (prickly pear), yucca, and bougainvillea. Decorative species include preceding and <i>Pandanus</i> , Madagascar periwinkle, euphorbias, etc.	Landsaped area with access limited to pathways and designated recreation areas, including camp sites

Comments:

1. Cuttings or young specimens should be collected of as diverse as possible a range of creepers, grasses, sedges, herbs, and shrubs and these planted between brushwood or bamboo fences, or through old cotton fishing nets draped over the dunes. These cuttings and young plants should be collected over a wide area to avoid seriously denuding any section of dune.
2. Bougainvillea planted at closely spaced intervals in a frame of short wooden poles connected in a criss-cross pattern by barbed wire makes an effective barrier to people and animals.

ANNEX 5. WORKING GROUP MEETINGS – 1998**ICZM FORUM MEETINGS:**

- (1) 25 April. Presentation of Beira ICZM Project.
- (2) 29 September. Discussion of the ICZM Strategy Plan.

ICZM TECHNICAL WORKING GROUP MEETINGS:

- (1) 5 May. Emergency Works.
- (2) 23 July. Coastal Zone Issues.
- (3) 23 July. Integrated Coastal Zone Management Planning I.
- (4) 24 July. Institutions: Status and Needs for Change.
- (5) 13 August. Development Options for Coastal Zone.
- (6) 13 August. Infrastructure and Water Supply.
- (7) 24 August. Integrated Coastal Zone Management Planning II.
- (8) 24 August. Biodiversity and Coastal Conservation.
- (9) 4 September. Long-term Needs for Shore Protection.
- (10) 15 September. Discussion of Draft ICZM Strategy Plan.

Note: Average attendance was 14 persons. Participants were City, Provincial, and Central Government officials and community representatives.

ANNEX 6. PRIORITY USES**CZM PROGRAM -- PRIORITY USES AND CONTROLS****1) Urban Seacoast Zone****Pria Nova to Punta Gea**

- Uses: Residences, agriculture, civic, nature protection
- Needs: Shore protection, particularly around P. Gea
Identification of nature reserves
Restrict new development

Punta Gea to Hospital

- Uses: Residences and light commercial
- Needs: Shore protection and dune stabilization
Development controls; e.g, setbacks from dunes
Public education

Hospital to Estoril

- Uses: Tourism priority; e.g., convert private residences to tourist facilities.
- Needs: Shore protection; dune stabilization and landscaping
Close beach road to general traffic

2. Urban Lowlands Zone

- Uses: Agriculture, residential
- Needs: Manage drainage (flooding, circulation, water table)
Improve sanitation; provide drinking water
Emergency preparedness (health, flooding)
Public education

3. Eastern Rural Zone

- Uses: Agriculture, fishing, aquaculture, light residential
- Needs: Estuary protection (mangroves)
Beach & water quality protection

4. Northern Rural Zone

- Uses: Agriculture, light commercial and residential
- Needs: Water quality
Improve drainage
Shore protection

ANNEX 7. INTEGRATED COASTAL ZONE MANAGEMENT PROGRAMME WORK PLAN BUDGET

Based on the ICZM activities suggested in *Paragraph 4.3* of the current report the following activities are to be undertaken by the Beira Coastal Directorate with assistance of other agencies and stakeholders. Support from foreign aid for these activities should be considered. The costs are estimates (in USD) and give only in general terms the level of support needed. Several activities can be sub-divided, if deemed necessary.

1. Awareness USD 65,000

- a. USD 45,000 Conduct a continuing programme of public awareness of the needs for coastal protection and conservation utilising the public media, posters and signs, shows, and presentations to stakeholders.
- b. USD 10,000 Conduct a special awareness programme for dune protection.
- c. USD 10,000 Conduct a special awareness programme for decision makers.

2. Land use control USD160,000

- a. USD 50,000 Organise a system of permit application and review for development in the Coastal Zone.
- b. USD 40,000 Organise a special environmental impact assessment (EIA) system for permit application reviews.
- c. USD 70,000 Prepare a complete set of guidelines and standards to control development in the Coastal Zone, in co-operation with agencies and stakeholders and in agreement with use priority designations (See.

Note: This work must be closely integrated with that responsive to the new Beira Structure Plan (to be completed in 1999).

3. Dune maintenance USD 235,000

- a. USD 190,000 Rehabilitate the whole dune system, including closing of blowouts, replanting, installation of windscreens, building of safe accessways such as boardwalks, and rebuilding the low retaining wall.
- b. USD 10,000 Train, equip, and organise a special corps of uniformed Beach Patrol guards assigned to the Coastal Authority for enforcement of dune management rules.
- c. USD35,000 Equip the Port to offload sand as an alternative sand source to avoid sand removal from dune/beach (design and construction).

4. Shore protection USD 230,000 + construction

- a. Implement long term plan for construction of shore defences recommended by the Coastal Management Project given in Annex 3. This work can be divided into subprojects of USD 10,000 to USD 4,000,000
- b. USD 100,000 Provide equipment to help CMB conduct a continuous programme of repair of structures using the workforce and equipment of the Coastal Directorate.
- c. USD 50,000 (tech. asst). Prepare a Readiness and Rapid Response plan to reduce cyclone damage, including storm strike prediction

- d. USD 50,000 (tech asst) Organise a system for long term cost recovery for supporting coastal protection works.
- e. USD 45,000. Study of private vs. public responsibility for costs of shore protection works. A City policy should be created for cost sharing, guidelines drawn, and legislation enacted. This an innovative effort which goes deep into existing policies and traditions of fairness.

5 Drainage alternative USD 350,000

- a. USD 350,000 (tech asst) study the feasibility of rerouting drainage through the original Chiveve River channel (hydrology, topography, routing, excavation, demolishment and rebuilding outlet). The investment will be a joint private/public venture -- private funds to rebuild outlet in combination with commercial development.

6 Environmental management USD 175,000

- a. USD 150,000 Inventory of mangrove and other wetlands and devise scheme for protection (and cutting where sustainable, including replanting), organise local committees for guidance, designate preserves and greenbelts (no-use zones).
- b. USD 40,000 Study feasibility of establishing nature reserves.
- c. USD 25,000 Set up programme for monitoring of environmental water quality.

7 Pungue estuary USD 50,000

- a. USD 50,000 Examine sources of soil erosion in the Pungue catchment, and recommend ways to reduce siltation of the Pungue Estuary.

8 ICZM Action Plan preparation USD 350,000

- a. USD 350,000. Technical assistance to CMB and Province in preparation of a detailed Action Plan, including policies, rules, activities, manpower, guidelines, EIA system, institutions, etc.

9 Training USD 80,000

- a. USD 25,000 Training sessions at Delft, Holland, in ICZM (summer, 1999); for one person from CMB and one from MICOA (Provincial).
- c. USD 15,000 training fund to enable Beirans to participate in ICZM training programmes in South Africa.
- b. USD 30,000 Study tour (Sri Lanka) for two officials.
- c. USD 10,000 Seminar programme in Beira, invited specialists.

10 Seaport USD 75,000

USD 75,000 Environmental Impact Assessment/Audit of Seaport

ANNEX 8. RECOMMENDED ICZM ACTION PLAN STRUCTURE

1. Introduction

- General purpose with reference to the ICZM Strategy Plan and formation of a Coastal Directorate, Forum, and inter-agency co-ordination system by the *Conselho*; need for durability.

2. Status of coastal management

- Present level of interventions, coastal works and protection measures, regulations, agencies, co-ordination, budgets, etc.

3. Coastal issues to be resolved

- Priority list of issues (from approved Strategy Plan) arranged by costs and time schedules.

4. Policy formulation

- Goals; legislative and executive policies for ICZM

5. Boundary definition

- Set final boundaries for Coastal Zone and Sub-Zones (preliminary zonation in Plan).

6. Jurisdiction

- Clear policy for jurisdiction of Coastal Directorate and other agencies with coastal interests.

7. Authorisations

- Official authorisations of programme by Assembly/CMB, including: 1) objectives, 2) mandate for Coastal Directorate, 3) institutional set-up, 4) staffing, 5) equipment, 6) training, 7) budget, 8) cost recovery, 9) FORUM and stakeholder participation, 10) rule making permit letting, and EIA authority, 11) enforcement powers, 12) co-ordination mechanisms, and 13) incorporation of the entire programme listed in Item 8 below.
- Official agreements by Central and Provincial government to align programmes and agencies with CMB coastal programme .
- Create a Forum with legislative authorisation and designated representative membership.

8. Programme details

- Construction and maintenance of coastal protection works (including new works and restoration of dunes)
- Drainage: Operation of *Desaquadouro* (revised protocols) and internal drainage system repairs and operation; design alternative drainage system using Rio Chiveve
- Regulatory programme for coastal development: permit letting, standards/guidelines for development, permitted/prohibited actions, EIA system, higher review (Forum review committee), appeals system

- Regulatory programme for dune and beach: sand mining, access, vehicles
- Training of coastal managers
- Education and community awareness
- Monitoring of beach, water quality,
- Environmental management: preserves, nature reserves, pollution control, mangrove protection; regulatory programme for resource reserves (mangrove complexes and low marshes)
- Devise and operate storm readiness system, including warnings and contingency plans for beach repairs and other needs

9. Administration

- All particulars on administrative procedures to be used by Coastal Directorate.

10. Budget

- All particulars on budget: sources, management, accounting. Funding may come from local, provincial, or central government, from cost recovery, or from international donors.
- Timetable for the various activities with budget linkages.

ANNEX 9. STATEMENT ABOUT RESTORATION OF CHIVEVE RIVER

The *Conselho* Municipal da Beira is engaged in a project to improve the coastline of Beira by making important repairs to the sea defence system along the coast and by creating an Integrated Coastal Zone Management Plan to better organise future use of the coastal area. This work is assisted by funding from the Royal Netherlands Embassy in Maputo.

In this connection, the *Conselho* is being assisted by the consulting firm of ARCADIS Euroconsult in designing short term Emergency Works to provide immediate protection of the seacoast of Beira, to be accomplished this summer, and a longer term plan to provide for more permanent coastal defences.

For the long term, several experts have recommended elimination of the present drainage outlet at Palmeiras because it is arresting the westerly movement of sand along the beach and causing damaging erosion of the shore all the way to *Ponta Gea*. Elimination of the Palmeiras outlet would require rerouting of the drainage water from this outlet to the Chiveve River and into the Harbour area. To do this the Chiveve River would have to be revitalised -- its flow way would have to be improved and its mouth reopened, necessitating replacement of the present small box culvert that now drains the Chiveve channel into the fishing port under the old bridge. The culvert does not have sufficient capacity to handle the required flow and would have to be replaced with a wide channel, similar to the old river mouth, through the now vacant area.

This wide channel could be covered with a column supported concrete deck to provide surface area for development. It would be possible to create a new commercial waterfront facility here with integrated retail, entertainment, and/or residential space in the vacant area between the old bridge and the fishing port. Such development, by private sector investment, is realistic and may be necessary to fully justify the Chiveve River revitalisation. Waterfront malls have been universally successful in ports around the world. A concept sketch is attached.

Comments are solicited from those who are making plans for this area, such as modernisation of the fishing port. We believe that redirecting drainage flow by reopening the Chiveve River mouth may reduce siltation in the fishing port and have many other benefits to the City.

Note: This statement was circulated for comment in June, 1998.

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