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DIRECÇÃO DE ENGENHARIA





FINAL REPORT

Simplified Environmental Study of the Dredging of Beira Port Access Channel

PREPARED FOR:
DIRECÇÃO DE ENGENHARIA DOS PORTOS E CAMINHOS DE FERRO DE MOÇAMBIQUE, EP.

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1 Introduction

The company CFM ("Caminhos de Ferro de Moçambique" - *Mozambique Railways)* intends to dredge the Access Channel to the Port of Beira, with the intention of returning it to its original dimensions, to allow, once again, 50,000 DWT ships to enter, and to promote the revitalisation of ship movement in the Port of Beira.

Various studies had been conducted for this in the past, the most important being the Dredging Maintenance in the Beira Channel Feasibility Study, conducted by JICA in 1998, which included an environmental assessment of the dredging process of the Port of Beira Access Channel.

According with the *Environmental Impact Assessment Process Regulation* (Decree 45/2004) all public and private activities must initiate an Environmental Impact Assessment Process submitting information to the Environmental Impact Assessment Authority about the project which enables the classification in environmental categories and the consequential definition of which type of environmental assessment is required.

CFM submitted the Screening Report to the National Directorate of Environmental Impact Assessment (DNAIA) at the end of April 2006 to initiate the environmental impact Assessment Process, of the Dredging of the Port of Beira Access Channel Project Process.

With this document as reference, DNAIA classified the project as being of Category B, requiring the submission of a ***Simplified Environmental Study (EAS*)**, after the approval of the respective Terms of Reference by the DPCA (Ref 334/DGA/DPCA/06 of the 15th of May). The Terms of Reference were submitted by CFM in June 2006, having being approved by the Sofala DPCA (Provincial Office of Environmental Coordination) in July, 2006 (Ref 512/DGA/DPCA/06 of the 3rd of July) (See Annex 1).

In October 2006, CFM contracted CONSULTEC – Consultores Associados Lda to conduct the Simplified Environmental Study of the Dredging of the Port of Beira Access Channel.

CONSULTEC, Ltd is a consulting company registered as an Environmental Consultancy in the National Directorate of Environmental Impact Assessments (DINAIA) which is part of the Ministry of the Coordination of Environmental Action (MICOA).

This report includes the Simplified Environmental Study and the Environmental Management Plan for the Dredging of the Port of Beira Access Channel. This report was conducted in accordance with the respective Terms of Reference, taking into account MICOA recommendations, the national legal requirements and the general activity guidelines.

The structure of the report was defined taking into account the structure recommended by MICOA and by the Terms of Reference of this study.

During the Environment Impact Assessment process efforts were made from the beginning to involve all stakeholders through contacting interested and affected parties.

2 Legal Framework of the activity

2.1 Environmental Impact Assessment Process

The *Environmental Impact Assessment Process Regulation* (AIA), approved by Decree nº 45/04 on the 29th of September, and included in the Environmental Law (Law nº 20/97), applies to all public or private activities which directly and indirectly affect the environment.

The Regulation defines the environmental assessment process, and is comprised of; a definition of the environmental studies required for an environmental licence, the required contents of an environmental study, the public participation process, the process of revising studies, the decision about environmental Feasibility, and the granting of an environmental licence.

For the definition of required environmental studies required for an environmental licence (Article 3), the Regulation categorised the activities in three classes:

Category A: projects that could have significant impacts due to the proposed activities or the sensitivity of the area, requiring a full EIA, including an Environment Management Plan (EMP). Projects classified as Category A projects are listed in the EIA Regulations' Annex.
Category B: corresponds to projects that would have negative impacts with lower duration, intensity, extension, magnitude and/or significance, requiring a Simplified EA and EMP. Annex II of the Regulations for Environmental impact assessment for Category B Projects describes the activities of low environmental Impact, eligible for Simplified Environmental Assessment (SEA) and Environmental Management Plan (EMP).
Category C: for projects that do not require any EA, but which are subject to the rules included in specific directives.

The Environmental Impact Assessment regulation defines the EPDA and EIA report structures for Category A projects, as well as for Simplified Environmental Studies (SES) reports required for Category B classified projects.

Annex I of the regulation lists the circumstances that result in a Category A classification, taking into account the sensitivity of the intended area of the project as well as the type of activity proposed, while Annex III contains the list of activities classified as Category C.

The **General Guidelines for Environmental Impact Studies** were recently published in the *Boletim da República* through Ministerial Diploma nº 129/06, on the 19th of July; it details the procedures for the Environmental Licence and format, general structure and content of the Environmental Impact Studies.

On the same Diploma, the **General Guidelines for Public Participation in the Environmental Impact Study Process,** that defines the basic principles with reference to public participation, methodologies and procedures, was also approved. It should be highlighted that these guidelines requires an interactive public participation process, which begins in the development action design phase, and continues during the construction and operational phase.

In Mozambique, the EIA process is a legal requirement according to the Environmental Law (Law nº 20/97). At the same time, the EIA process is ruled by the EIA Regulations (Decree nº 45/2004).

In terms of the EIA regulations, the dredging activities of the Port of Beira Access Channel are classified as Category B activities and are subject to a Simplified Environmental Study. The relevant criteria that result in this classification include:

- The dredging does not aim to open any new channels nor deepen them, it will simply return them to their original size,
- Other studies that have been done in the area, including an Environmental Assessment, included in the Maintenance and Improvement of the Beira Access Channel Study completed by JICA in 1998.

The Environmental Impact Assessment Process for the production of a Simplified Environmental Study can be seen in the diagram below (Figure 2.1)

According to the Regulations, the Simplified Environmental Studies should contain:

- Non-Technical Summary, with the main questions addressed;
- Description of the project and location;
- Legal Framework;
- Environmental Baseline, with a brief description of the environmental status in the study area;
- Identification and assessment of Impacts and Mitigation Measures;
- Environmental Management Plan, with monitoring of predicted impacts, mitigation measures and accident contingency plans;
- Public Participation Process Report

As previously mentioned, the Public Participation Process is not compulsory in Category B classified projects. Despite this, to complete a correct impact assessment and to complete adequate mitigation measures a simple participation process, with interviews with the principal stakeholders in the project, is considered important.

During the conducting of this study, key stakeholder consultation was made, namely the local fishing community and the Beira Municipality (see Annex 2).

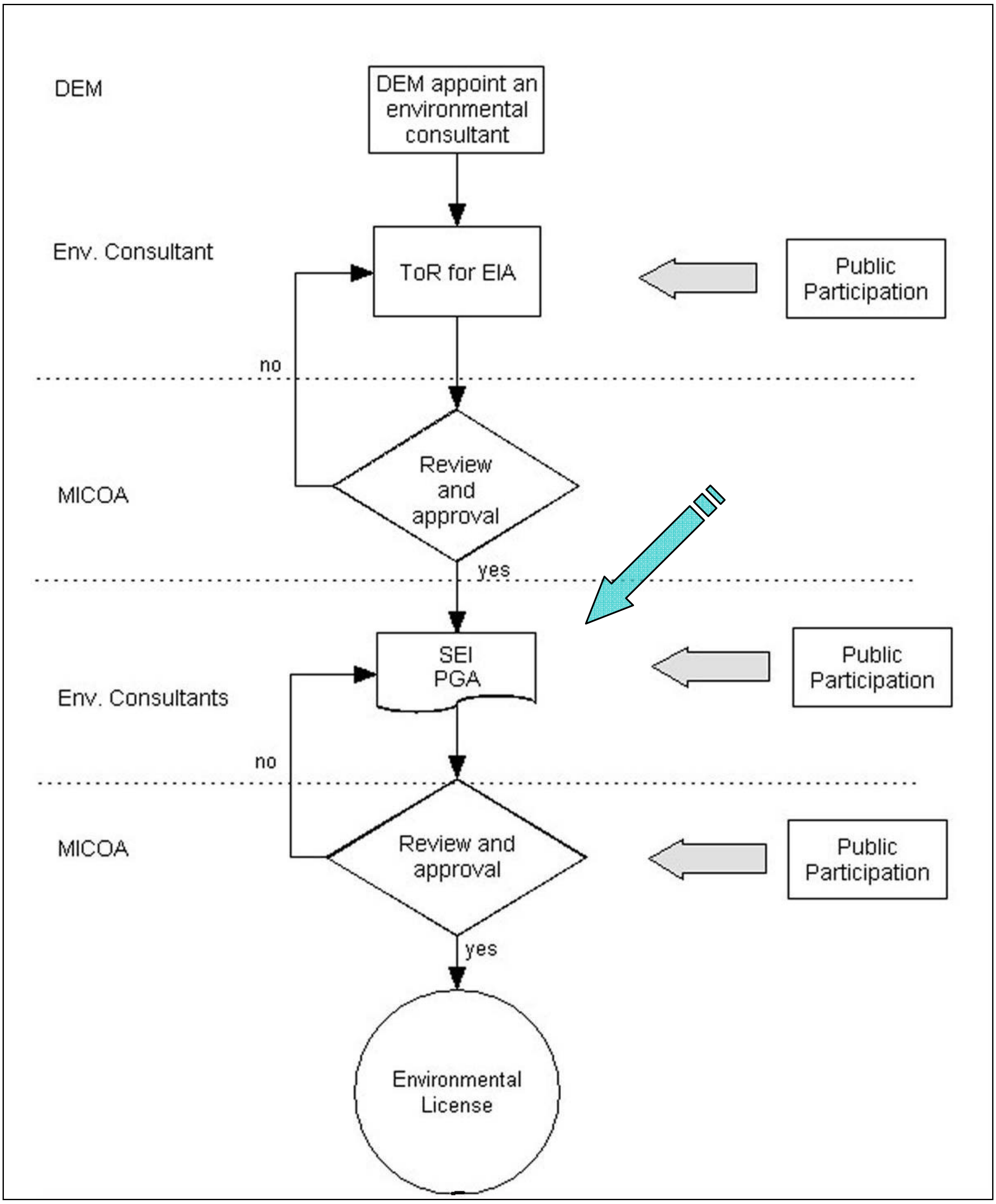


Figure 2.1 – Environmental Assessment Process. The arrow indicates the current stage of the process

2.2 Legal Framework relating to the Environment

The **Constitution of Mozambican Republic** defines the right of all citizens to live in a balanced natural environment and their obligation to protect it. Furthermore, the State is required to (i) promote initiatives capable of ensuring the ecological balance and the preservation of the environment; and (ii) implement policies to prevent and control pollution and to integrate environmental objectives in all public sector policies so as to guarantee the citizens' right to live in a balanced environment under a sustainable development framework.

The **National Environmental Policy**, approved by Resolution Nr. 5/95, dated 6th December 1995, establishes the basis for all environmental legislation. According to Article 2.1, the main goal of this policy is to ensure sustainable development in order to maintain an acceptable commitment between socio-economic development and environmental protection. In order to reach this goal, this policy must ensure, among other aspects, the management of the country's natural resources – and the environment in general – in order to preserve its functional and productive capacity for present and future generations.

Environment Law

The Environment Law (Law nº 20/97) was approved by the Republican Assembly in 1997 defines the legal basis for the sound use and management of the environment as a means to safeguard sustainable development in the country.

Some of the basic principles of Environmental Management are:

- Environmental management should guarantee improvement in the quality of life of its citizens and the protection of biodiversity and ecosystems;
- Recognising and valuing local community traditions and knowledge;
- Give priority to systems that prevent environmental degradation;
- An integrated and all-encompassing perspective of the environment;
- The importance of public participation;
- Principle of polluter-pays;
- Importance of international Cooperation.

In terms of environmental pollution, this law limits the "production, or deposit on or below land, the dumping in the water or the atmosphere, of any toxic or polluting substances, or the practice of activities that accelerate erosion, desertification, or deforestation or any other form of environmental degradation" to the legally established limits (Article 9). The law defines the establishment of environmental standards through regulation (Article 19) that would happen through Decree nº 18/04 of the 2nd of June.

Furthermore, it stipulates that in the planning, implementation and operational phase of the project that the protection of biological resources should be guaranteed, in particular the animal or plant species threatened by extinction or that, through their genetic, ecological, cultural, or scientific value, require special attention; this extends to their habitats, especially those that are in environmental protection areas (Articles 12 and 13).

Decree nº 18/04 of the 2nd of June approved the **Standards of Environmental Quality and the Emission of Effluents Regulation**. The regulation aims to ensure the control and inspection of the quality of the environment, being applicable to all public or private activities that could indirectly or directly affect the environment.

It specifies:

- Parameters for the maintenance of air quality (Article 7);
- Standards of gas pollutant emissions for a range of industries (Article 8);
- Standards of gas pollutant emissions for mobile sources (Article 9) – including light and heavy vehicles;
- Standards of the receiving body – sea/ocean (Article 16).

The Ministry for the Environmental Action Coordination at the national level and the Provincial Office for Environmental Action Coordination of Sofala at the provincial level ensure the adherence to these laws.

Due to the need to establish legal inspection mechanisms for public and private activities that directly or indirectly could possibly cause a negative impact on the environment, the **Environmental Inspections Regulation** (decree nº 11/2006 of the 15th of July) aims to regulate supervision, control and inspection of the adherence to the standards of environmental protection at a national level.

Water Law

The Water Policy and the **Water Law** (Law nº. 16/91, of the 3rd of August) define the management of water resources in Mozambique. The basis of these documents are: the principle of public water domain, water management based on hydrographic basins, the principle of user-pays and polluter-pays, concessions and licence standards for water use and the safe-guarding of ecological and environmental equilibrium.

The Water Law defines (in Article 54) the regulation of the standards of effluent quality, water receiving bodies, system technologies and treatment methods. As was mentioned before, the Environment Law also defines the regulation of the standards of environmental quality.

The responsibility of the polluter is reinforced in Article 55 that establishes that, in the case of contamination or degradation, the polluter is obliged, independent of the penalty applied, at their cost, to return the environment to the condition it was in before the event.

The **Sea Law** (Law nº. 4/96, of the 4th of January) defines that the economic exclusive zone of the Republic of Mozambique as being "**comprised of the strip of the sea past and alongside the territorial sea that extends a distance of 200 nautical miles, measured from the base line from where the territorial sea is measured"** (Article 9). This zone is under the jurisdiction of the Mozambique State, which has the sole rights of use and profit, and also the conservation and management of its resources. To fulfil this function the state has designated two institutions:

- National Institute of Hydrography and Navigation (INAHINA)
- National Marine Institute (INAMAR)

According with the Sea Law, the Mozambican Government has the responsibility of regulating and administrating all sea activities within the waters of Mozambican jurisdiction, as per international law, as found in Article 34, namely in matters related to the protection and preservation of the marine environment and protection of archaeological objects.

However, Decree nº. 495/73 of the 6th of October, relating to **water pollution**, is still applicable. It determines various protection measures to safeguard against the pollution of waters, beaches and coastlines of what is called "Portuguese Ultramar" of which the Mozambican coast is included. The Decree prohibits, apart from the case of a special licence, the disposal of any substances that could pollute the waters, beaches or coastline, namely petrol products or mixtures containing them. Equally, it prohibits the pollution of any part within the area of jurisdiction of the maritime authorities by any outside party. The maritime authorities will be responsible for taking adequate measures to impede or reprimand violations of these laws.

This article will soon be integrated in one *Regulation for the protection, management and development of the Coastal, Marine, Lacustrine and Fluvial Environment,* which is presently being prepared by MICOA.

Fishing Law

The **Fishing Law** (Law Nº. 3/90) and the **General Regulation of Maritime Fishing** (Decree 43/2003) define the regulation of fishing activity and activities relating to management, and protection of ecologically sensitive marine areas and marine areas home to juvenile species.

Both the Ministry of Fishing, at the central or national levels, and the Provincial Office of Fishing of Sofala at the provincial level, ensure the observance of what was legally established.

Wastes

The Environment Law prohibits the disposal of pollutants on surface or subterrain, or the releasing pollutants into the atmosphere or in water bodies and prohibits importing by-products or dangerous waste to national territory (Article 9). Furthermore, the Water Law (Law nº 16/91, of the 3rd of August) prohibits the accumulation of solid waste or dumping of any substances that contaminate or pose danger of contaminating waters (Article 53). In the past the management of waste was managed by the **Waste Management Regulation** (Decree nº 13/2006, of the 15th of June).

The objective of this regulation is to establish rules regarding the production, disposal on soil or below soil, or releasing into water or into the atmosphere, of any toxic substances or pollutants, including practicing polluting activities that accelerate environmental degradation, with the aim of preventing or minimizing their negative health and environmental impacts.

The regulation classifies dangerous and non-dangerous waste and stipulates that MICOA is responsible for dangerous waste material management, namely the licence that is associated with the management of dangerous waste or toxins. It also states that public and private entities that manage waste must have a Waste Management Plan before beginning their activities, valid for a period of five years from the approval date.

Procedures for the separation, treatment, collection, movement, and methods of disposal, are defined in relation to dangerous wastes. Furthermore, it states that waste can only be moved away from any waste-producing entity's installations by MICOA approved transport operators, and that the cross-frontier movement of waste material must obey the Basileia Convention, ratified by Mozambique by Resolution nº 18/96, of the 28th of November.

Atmospheric Emissions and Quality of Air

Article 9.1 of the Environment Law prohibits the release of any toxic or polluting substances into the atmosphere outside of the legally established limits. The **Environmental Quality and Effluent Emission Standards Regulation** (Decree nº 18/2004) defines the pollutant emissions standards as well as fundamental parameters that characterise air quality.

In relation to mobile sources, the regulation defines maximum emission limits for different categories of vehicles, according to determined types of fuels used.

The standards of air quality stipulated by Decree nº 18/2004, considered necessary to maintain the air's ability to self-regulate and purify, and to not incur a significant negative impact on public health and ecological balance, are presented in the following table.

Table 2.1 –Standards of Air Quality according to Decree 18/2004

Parameter ($\mu g/m^3$)	Testing Time							
	1 Hour		8 Hours		24 Hours		Annual Arithmetic Average	
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
Sodium Dioxide (SO_2)	800	-	-	-	365	-	80	-
Nitrogen Dioxide (NO_2)	400	-	-	-	200	-	100	-
Carbon Monoxide (CO)	40.000	-	10.000	-		-		-
Ozone (O_3)	160	-	-	-	50	-	70	-
Total Suspended Particles (TSP)	-	-	-	-	200	-		-
Lead (Pb)	3	-	-	-	-	-	0,5-1,5	-

Article 22 of this Regulation takes into the account the possibility of extraordinary emission of pollutants into the environment, namely through breakdowns or for other unpredictable circumstances, and needs special authorisation that must be granted by the Ministry of Environmental Action Coordination (MICOA), along with the payment of a determined tax according to the circumstances detailed in Article 23.

Relating to noise, Article 20 of the Decree nº 18/2004 states that noise emissions standard will be approved by MICOA (the date of the completion of this standards report has still not been published). The same article states that the noise emission standards will be established taking into account the source of the noise.

2.3 International Conventions

In the terms of Article 18 of the Constitution of the Republic of Mozambique (CRM, 2004) the approved and ratified conventions or treaties become active on their date of publication in the *Boletim da República*.

Before they are published, the conventions or treaties are not legal documents within Mozambique.

Furthermore, in most cases, it is not enough for the Convention or Treaty to simply be ratified by the Mozambican Government and published in the *Boletim da República*.. To be executable or approvable it is necessary that certain convention findings be converted into concrete internal law regulations.

There are some International Conventions that have been ratified by the Mozambican Government related to pollution and/or environmental protection of the sea of which the most notable is the National Convention for the Prevention of Pollution by Ships of 1973 and its 1978 Protocol – MARPOL 1973-1978.

The Republic of Mozambique joined the National Convention for the Prevention of Pollution by Ships of 1973 and its 1978 Protocol, both known by their abbreviation “MARPOL 1973-1978” in Resolution n.º 5/2003 of the 18th of February published in the Bulletin of the Republic n.º 7, 1st Series of the 25th of February 2003, 3rd Supplement.

MARPOL 73/78 is the most important international convention in relation to marine environment pollution prevention. It is one of the few conventions that prescribe specific emission limits instead of prioritising politically strategic objectives.

The Convention includes findings whose objective is to prevent and minimise marine pollution derived from the disposal of prejudicial substances or effluents containing such substances, resulting from accidental pollution or from routine operations.

The definition of “prejudicial substance” is important, and the concept is defined in Article 2 of the Convention as, “meaning any substance that once released into the sea is: susceptible to cause harm to human health, damage to living resources and marine life, affect recreation areas, or to interfere with other legitimate uses of the sea including any substance subject to control by the present Convention”.

Furthermore, and contrary to the International Convention on Civil Responsibilities due to Harmful Effects of Hydrocarbon Pollution Protocol, 1992 (CLC 1992) the definition given to ships is more all-encompassing, as, for the MARPOL 73/78, “ships are any type of vessel that operates in the marine environment and includes hydrodynamic vessels, air-propelled vehicles, submarines, floating structures and fixed or floating platforms”, which all relates exactly to the case of the present study.

Therefore, in accordance with MARPOL, the following obligations of the company contracted by CFM for the dredging are comprised of the following:

- **a.** Immediately complete a report of any incident involving prejudicial substances in the terms of Article 8 of the Convention and of Protocol 1 of the Convention;
- **b.** Have an emergency plan approved by the “Administration” in the case of hydrocarbon pollution in the terms of Rule 26 of Annex 1;
- **c.** Have an International Certificate of the Prevention of Pollution by Domestic Waste, in accordance with Annex IV of the Convention and its Appendix;
- **d.** Do not discharge any domestic waste into the sea that are not in accordance with the conditions of Rule 8 in Annex IV;
- **e.** Do not release into the sea, whether it be from ships or fixed or floating platforms, any substances listed in Rule 3 of Annex V, that are not in the prescribed conditions in the same Rule or in Rule 4 of this Annex;
- **f.** Have a waste management plan and other established directions as per Rule 9 of Annex V;
- **g.** Have a Waste materials managed Register Book.

Along with these conventions ratified by the Mozambican Government, various other international accords relevant to the project are of note. Amongst them:

London Convention, 1972

The Convention on the Prevention of Marine Pollution through the Disposal of Waste and other materials regulates the disposal of materials listed within it. Article 4 forbids the disposal of prohibited substances (presented in Annex 1) and lists which substances require a licence to be deposited (Annex II). The convention prohibits the disposal of any waste produced through normal vessel activity (Article 12).

Amongst other substances, Annex I Prohibits the disposal of any type of material (solid, liquid, semi-liquid, gas, or in a latent state of life) that even having been degraded chemically, physically, or biologically, produce negative effects on marine organisms or put human life in danger.

Materials produced from dredging, which contain small quantities of these components, are subject to a licence before being deposited in marine waters in accordance with the procedures prescribed in Annex II.

European Union Council Decision (n.º 94/156/CE) of the 21-02-1994

Despite the Council Decision only being applicable to European Union Member Countries, some of its guidelines can be applied to the project, namely, the clause for the prevention of dredge waste into the sea (Article 9).

The article determines that the prohibition of disposal materials is not applicable to the disposal of dredge waste in the sea on the condition that: (i) the dredges do not contain significant quantities and concentrations of substances considered harmful; (ii) the disposal is done under a special licence by a qualified national authority in the territorial waters of the contracted party.

In the case of a suspected violation of the article, the contracted party will cooperate in the research of the case.

To grant a special licence, the qualified national authority needs to take into account:

1. The quantity of waste that will be deposited.
2. The contents of the substances considered harmful;
3. The location (eg: coordinates of the disposal location, depth and distance from the coast) and its relation to zones of special interest (eg: tourist attraction areas, breeding areas, or areas of juvenile and fish development, etc.);
4. The characteristics of the water, namely: (a) Hydrographical properties (eg: temperature, salinity, density, profile); (b) Chemical properties (eg: pH, dissolved oxygen, nutrients); and (c) Biological properties (for example, primary production and benthonic animals). The data should include sufficient information about average annual levels and seasonal variations of these properties;
5. The occurrence and effects of other deposits eventually done in the disposal location.

In addition to this aforementioned information, completed reports of dredging operations should include:

1. The type of waste;
2. The quantity and composition of materials deposited, such as physical properties (for example, solubility, density) chemical and biochemical properties (eg: lack of oxygen, nutrients) and biological properties (eg: existence of viruses, bacteria, fungus, and parasites);
3. The toxicity of the dredged materials.

2.4 Relevant Institutions and Authorities

MICOA

The Ministry of Environmental Action Coordination (MICOA), created by Presidential Decree nº 2/94, of the 21st of December, is, at the central level, the authority that best understands the environment, with the functions and main objectives established by Presidential Decree nº 6/95, of the 16th of November. At the provincial level it is represented by the Provincial Offices of Environmental Action Coordination (DPCA).

The Centre of Sustainable Development (CDS), specialised in development and coastal management, was specifically created within MICOA to manage the coast. It was formally created through Decree nº 5/03, of the 18th of February. This centre is a public institution endowed with administrative autonomy that has the objective of: the coordination and promotion of studies and their dissemination, technical assistance, training, development of pilot management activities relating to the coastal, marine and lacustrine environment that contribute to the creation of policies and formulation of legislation that promote development of the coastal zones.

The CDS should be outspoken about scientific questions and those of the coastal and marine environment management whenever required. Amongst the responsibilities of the CDS – Coastal Zones, the following should be addressed:

- Promote the integrated planning and implementing of Environmental Management Best Practices, in collaboration with other relevant institutions;
- Promote and watch the monitoring of the state of the environment, use and conservation of natural resources and biodiversity of coastal zones, and
- Provide advisory services in environmental material in coastal zones.

INAMAR

The National Marine Institute (INAMAR), legally constituted by Decree nº 32/04 of the 18th of August, is the maritime authority lead by the Ministry of Transport and Communications. According to the Decree, INAMAR is the administrative organ that is responsible for preventing and combating maritime pollution, in all national territory waters. The institute assumed the functions of SAFMAR (Administration Services and Maritime Monitoring), created in 1994.

INAMAR plays the role of maritime authority in the areas of maritime jurisdiction, lacustrine and riverine; the promotion of the establishment and maintaining of maritime security in relation to all maritime activities; and the promotion and creation of incentives for efficiency and competition through economic regulation, especially in the interest of the users and providers of services.

Within their responsibilities the most notable are listed below:
- Security and maritime administration and protection of ships and ports;
- Propose legislation and regulations to call attention to environmental damage that could be caused by vessels or other floating or fixed structures in the sea, taking into account international conventions;
- Licence, monitor and control Marine activities, monitor the observance to legislation and security regulations for infrastructures;
- Authorise and monitor dredging activities in the ports and interior waters;
- Promote preventative actions and combat marine pollution;
- Participate with or affiliate with organisations and international forums that work for the establishment of rules and norms, such as practices and procedures to prevent, reduce, control and combat pollution of the marine environment by ships; and
- Take necessary measures that could be necessary to prevent, reduce, control and combat pollution of the environment by ships.

INAHINA

The National Institute of Hydrography and Navigation (INAHINA) is the juridical face and have administrative and financial autonomy. The institute was established in 1989 (Decree nº 40/89 of the 5th of December), but its Organic Statute was readjusted by Decree nº 39/94 of the 13th of September, to take into account the current development situation in the sector. Its roles and responsibilities are defined in Decree nº 27/2004 of the 20th of August.

This institution works in the technical and scientific areas of Mozambican territorial waters, aiming to guarantee shipping security and to contribute to the country's development in the scientific and environmental protection areas, and providing support to the research of existing marine resources.

Amongst INAHINA various responsibilities, of note are their study results and technical recommendations about projects involving new dredging, hydraulic maritime works, and other works that could affect the hydrographic patterns of ports and beaches.

Amongst their roles the following are of note:

- Coordinate, promote, develop and monitor activities that are conducted relating to hydrographic, physical oceanography, national maritime security, nautical cartography, and maritime signalling;
- Approving of projects or plans relating to lighting up or placing of buoys on coasts, ports, or navigational channels being conducted in any part of national territory;
- Approving of the execution of all projects, and works that could affect hydrographic charts and plains (published or being published), as well as all topographic studies of charted areas, with the final aim of improving security and the updating of nautical documents.

INAHINA is responsible, amongst its other roles, for the definition of hydrographic norms, assuring the lighting (through lighthouses) or placing of buoys in maritime waters and to release study results and technical recommendations about new dredging projects, hydraulic maritime works and other work that could alter the hydrographic norms of ports and coastlines.

EMODRAGA Legal Rights

The Mozambican Dredging Company (EMODRAGA, E.P) is a public company of the Mozambican Government, with administrative, financial and patrimonial autonomy, that is subordinate to the Ministry of Transport and Communication, according to Decree N^{o} 38/94 of the 13th of September. Based in the city of Beira, the company conducts dredging services for the whole country, principally in the Ports of Beira, Maputo and Quelimane.

Their main objective is to conserve the channels and access to national ports as well as manoeuvring basins, anchoring areas and coastal zones. In addition, EMODRAGA must also conduct construction dredging for the enlarging or deepening of access channels to ports and participate in hydraulic works in ports and waterways. The Decree also defines that EMODRAGA specifically works in port engineering, and the production of sands destined to be used in construction.

2.5 Legal Framework of the Activity

At present, no legislation or specific guidelines exist about dredging operations or for the disposal of the dredged material. In accordance with INAHINA statutes, the institute must be consulted regarding any dredging operation, hydraulic works or any other activity that results in changes of the hydraulic pattern. However, according to an assessment conducted by the World Bank in 1999, it was found that this type of consultation doesn't occur in a majority of cases.

There is a lack of coordination within the different government institutions in charge of the management of the coastal and maritime area, mostly between CFM, INAMAR, INAHINA and MICOA, who have their responsibilities overlapped especially in port areas.

The lack of a National Dredging Plan or a Dredging Contingency Plan makes it difficult to form an integrated vision of the consequences of dredging on the integrity of the coastline, which according to their statutes, are the responsibility of INAHINA.

The control of the dredging locations and the volume of dredged materials removed by EMODRAGA or any other dredging company contracted by CFM is presently the responsibility of CFM, under the overall responsibility of INAHINA; but the licence is issued by INAMAR.

3 Project Definition and Description

3.1 Definition and Justification

The city of Beira was founded in 1884 as a military base with a naval port. The existence of this navel port, from the beginning, has accompanied and contributed to the economic development of the city and the central region of the country in general. The city is located on the western bank of the River Pungue Mouth, and the port is situated approximately 20km from the open see (Figure 3.1 and 3.2)

Figure 3.1 – Satellite image of the city of Beira and the location of the port. The estuary of the Access Channel to the port can be seen in the darker parts and in the clearer parts the sedimentation in the channel*. (Adapted from Google Earth, 2006)*

Figure 3.2 – Aerial view of the City of Beira, with the Fishing Port in the middle, followed on the left by the Port of Beira on the Bank of the Pungue River *(USGIS, 2006)*

Port activities are completely dependent upon the functioning of the Access Channel and the free transit of ships that use the Port. Due to the high level of sediment that continually flows into Sofala Bay, periodic maintenance of the navigation channels by dredging is fundamental.

However, due to constraints in dredging maintenance activities, the Port Access Channel (created in 1988) is presently suffering high levels of sedimentation, putting at risk the everyday functioning of the Port of Beira.

In its original state the channel (depth of -8.0) allowed for ships of up to 50,000 DWT of weight. However, with its current condition, the Port can only receive ships of up to 20,000 DWT at high tide (this value could reach up to 25,000 DWT in spring tides).

Studies conducted by CFM shown that in 1996, about 86% of ships attending for the Beira Port had to wait for appropriate tides to enter the Port facility (i.e. 6.5m tides). In 2000, the number of cargo ships attending to the Port had increased 61% and also the "tide waiting time", increasing the traffic contrains, due to the increase in the Access Channel sedimentation.

The worldwide trend tending towards ever-increasing sizes of ships to increase the efficiency of maritime transport further reduces the possible number of vessels that can utilise the Port of Beira, resulting in economic losses for the Port.

Because of this, CFM intends to conduct an Emergency Dredging, considered indispensable for the future functioning of the Port. This high-scope dredging presently proposed has the main objective of removing the excess materials in the Port of Beira Access Channel, to return it to its original width and depth, which was established in the 1989 dredging.

In the short term, it is hoped that the dredging will allow for an increase in the number of vessels that can reach the Port and reduce the waiting time, which would result in more economic activity for the Port.

In the medium to long term, it is hoped that this economic impulse can improve economic activities throughout the city, directly or indirectly linked to the Port, as well as economic activity in the Province and the country's central zone, with an increase in commercial traffic in the Beira Corridor.

3.2 Background

Dredging to the Port of Beira Access Channel has been conducted since colonial times (since about 1924), to ensure navigation channels in the area remain open.

In the 1980s (between 1985 and 1988), the channel was dredged at approximately 0.33 million m^3 of sediments per year by EMODRAGA dredging ship "Rovuma" and in the areas in front of the fishing terminal cargo terminals, close to 0.8 millions m^3 were removed during these 8 years (JICA, 1998)

In 1989 large scale dredging was conducted over 19 months by the company Breenjenbout-Voskalis in association with EMODRAGA, to deepen the Port of Beira Access Channel. This project, conducted during the expansion of the Port of Beira, deepened the existing channel (-6.0 m) to the depth of -8.0 m, removing more then 10,000.00 m^3 of sediments (JICA, 1998)

Part of the dredged material of this operation was deposited into the sea, in pre-established disposal zones; other part was used for the physical rehabilitation of the Port and expansion of the container area. Most of the sediment was deposited on land in the area where Terminals 10 and 11 are presently located. The Praia Nova area also results from the dredging material deposition.

To maintain the Channel functionality, frequent dredging maintenance would be necessary of nearly 2.5 million m^3 of sediment per year to fight the estuary high level of sedimentation. However, the lack of a robust dredger with the capacity to dredge this amount of sediment annually, along with the natural sedimentary dynamic of the coast, did not allow the Channel to be maintained at its original dimensions.

EMODRAGA current fleet has three boats for research and general activities and four dredgers, of which only two have large capacity – the 44-year-old "Rovuma" and the 5 year old "Arangwa" (figure 3.3). Their suction capacities are 1.528 m^3 and 1.000 m^3 respectively, and they are responsible for the maintenance of the Access Channels of Maputo, Beira and Quelimane Ports.

Figure 3.3 – Photo of EMODRAGA two main dredgers, Arangwa (on the left) and Rovuma (on the right). *Consultec, 2006*

Despite working at full capacity, the current fleet does not have the capacity to dredge the 2.5 million cubic metres of sediment annually for the maintenance of the Port of Beira Access Channel. In the table below, the total amount of volume dredged per year is shown for the last 15 years. As can been seen, the total amount of dredged sediments over these years comes to a little more than half of the recommended annual amount (EMODRAGA, 2006).

Table 3.1 – Volumes dredged by EMODRAGA since the opening of the new Access Channel until 2005

Year	Volume dredged (m^3)
1990	143.190
1991	774.737
1992	191.603
1993	1.142.970
1994	587.609
1995	36.230
1996	36.830
1997	559.858
1998	1.170.853
1999	2.073.776
2000	1.100.401
2001	1.717.539
2002	2.204.025
2003	1.318.102
2004	1.969.460
2005	864.542
Total	**14.174.638**

Source: Adapted from EMODRAGA, 2006

At present, due to the substantial sediment build-up that has occurred over the last few years, and due to the inability to conduct adequate dredging, the depth of the channel has reduced from -8.0 m to -4.0 m and a varying width of 135-200m to 75m im most of the channel. In the zones where the sedimentation appears most critical,, navigational channel displacements can be seen - at the Macuti curve, vessels navigate at about 350 metres further south of the original Channel.

In the figure below, the Access Channel can be seen with different sections in accordance with the original 1989 plan. The grey zones schematically represent potential zones for the dredge materials. Table 3.2 shows the channels characteristics at each section.

The most critical areas of sedimentary build-up are at the Macuti bank – in sections E12, E11, E10 and E9 of the channel - and in section E8. Within the actual Port itself, sections E5 and E15 are found to be completely filled with sediment, being sometimes one metre above the average sea level (JICA, 1998; CFM, 2006).

Table 3.2 – Dimensions of the opening of the Channel in 1990 per section

Sections of the Channel	Depth (m)	Width (m)	Length (m)
E1 ([1])	10.00	50	987
E2 ([2])	12.00	50	646
E3 ([3])	13.50	50	260
E5	5.50	200	970
E15	7.50	145	970
E4	8.00	200	3,050
E6	8.00	135	2,134
E7	8.00	135	2,160
E8	8.00	135	2,186
E9	8.80	135 - 250	1,614
E10	9.20	200 - 155	3,394
E11	8.70	155	2,428
E12	8.80	140	2,224
E13	8.50	140	4,375
E14	8.70	160	3,700

[1] In front of commercial Terminals 6-11
[2] In front of commercial Terminals 2 -5
[3] In front of loading Terminal 12

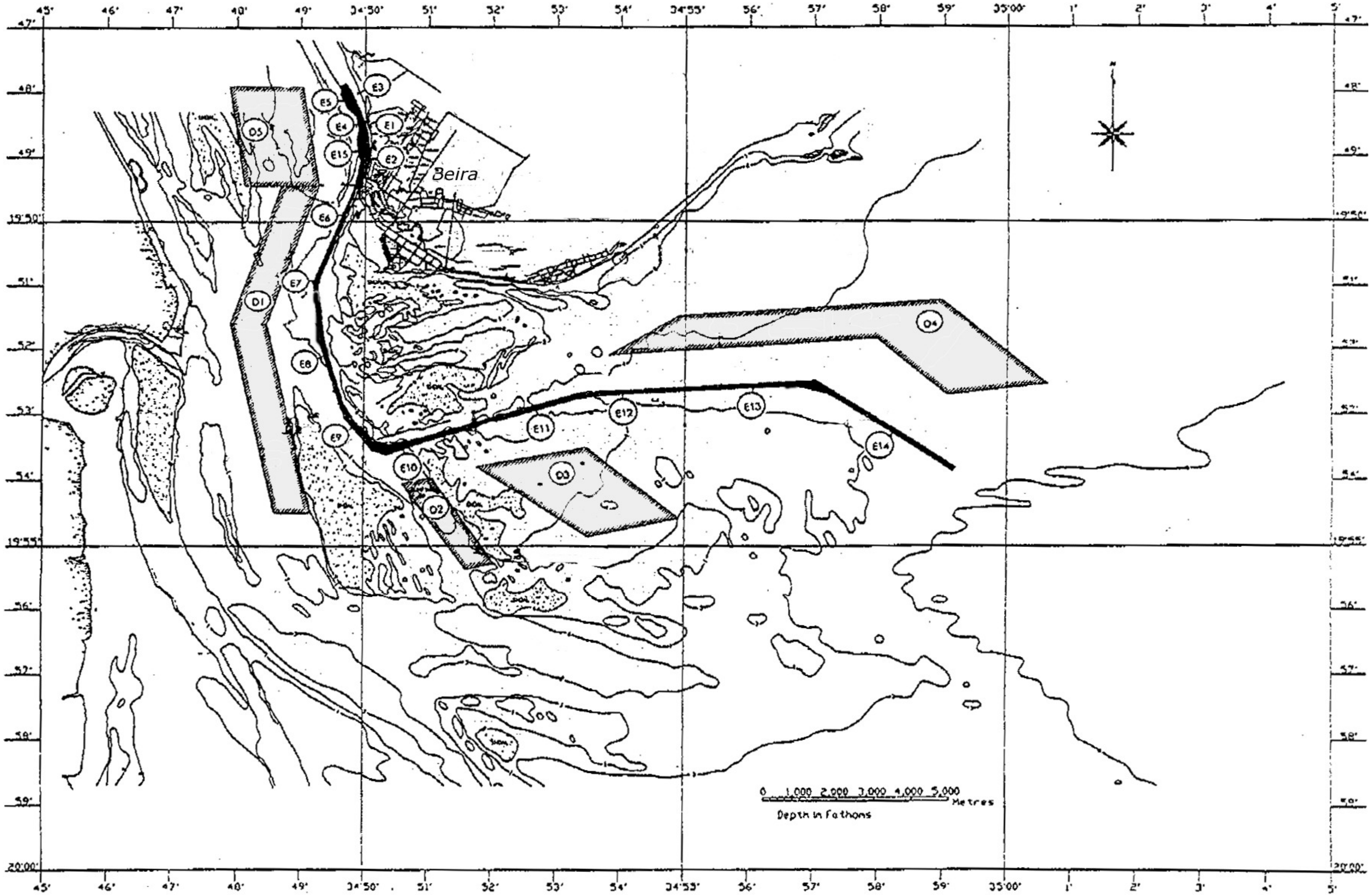


Figure 3.2 – Diagram showing the locations of the Access Channel sections and dredge material deposit zones (grey zones D1-D4) *(adapted JICA, 1998)*

To avoid this situation of high sediment build-up repeating, CFM intends to acquire a new ocean-dredging vessel with the capacity of dredging 2.500 m^3/year, to ensure that along with EMODRAGA work, the channel remains stable with its original dimensions. EMODRAGA will also increase its fleet in 2007, with a new dredging vessel with the capacity of dredging 1,000 m^3.

Some studies of the Beira estuary have already been conducted, the highlight being the study conducted by the Japanese International Cooperation Agency (JICA) in 1998 regarding the maintenance and improvement of the Beira Access Channel.

This study assessed in detail various environmental factors of the Channel and modelled its sedimentary dynamic, as well as pfysically and chemically analysed the sediments. This detailed sediment analysis (see Annex 3) did not identify significant quantities of heavy metals, toxic materials or nutrients and concluded that it was free of contamination and did not represent danger of environmental contamination to the organisms.

Within the hydrodynamic models produced in the scope of this study, the Bijker mathematical model was used to simulate sedimentation levels in the Access Channel and in the Bay. This model was calibrated and verified by using sediment data obtained between August 1990 and August 1991. Several parameters were taken into consideration, as currents and wave climate, tide variation, sedimentation dimension and time, annual mean erosion rates and sediment transport. This model was used to predict the sediment behaviour in the Channel, in the dredge materials deposit areas and in Sofala Bay in general.

3.3 General Project Description

3.3.1 Introduction

The Port of Beira Access Channel is close to 27km in length (from the Port Fuel Terminal until the coastal zone in front of the Lighthouse), and its original dimensions (in 1989) included a width of between 135-250m and a depth of -8,0 and -9,2m.

To re-establish the Channel's original dimensions it is estimated that the dredging should remove 8,000,000 m^3 of sediment. This sediment is believed to mainly consist of fine sands and silts, with an average density of 1.8 tonnes/m^3 (JICA, 1998) which after being transported by the tide, is finally deposited in the bottom of the Channel.

Due to the critical situation at the Macuti Bank (sections E7, E8 and E9) and the contrains this section has being causing to maritime navigation to BeiraPort, these sections will be prioritised within dredging activities.

As EMODRAGA dredges are only suction dredges, appropriate only for the dredging of fine materials and not adequate for the removal of more gross materials, like those that exist in the Macuti Curve, and the characteristics of the proposed project - the quantity of material to be dredged and the dredging urgent character - the activity can not be conducted solely by EMODRAGA. Taking this into consideration there is a need for CFM to contract another external company.

At present CFM is in an international tendering process for the company that would be responsible for the dredging. This company would have to possess the necessary equipment and have large experience in similar dredging operations, and possibly would work in association with EMODRAGA when dredging the Access Channel.

As this selection process has still not been concluded there are still some details of the project not yet defined.

3.3.2 Dredging Technologies

The dredging could be done by various types of dredging technologies. They can be classified as mechanic, hydraulic and mixed (mechanic/hydraulic), and each of these has different types of mechanisms and operation (Torres, 2000).

Table 3.3 – Most Common Types of Dredging Technologies.

Category	Type
Mechanic	Bucket dredge
	Grab dredge
	Dipper dredge
Hydraulic	Suction dredge
	Cutter suction dredge
	Trailing hopper dredge

Mechanic dredges are used to remove gravel, sand and highly cohesive sediments, like clay, peat and highly consolidated silts. These dredges remove deep sediments through direct application of mechanic force to digg the material, independent of its density. Sediment removed by mechanic dredged is generally transported in barges, depending on the volume to be transported.

Hydraulic dredges operate by using suction to remove the sediments, and are the most appropriate for removing fine and slightly compacted sediments like those encountered in the Channel. This technology is presently in use by EMODRAGA in the maintenance of the Channel through suction dredging and self-conveyors.

The suction is done through a large sucking mouthpiece, with two dust suckers at the extremities of the movable arms that can be regulated according to the depth of the bottom (figure 3.3). With the assistance of water jets the material is broken up, and through *mouth* openings it is sucked and carried with the water through the suction tubes. This type of *mouth* is used only for fine material and material of little cohesion, in shallow cuts, and is not for cutting cohesive materials or for making cuts in banks whose material could fall again into the mouth and impede the suction (Torres, 2000).

Figure 3.3 – Example of a sucking moth, used by EMODRAGA in hydraulic dredging. *Consultec, 2006*

The self-conveying dredges have deep moving tanks (cisterns) of changing depths, where the dredged materials is deposited; this could be later transported to the sea where it is unloaded, avoiding the need for barges (figure 3.4 and 3.5). These hydraulic dredges, while sucking the sediment bring with them large quantities of water. As the dredging tanks are filled, this excessive water must be eliminated by pouring it out of the vessel – this process is known as *overflow* (figure 3.6)

Specific dredging characteristics depend upon the pumps and the energy source available but in general the length of the cut that this type of dredge ship can do in a straight line before turning around is in the order of 1,500 metres (Torres, 2000).

Due to the physical characteristics of the Channel, and the positive experiences resulting from the use of this dredging technology, leads to the assupmtion that this method will be used by the company contracted to dredge the Channel.

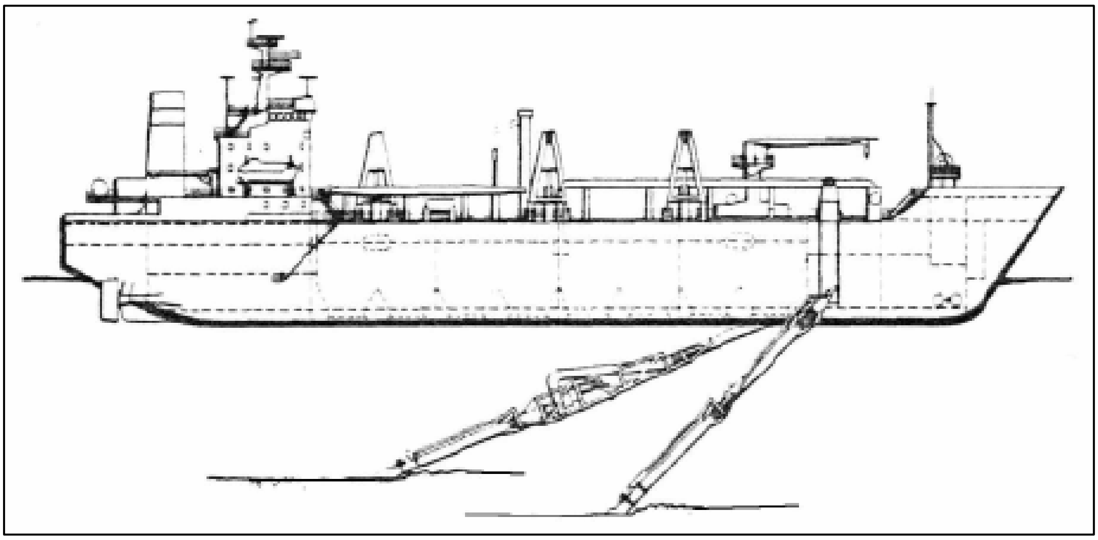


Figure 3.4 – Diagram of a self-conveying hydraulic Dredge, similar to the one presently used by EMODRAGA in their maintenance dredges of Port Channels.

***Figure 3.5 – Detail of the sediment storage cisterns of EMODRAGA dredging ship "Arangwa"**, Consultec, 2006*

Figure 3.6 – EMODRAGA Dredge "Arangwa´s" Overflow system. The crane can also be seen that controls the mechanic suction arm. Above, detail of the Overflow. *Consultec, 2006*

An alternative to the normal suction dredging technique, Cutter Suction Dredges use a rotational sucker, equipped with blades to break up the settled materials so it can be sucked into the interior of the tube that is inserted in the centre of the rotor. It functions in the exact same way as the simple suction method, however it is more efficient, and rather than dredging in a straight line, the dredge's movement is in an arc shape.

Despite CFM not expecting the existence of large materials at the bottom of the channel – possibly some leftover cables, nets and other small items – or any geological obstacle, , this suction alternative could facilitate the removal of dredge materials especially in the case of some of the areas containing more compacted sediments than predicted.

The use of explosives is not considered aplicable for this marine system, as they are generally used to facilitate dredging operations in areas of more consolidated sediment.

3.3.3 Description of the Dredging Process

The predicted length of the dredging is directly related to the type of equipment used by the contracted companies. However, it can be predicted that more time will be spent in the Channel's most critical zones like the Macuti Curve – between 8 and 10 months of permanent activity (24h/day) – and in the areas with less sediment, it could take place for about 12 to 16 hours per day (EMODRAGA, 2006).

Therefore the total dredging operations on the Port of Beira Access Channel can be expected to be 12 to 18 months.

Information obtained from both CFM and large-scale dredging companies show that, on average, self-conveying large-scale dredges have the following characteristics:

- Approximately 3,500,000 litres of fuel is used per 5 million m^3 of materials dredged.
- The vessel needs to return to the Port for refuelling of maintenance about once per week.

- For dredges that operate continually, generally the crew is comprised of 16 people, with 8 workers per shift. This crew is much specialised for this type of work, and generally work on dredging vessels.

The assumptions are based on self-conveying dredges that work in conditions similar to those expected for this project. However, the details of the characteristics of the procedures can only be confirmed once the company begins the Channel dredging operation.

The dredged material will me be quantified by an *in situ* measurement process, comparing the profiles of the initial survey with those taken at the end of the project. These surveys, along with all others, will be conducted by the contracted company, with appropriate people and equipment, and they will be accompanied by CFM representatives, that will ensure all equipment is correctly calibrated.

The difference between the volume of *in situ* material dredged observed the initial and final survey will be considered the final computed result of the project, taking into account vertical and horizontal tolerances, and the angle of the cut agreed upon.

These results will be included in the final report to be presented to CFM at the end of the work, together with daily reports about dredging activities.

Some of the initial surveys of the local bathymetry have already been conducted by INAHINA at the beginning of 2006, with the intent of identifying the most critical zones in the navigational Channel and to help CFM in deciding the quantities of sediment that should be removed.

It is likely that new surbey will include the entire dredging area and extend about 50m past these limits, to ensure that the data can be used to calculate the bathymetric levels throughout the Channel.

3.3.4 Dredging Disposal Sites

There are essentially three alternatives for disposal dredged material: disposal in the open sea, disposal in a confined area on land site and beneficially utilising the material.

In self-conveying dredges where the bottom is movable, dredged material is normally transported and disposed at sea in appropriate sites for the disposal of dredged material. In the study area, the materials from maintenance dredging have been deposited in Sofala Bay in zones usually designated by D1, D2, D3, D4 and D5 (see figure 3.2).

Disposal in the water column can occur in a predominately dispersive or non-dispersive manner. In areas that have a non-dispersive characteristic, like the disposal areas in the Bay, the intention is that the material stays at the bottom.

The survey conducted by INAHINA showed that of all the disposal zones the only appropriate one for receiving dredge material is Zone D4 which is still not completely filled in (CFM, 2006). D4 is located 12km from section E9 of the Channel and approximately 23km from the Port.

Depending on which section of the Channel is being dredged, it is possible that the current disposal location could be far away from the dredging zone, resulting in dredging vessels sometimes spending more time carrying the materials to the disposal area than time actually dredging. Searching for new disposal sites in the areas involved in the dredging during the initial probes could be an efficient alternative in the short to medium term for the Channel dredging activities.

If the contracted company locates new appropriate sites for disposal dredged materials during the survey stage these could later be used, after the analysis and agreement from CFM.

The chosen disposal sites should be adequately marked with buoys and lights, not only to facilitate the disposal of dredged materials but also for identification of areas where survey will be conducted at the end of operations.

The disposal of dredged sediments on land, in the majority of cases, will be conducted by pumping the dredged material directly to the disposal site. For this alternative, it is necessary to have available a pumping system adapted to self-conveying dredges and that the on land disposal areas allow for sufficient access for vessels to get close enough to pump the sediments.

In general, CFM predicts that the potentially usable materials will be deposited on land except for when the dredging is being conducted a large distance from land. It is also expected that part of the dredged material will be used for the Port of Beira's expansion.

The capacity in which ships are able to get closer to the coastline will determine where the best site for the on land disposal of dredged materials is.

4 Environmental Description

4.1 Climate

The climate in the Beira region is in an intermediary zone, between the convergence and ascendance air zones and the divergence and subsistence zones. According to KÖPPEN, it is a humid tropical climate with two distinct seasons: the wet season between October and March, and the dry season, between April and September. It is dominated, generally, by masses of foggy air and thermal rains, but also cyclonic conditions. As can be seen in Figure 4.1, below, this type of climate dominates much of Mozambique, including the area being studied.

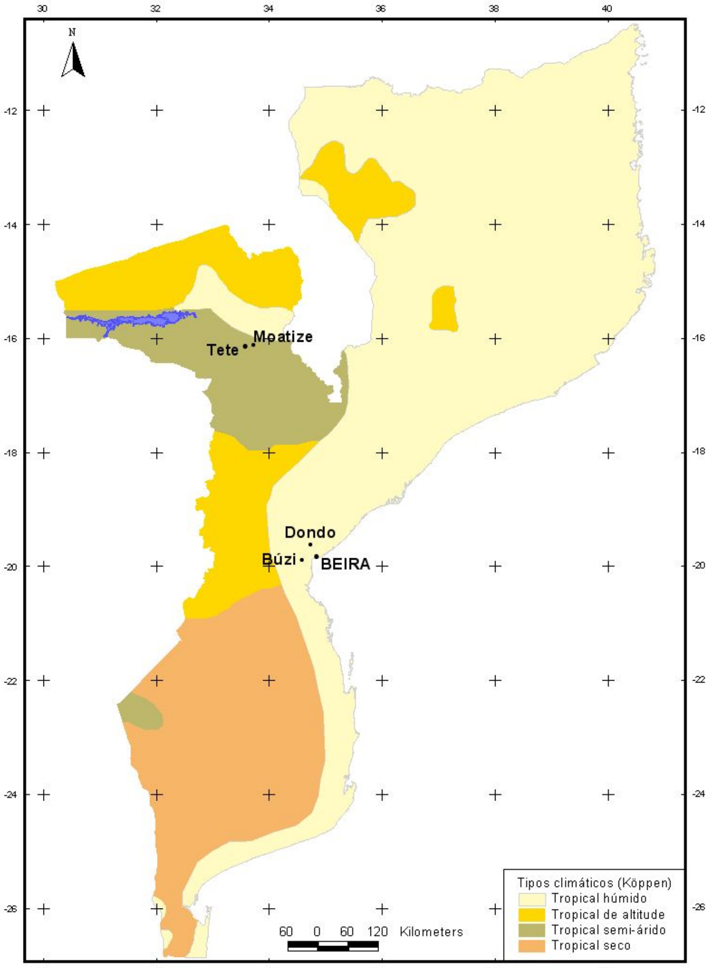


***Figure 4.1 – Types of climate according to Köppen's classification. Beira is located in a humid tropical climate** (Source: National Institute of Meteorology – INAM)*

4.1.1 Temperature and Rainfall Standards

The city of Beira has an average annual temperature of 24.6°C, while the coldest month (July) has an average temperature of 20.6°C and the hottest month (January) has an average temperature of 27.7°C.

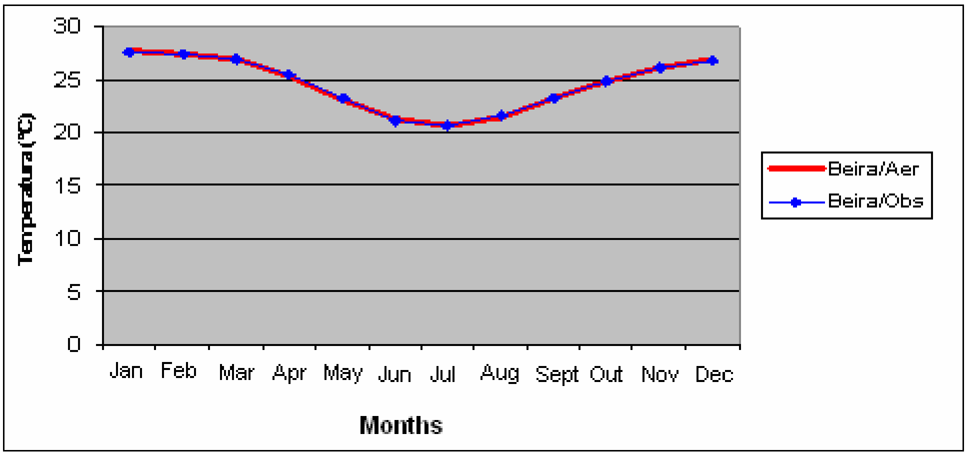


Figure 4.2 – Average Monthly Temperature in the Beira Region, measured in the Airport Observatory *(Source: National Institute of Meteorology – INAM)*

The total annual rainfall in the city of Beira varies between 1553mm and 1473mm and the rain is concentrated in one period of the year – from October to March, principally in the latter two months of February and March.

The lowest average monthly rainfall occurs in September, registering 25.1mm, and reaching 288.2mm in February. Figure 4.3, below, presents the results obtained from stations at Beira Airport (1968-1990) and Beira Observatory (1961-1990).

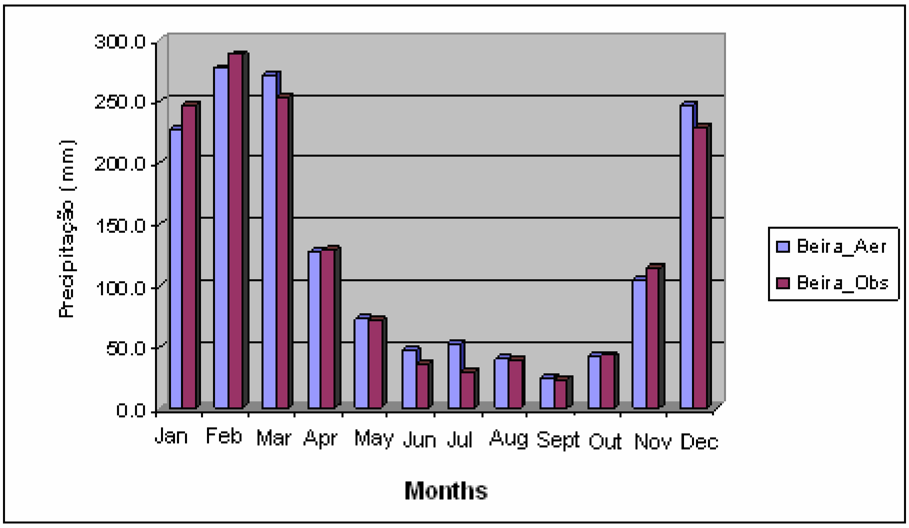


Figure 4.3 – Average Monthly Rainfall – 1968 to 1990 – Beira Airport and 1961-1990- Beira Observatory *(Source: National Institute of Meteorology – INAM)*

4.1.2 Wind

In the Beira region, according to the statistics obtained in the Beira Airport Station in the period between 1961 and 2005 (Figure 4.4) the predominate wind direction was South East (46%) followed by, in decreasing order, from the East quadrant (23%), Southeast (13%) and South (8%), leaving the rest with percentages of less than 4%.

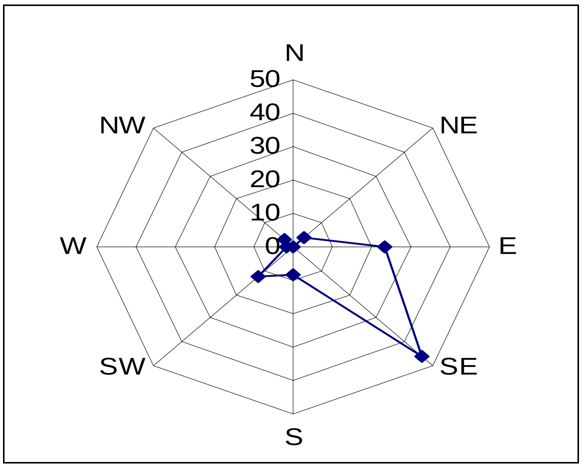


Figure 4.1- Predominant Wind Directions observed in the Beira station between 1961 and 2005 *(Source: National Institute of Meteorology – INAM)*

Regarding velocity, an average annual wind velocity in the study area has been observed as 12.7 km/h, with a minimum average value in the month of June (10.7 km/h) and maximum average observed in the month of October measuring 15.4 km/h (Figure 4.5). However, in the period between 1961 and 2005, the highest monthly average wind velocity reached a value of 19.5 km/h in the month of September 1972.

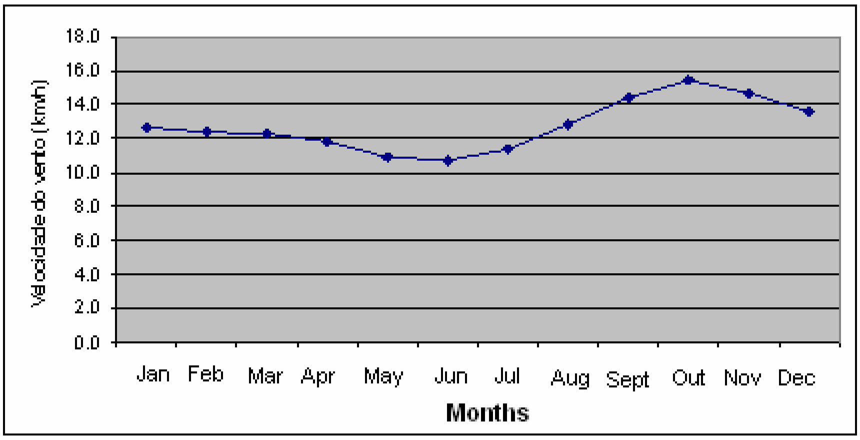


Figure 4.2 - Average monthly Wind Velocity – 1961 to 1990 –Beira Airport Meteorological Station *(Source: National Institute of Meteorology – INAM)*

4.1.3 Cyclones

Mozambique is frequently affected by tropical cyclones originated in the Mozambican Channel or to the east of the Channel, depending upon the atmospheric conditions. In general, the high intensity tropical cycles are those that originate to the southeast of the Mozambican Channel. These cyclones move to the west, crossing Madagascar and, as they cross the Mozambican Channel, are fed by the hot waters that intensify them.

These cyclones are characterised by intense rains in the coastal areas, along with strong winds and rains. The cyclone period in Mozambique usually begins in the month of November, and can continue to occur until the month of April. On average, three to five cyclones form each year in the Mozambican Channel, with the most affected regions being coastal regions in the centre and north of Mozambique.

Figure 4.6 below shows the cyclone risk zones on the Mozambican coast.

During the period between 1975 and 2003, 57 cyclones were recorded that affected the Province of Inhambane and the central zone, 14 reached Beira, according to the Table 4.1 presented below.

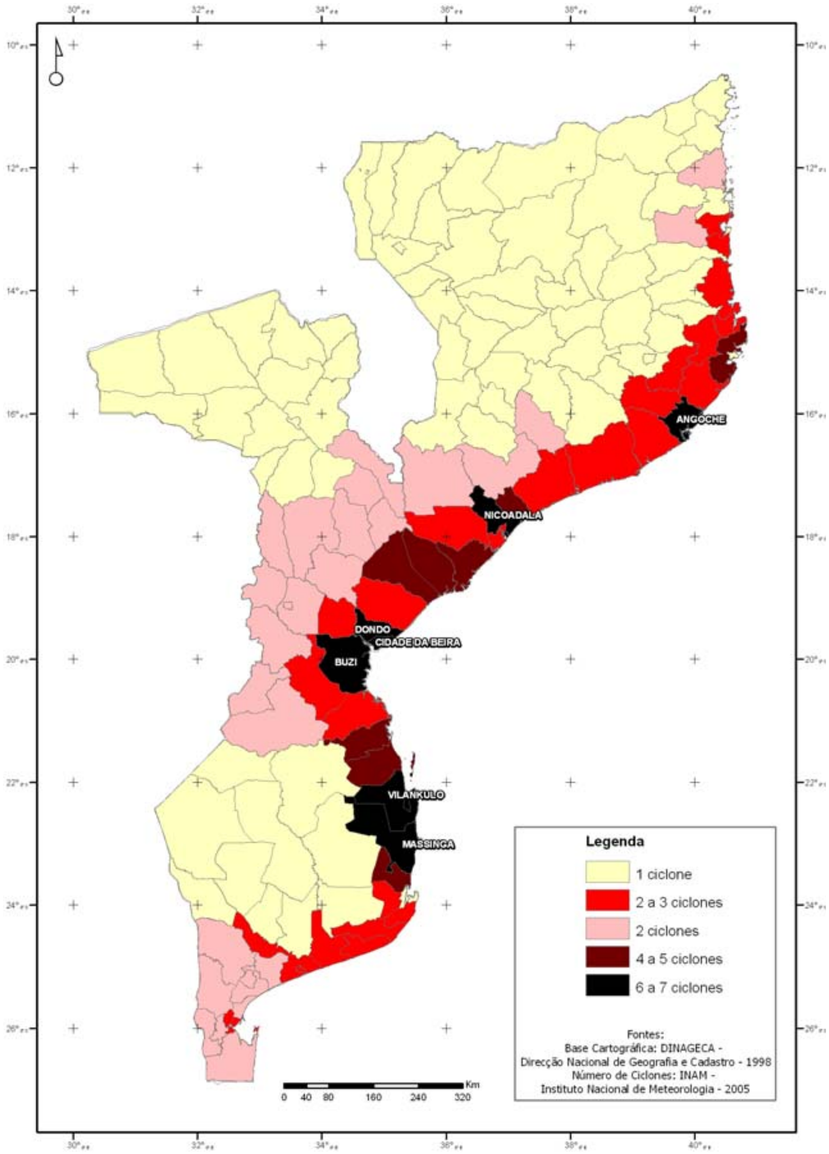


Figure 4.3 – Cyclone Risk Zones — Number of tropical cyclones between 1970 and 2000 *(Source: National Institute of Meteorology – INAM)*

Table 4.1 – Distribution of Tropical Cyclones in Inhambane Province and the Country's Central Zone – 1975 to 2003

Year	South and Central Zone			
	Vilanculos	**Beira**	**Quelimane**	**Pebane**
1975	Blandine	Bland;Elsa	Bland;Elsa	Bland;Elsa
1976	Danae	Dana;Gladis	Dana;Gladis	Dana;Gladis
1977		Emilie	Hervea	
1978	Angele		Angele	Angele
1981	Edwige		Benedicte	Benedicte
1982			Justine	Jus;Electre

Year	South and Central Zone			
	Vilanculos	**Beira**	**Quelimane**	**Pebane**
1983				Elinah
1986		Berobia	Berobia	
1988	Hely	Hely;Filão	Hely;Filão	
1994	Nadia	Nadia	Nadia	Nadia
1996		Bonita	Bonita	Bonita
1997	Gretelle	Lisete		
1998			Beltane	
2000	Eline	Eline	Eline	Eline
2001		Dera	Dera	Dera
2003	Japhete	Japhete	Jap;Delfina	Jap;Delfina
Total	**9**	**14**	**18**	**16**

Source: National Institute of Meteorology – INAM, 2006.

The city of Beira is therefore situated in a region considered to be of high vulnerability to the occurrence of tropical cyclones. In March 1994 this region was severely affected by cyclone Nádia. This cyclone, which had wind velocities in the order of 190 km/h from its formation until its dissipation, and a minimum pressure of 925 HPA (INAM, 2005 – not published), crossed the Mozambican Channel.

Below some information is shown about tropical cyclones that affected meteorological conditions in Beira between 1994 and 2003 (Table 4.2).

Table 4.2 – Distribution of Tropical Cyclones that influenced meteorological conditions in Beira between 1994 and 2003.

Year	Tropical Cyclone	Velocity (km/h)	Pressure (hPa)
1994	Nadia	190	925hPa
1996	Bonita	200	920
1997	Lisete	100	980
2000	Eline	200	930
2001	Dera	160	955
2003	Japhete	200	927

Source: National Institute of Meteorology – INAM, 2005.

4.2 Geology and Geomorphology

4.2.1 Geology

Geologically, the city of Beira is situated on Phanerzoic sedimentary rocks from the tertiary and quaternary ages.

The Beira region is dominated by sedimentary rocks, namely Pliocene, denominated Mazamba Formation, and those from the Quaternary age, constituted of sandy silt, and sandy clay-sand. On the more coastal part, the quaternary sediments are covered by more recent materials namely silt and parallel coastal dunes.

In accordance with seismological researches, the City of Beira is situated close to two active seismic belts, the interior Urema Fault, and the Coastal Chissenga Fault, to which the great Fault of Dondo is associated.

4.2.2 Geomorphology

The city of Beira extends over a coastal plain formed by alluvial and marine accumulation during the last marine regression event, occurring in the beginning of the Quaternary (Pleistocene). This phenomenon happened along the entire eastern African coast and allowed, in the study area, for the rivers Pungue and Buzi to deposit continental sediments originating from outcrops located at the city of Beira.

This last regression was responsible for the formation of the oceanic coastal dunes that created conditions for the formation of lakes along the coast and the extensive flood plains.

The conditions for the most part of the Beira area are associated with process of abrasion and active sedimentation of the coastal and fluvic-marine environments, being those sectors susceptible to morphodynamic processes, specially the areas permanently inundated or under the control of seasonal tides.

The marine system extends along the coast and comprises continuous sandy dunes, and sandy beach strips, that most of the time are interspersed with small depressions or permanently inundated depressions (zones inundated by the sea) and part of the Sofala Bay.

The estuary system is characterised by deltaic river regions consisting of Mangrove plains and a low swampy coast; regions influenced by the tides, and part of Sofala Bay. The fluvial system is associated with hydrology and the network of natural drainage in the area being studies, dominated by the Ucarranga, Buzi, Pungue and Savane Rivers.

The coastal zone is, from a geodynamic viewpoint, relatively complex because it has formations derived from active accumulation processes, from recent filling (alluvium and colluviums), alongside cleared surfaces and eroded terraces. It makes up part of a diverse system of humid lands, with marine, estuarine and fluvial systems being of note.

The movement of the tides influences the volume of water retention and its distribution within the plain. The Beira coast suffers the highest tidal amplitude in the country, in part due to the region's extensive continental platform.

Regarding the susceptibility to erosion, the process occurs due to the climatic conditions and the absence of fauna coverage in some sectors, exposing the surface to the following forms of erosion: Aeolian (during the dry season), pluvial (during the rainy season) and to marine erosion, that occurs throughout the year, intensified by pring tides.

There is evidence of beach erosion and dune vegetation destruction. The slope of the beach, close to the Pungue River mouth, appears to be, relatively steep, indicated the occurrence of erosion.

Erosion of the coastal dunes has reached an average of one metre per year, since 1982, and is accelerating, principally due to sand being transported along the coast, erosion caused by wind, people removing sand, storms, and waves. In Figure 4.7 erosion suffered along Praia Nova can be seen.

Figure 4.4 – Praia Nova, located in at the end of the Beira estuary. *Consultec, 2006.*

4.3 Water Resources

At a regional level three large international rivers that release water into the Indian Ocean stand out: Zambezi, Pungue and Buzi, the last two releasing their waters into Sofala Bay.

Apart from the two large hydrographic basins of the Pungue and Buzi Rivers, the Savane and Ucarranga Rivers hydrographic basins are also related to the area of study, located respectively to the north of the Savane River and to the south of the Buzi River, along with other small coastal basins as represented in Figure 4.8.

Pungue Basin

The Pungue River Hydrographic Basin drains an area of 31,151 km² and releases this water into an estuary that has a width of up to 7km. The river is formed at an altitude of 2300m, with 50km of its length found in Zimbabwean territory, and 320km in Mozambican Territory. The basin has a diamond shape with the orientation of the larger axis NW-SE, and the average annual rainfall varies between 1800mm at the high points and 1000mm near to the river's mouth. There are various tributaries; the main ones are located on the right bank.

The average outflow of the Pungue River during the driest month, October, is 46.4 M m^3/month in the catchments zone for the City of Beira Water Supply (Sweco e Associados, 2004).

Buzi Basin

The Buzi River basin drains a total area of 29,720 km^2 of which 13% comes from Zimbabwean Territory, and 86% from Mozambique. The river forms in Zimbabwean Territory, to the northeast of the Chipinga people. Its total length is 366km in Mozambican territory and 31km in Zimbabwean.

In contrast to the Pungue basin, the Buzi basin's form is a triangle with the outlet at one of the vertices, this fact makes the basin more susceptible to floods. Amongst its tributaries of note are the rivers Lucite and Revué, both on the left bank.

Table 4.3 below shows the comparison between the annual average outflows of the rivers Pungue and Buzi.

Table 4.3 – Comparison of the Outflows of the Pungue and Buzi Rivers.

	Annual Average Outflow (millions m^3)	**Annual Average volume close to the river mouth (m^3/s)**
Pungue	3,800	120
Buzi (E188)	5,760	182

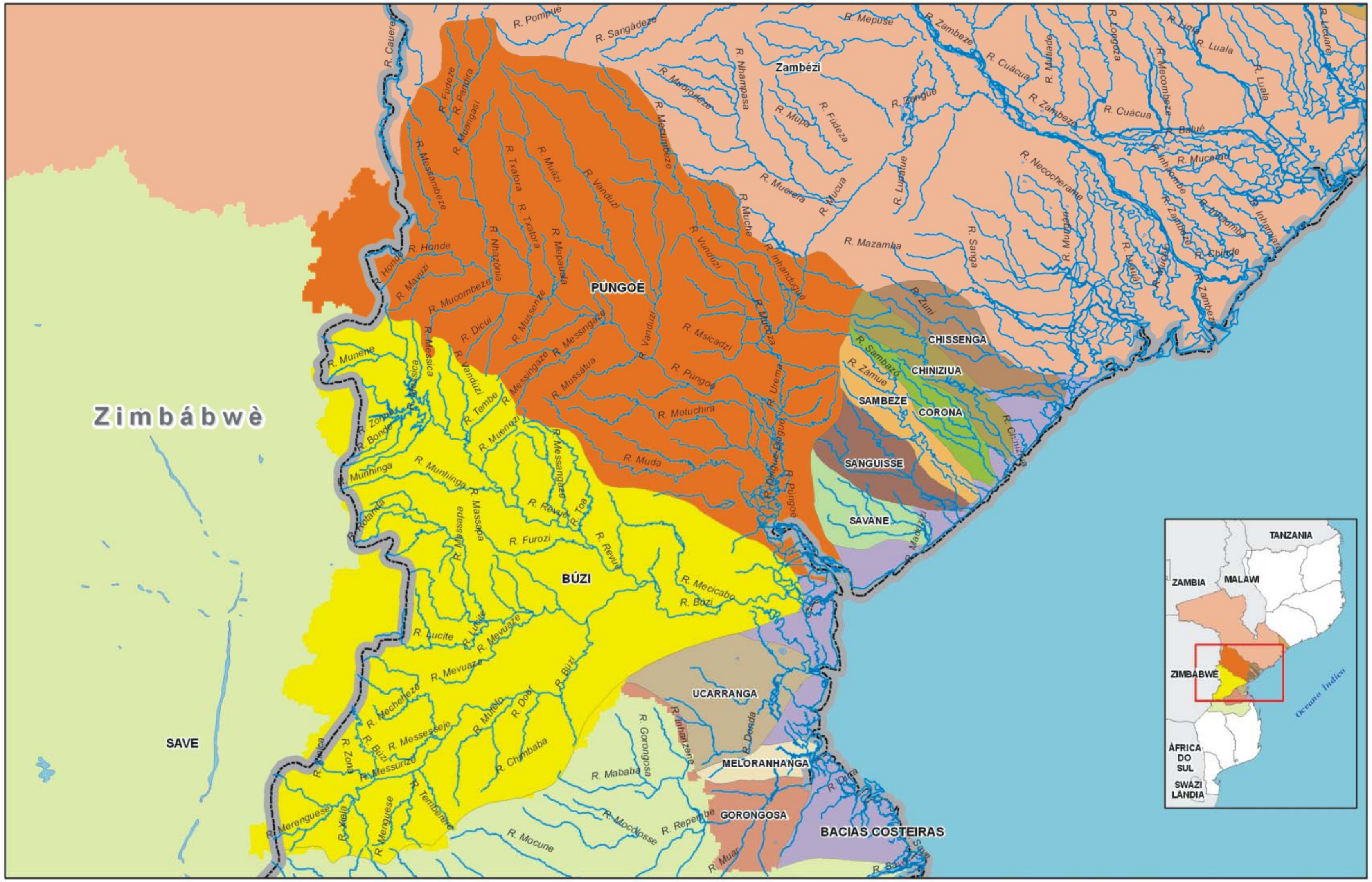


Figure 4.8 – Zambezi River Basins, Pungue and Buzi and other small hydrographic basins.

Zambezi Basin

The Zambezi River Basin represents the fourth largest hydrographic basin in Africa, after the River Basins of the Congo, Nile, and Niger Rivers. Its drainage area is 1,385,300 km^2, reaching Zambia (where it covers a majority of this territory (41%)), followed by Zimbabwe (19%), Angola and Mozambique (11% each), Malawi (8%), Namibia and Tanzania (2% each).

The Zambezi River forms in the Northeast of Zambia, on Mount Kalene, and has a length of approximately 2,800km, until it reaches the Indian Ocean. In Mozambique, the Zambezi River basin has an area of approximately 225,000 km^2; and its delta extends up to 100km along the coast with a width of 120km, covering close to 15,000 km^2.

4.4 Oceanography

4.4.1 Local Bathymetry

Sofala Bay constitutes the southern part of the Sofala Bank, representing the largest continental platform of the east African coast and is located in the central region of Mozambique between the latitudes 16° S and 21° S (Figure 4.9). The distance between the coast and the break in the platform is almost 80 nautical miles. The average depth of the platform in this region is approximately 20m.

The morphology of the Sofala Bank coastal zone is characterised by sandy banks and most are interlinked with mangrove swamps fringes. These environments are associated with the main rivers of the region, and may also occur to a lesser extent due to the small tidal channels..

The Central and Northern regions of the Sofala Bank have a flat bottom characterised by the presence of muddy sediments.

Sofala Bay is a system of shallow waters, whose average depth does not exceed 10m. The bottom topography is characterised by active sedimentary movement (JICA, 1998): High amount of sediment discharge coming from the Pungue and Buzi Rivers associated with a dominant tidal energy that creates intense sedimentation or erosion zones.

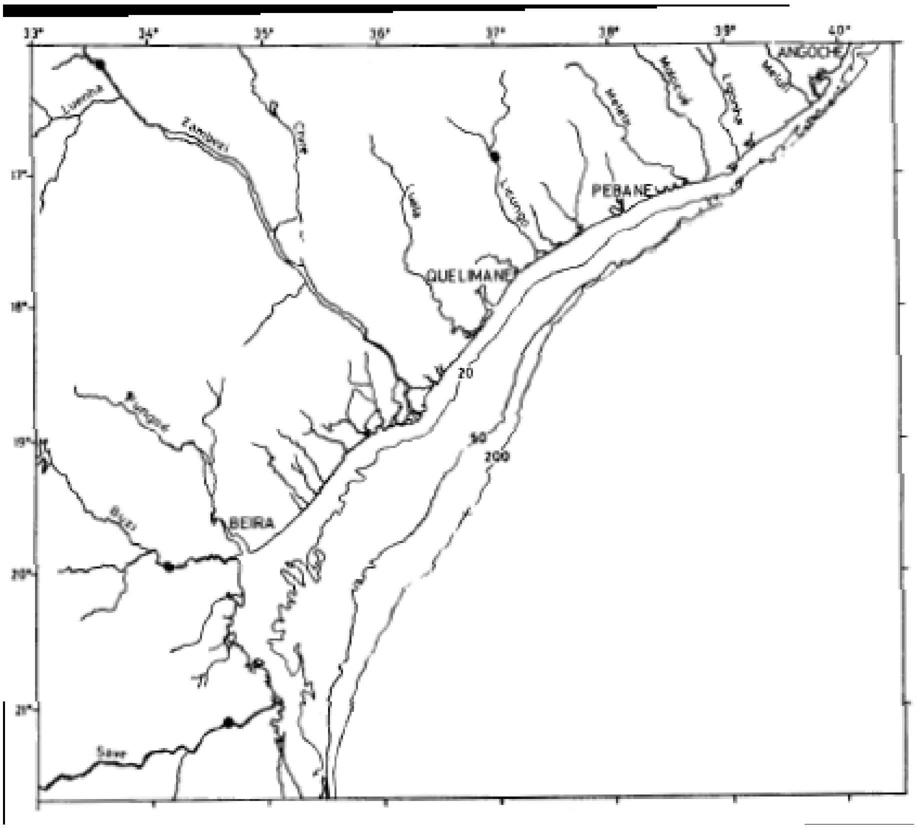


Figure 4.9 – Diagram of the Sofala Bay Bathymetry.

The areas adjacent to the Port of Beira have a very irregular sea bottom topography with frequent sand banks in contrast to the areas located further to the north of the Bay (like the Savane-Nhangau area) with the sea bottom slightly leaning in the direction of open sea (Figure 4.10).

The Port of Beira adjacent area has to be continually dredged to maintain the Port Access Channel in a suitable condition. Its sediment accumulation could increase 0.5 to 2 m in about four months (JICA, 1998).

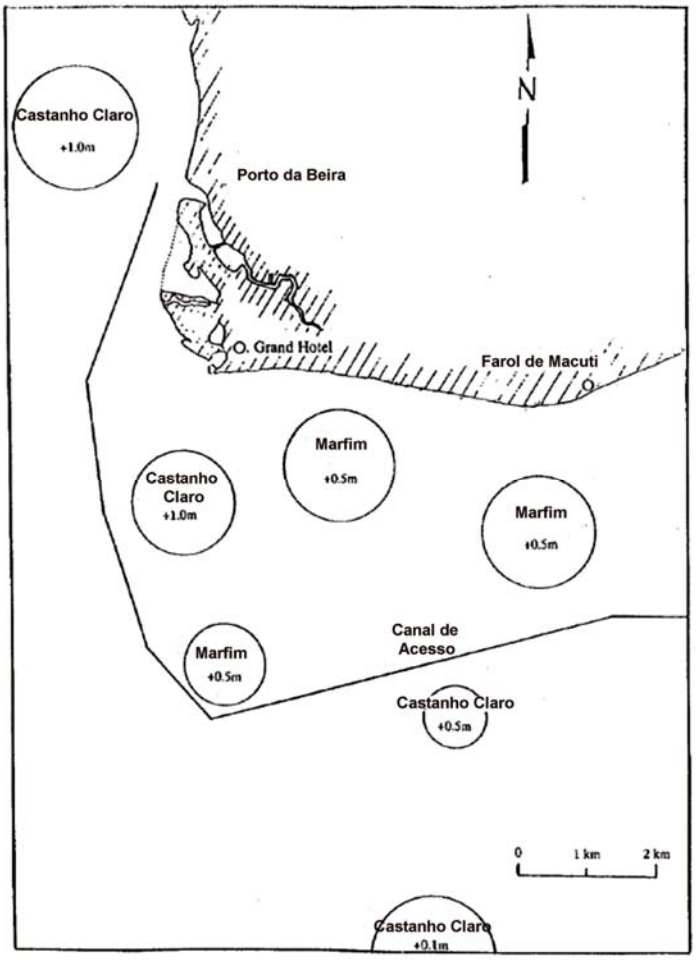


Figure 4.10 – Location of the main Sofala Bay sand banks along the Access Channel to the Port. The diagram also shows the average colour of sediments found in each bank. *Source: JICA, 1998*

4.4.2 Current and Tide Dynamics

<u>Currents in Sofala Bay</u>

The currents in Sofala Bay, similar to other coastal zones with low depth along the Mozambican coast, are controlled by the tides and are also strongly affected by winds.

In the study area the currents are extremely strong due to the high amplitude of tidal variation that happens in the bay. The current measurements conducted on the edge of the continental platform indicates the existence of a below surface one-directional current along the platform, indicating that they are guided by bottom topography. The North direction component is the most dominant. There is also evidence of a strong current on the surface, with a velocity of close to 50 cm/s, caused by the tides (ENTRIX and AUSTRAL CONSULTORIA and PROJECTOS Ltd. 1998)

The inner Bay currents, meanwhile, are shown to be strongly conditioned by bottom topography, and the main current follows the direction of the Access Channel. A study conducted using a floating buoy in 1997 (JICA, 1998) showed that during the incoming tide the surface currents flow in a north-northeast direction, and during the outgoing tide, in a south-southeast direction. These same currents, immediately after leaving the estuary for the east coast, change in direction to the east during the outgoing tide, and to the west during the incoming tide (Figure 4.11).

The outgoing current is more intense with fluxes ranging between 0.83 and 0.88 m/s while the incoming current shows flux between 0.19 and 0.31 m/s (JICA, 1998).

JICA (1998) concluded that the tidal currents along the Port of Beira Access Channel are influenced by the seasons, this being that the currents are slightly more intense during the humid season than during the dry season. The outgoing currents are more intense with average maximum velocities of 2.5 m/s.

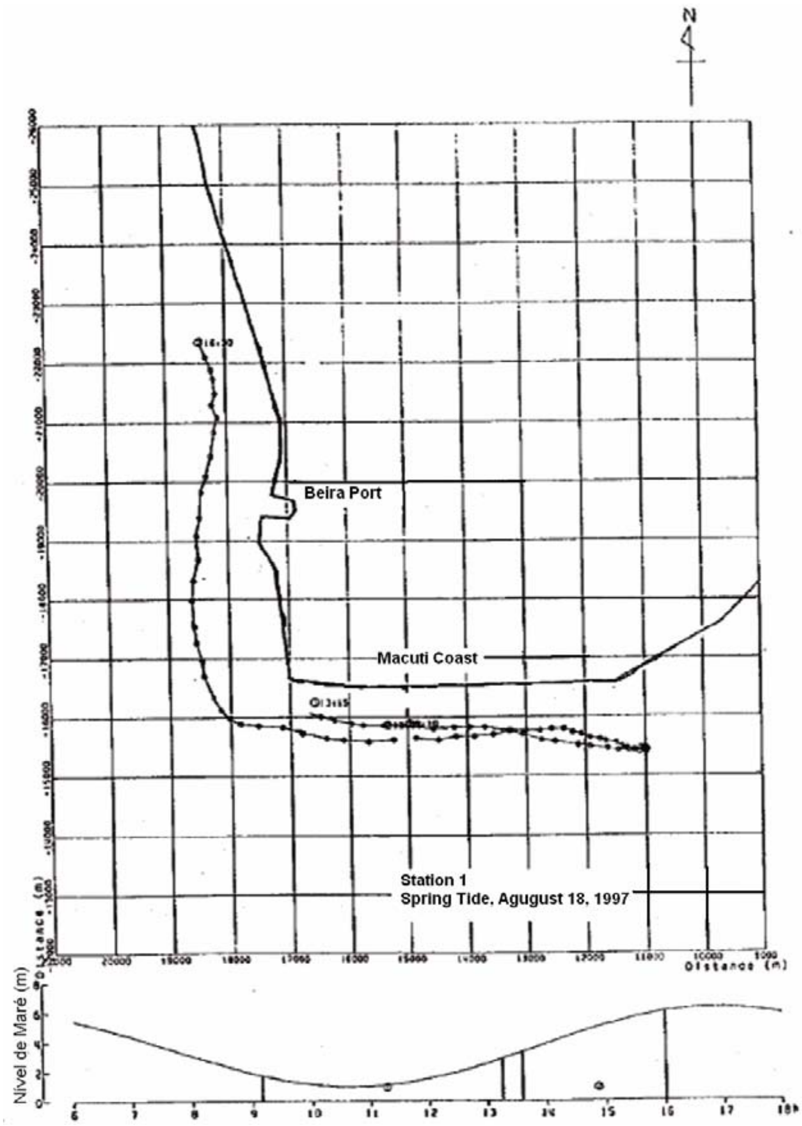


Figure 4.11 – Trajectory of the floating buoy used using the study. The graph below shows tides variation. *Source: JICA, 1998*

Tides Dynamics

The tides on the Mozambican coast are half-daily with a daily variance of between 10 and 20 cm in Maputo, Inhambane, Chinde, Quelimane and Angoche, and in the range of 30 to 40 cm in Beira, Pebane, Ilha de Moçambique, Nacala, Pemba and Mocímboa da Praia.

The tide's amplitude therefore varies along the coast registering its maximum in Sofala Bay, reaching close to 6.4m, largely as a result from the large extend of the continental platform (close to 120km of length), that has an amplifying effect on the tide. Throughout the rest of the Mozambican continental platform, even until its limit, the tide amplitude is close to 3m.

Tidal measurements conducted in the Port of Beira (JICA, 1998) confirmed the large tidal amplitude occurring in this area, with the following measurements being recorded:

- Highest Average Height at Spring Tide: 6.5 m
- Highest Average Height at Neap Tide: 4.2 m
- Average Sea Level: 3.5 m
- Lowest Average Height at Neap Tide: 2.7 m
- Lowest Average Height at SpringTide: 0.9 m

As the Sofala Bay continental platform is very large and shallow, as well as the entrance to the Port of Beira, the third-daily and forth-daily components – which are characteristic of shallow waters - must have a large influence on local tides. These components are responsible for generating asymmetric tidal patterns in the estuary environment, producing outflows of longer duration than inflows.

The variation of the water level in the Port of Beira region is close to 6.7m, with a minimum value of 0.6, and a maximum of 7.3m between the peak of low tide and high tide respectively (Figure 4.12). On average, the amplitudes vary during the year between 1.5m in neap tide, and 6.4m in spring tide.

These significant vertical variations of sea levels leads to a high sea incursion far into the Beira estuary and cause strong tidal currents, responsible for the high rates of sediment transportation in the region.

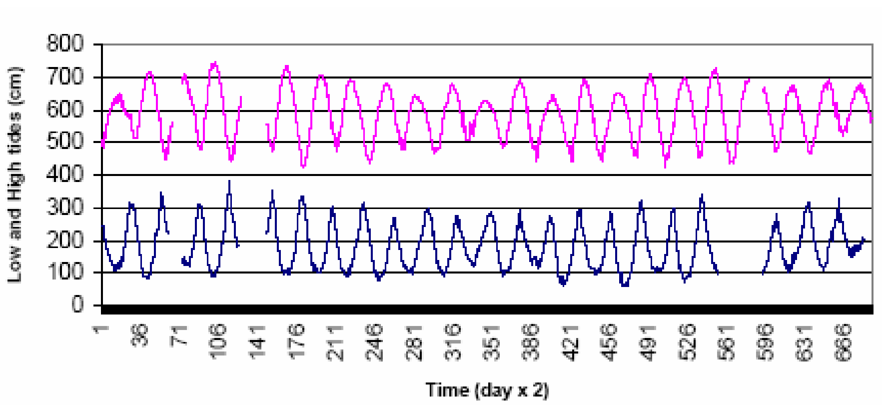


Figure 4.12 – Variations in the high-tide and low-tide levels (in cm) in the Port of Beira 1996, measured two times per day *(SETE et al, 2002).*

The water levels in the Beira region are strongly influenced by the characteristics of the water flow of the Pungue and Buzi rivers. Figure 4.13 shows the monthly variation curve of the average sea level indicating the period with the lowest values being between May until the middle part of November, and the highest values in the period between November and April, corresponding exactly to the dry and wet seasons of the aforementioned rivers.

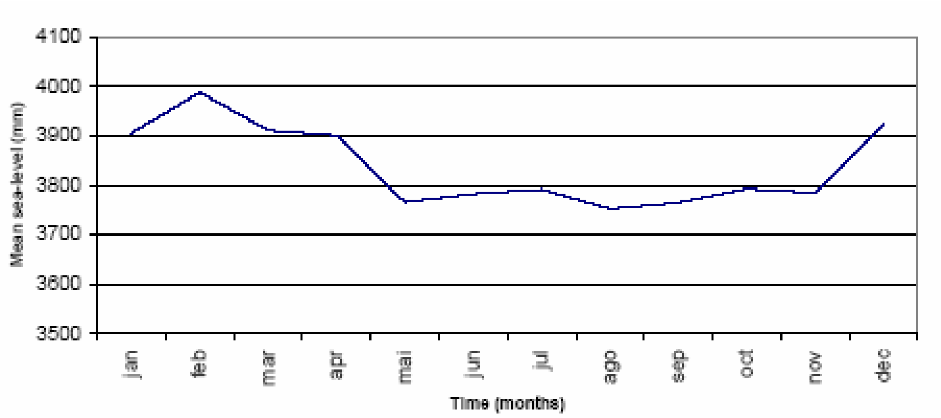


Figure 4.13 – Seasonal monthly variation of the average sea level in the Beira Estuary in 1996 *(SETE et al, 2002).*

4.4.3 Waves

There is little information about wave patterns in Sofala Bay. Nevertheless, some numeric models from 1998 estimate that the wave height in the area north of Sofala Bay (in short and deep waters) varies between 7 and 11.7m (JICA, 1998). The most common direction (more than 60% of cases) was in ESE-SE-SSE-S.

High period waves suffer hindrance on their way in to the coast due to the large continental platform. The wavelength diminishes and there is a gradual loss of energy, generating an increase in the initial wave height that begins gradually to decrease along the way.

Tables 4.4 and 4.5 summarise the main wave characteristics in shallow waters in Sofala Bay

Some modelled results from the international system GROW (OCEANWEATHER, 2006) for a point close to the study area indicate that in general, the siginificant waves come from the ESE to S middle direction (112.5º a 180º) 84% of the time, with of 0.5 to 2.0m average heights; from the NE to E direction (45º a 90º) 14% of the time, with heights of 0.5 to 2.0m. Waves greater than 2.5m height come from the SE-S sector 1% of the time, reaching up to 6.5m. The computed wavelengths indicate 4 to 12 seconds 85% of the time, and that wavelengths of up to 30 seconds could also occur.

Table 4.4 – Average Values for Wave Conditions of Waves close to the HBI Terminal Jetty Head Project Study Area *(JCI Limited, 1998)*

Wave Height		**Direction (degrees)**							
Min (m)	**Max (m)**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	Total
0	0.5	0.8%	1.6%	1.8%	2.0%	5.5%	5.6%	1.0%	18.2%
0.5	1	0.3%	0.8%	1.6%	2.5%	16.1%	16.8%	1.5%	39.7%
1	1.5	0.1%	0.4%	1.3%	3.7%	8.8%	10.1%	1.2%	25.5%
1.5	2	0.0%	0.1%	0.4%	1.9%	3.8%	4.6%	0.1%	11.0%
2	2.5	0.0%	0.0%	0.1%	0.8%	1.4%	1.6%	0.0%	3.9%
2.5	3	0.0%	0.0%	0.0%	0.4%	0.5%	0.4%	0.0%	1.4%
3	4	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.2%
4	5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
6	7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total		**1.3%**	**3.0%**	**5.2%**	**11.4%**	**36.2%**	**39.1%**	**3.8%**	99.9%

Table 4.5 – Sofala Bay Wave Characteristics – Waves of high Depth (returning period of 100 years) in Sofala Bay *(JCI Limited, 1998).*

	NE	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**Ormin-dir**
Height (m)	7	8	9	10.3	10.8	11.5	11.7	11.7
Wavelength (s)	12.9	13.8	14.7	15.7	16.1	16.6	16.7	16.7
Variation of Wavelength (s)	9.5-16.3	10.2-17.4	10.8-18.5	11.6-19.8	11.8-20.3	12.2-20.9	12.3-21.1	12.3-21.1

3.1.1 <u>Circulation and Control Factors</u>

The main intervening factors that generally determine the process of local oceanic circulation are: tides, bathymetry, wave patterns and the flows from the Pungue and Buzi rivers.

For a coastal system like the Beira estuary, tides and the bathymetry are the strongest controlling factors, creating a circulation dominated by the South-Southeast to East direction water flow during the outgoing tide, and a flow in a West to North-Northeast direction during the ingoing tide. These residual or liquid flows cause an anti-clockwise circulation (Figure 4.11 and 4.14).

In this circulation dominance of the outgoing tidal currents can be seen, creating a strong current due to the combination with the outflow of Pungue River. This current tends to direct itself to the south, falling away more to the bay west limit. It is confined to the main channels, dividing itself in the north limit of Pelicano Bank into two components, one flowing to the Macuti Channel and the larger of the two through the Rambler channel, reaching for the Buzi River mouth.

The incoming tide current tends to flow parallel to the Macuti coast reaching for the Pungue River mouth, combining with the coastal alongshore drift that is formed by waves that reach the coast from the SE. This current is more accentuated during the incoming tide, transporting eroded sediments from the beaches along the Macuti coast in the direction of the Pungue River mouth.

This current reaches the out flowing current of the Pungue River, diverts to the south reaching the Macuti channel perpendicularly. At the confluence of the two flows there is an area of intense sediment disposal along the coast between Praia Nova and Grande Hotel, caused by water flow stagnation. A large sand bank is found in this area (Ingenieurs Bureau Amsterdam, 1996).

Regarding erosion in the area, various factors have an impact on the beaches loss and gain of sediments. Among them, the alongshore drift waves and currents and the open sea currents and tidal currents open in the direction of the coast are of particular interest. By acting directly over the beaches, breaking waves are considered the most important factor in coastal erosion. When the waves are very intense, especially during cyclones or bad weather, loss of sediment processes are dominant, resulting in coastal erosion. Calm sea conditions create the best conditions for the disposal of sediment, resulting in beach growth.

The waves reach the northern coast of the Beira estuary on a certain angle creating sediment alongshore drift towards the East. This movement is responsible for the transport and redistribution of sediment along the beaches in the estuary northern coastline (Doxiadis associados, 1992). It is estimated that almost 70,000 to 80,000 m^3 of sediment is transported annually like this (Ascadis Euroconsult, 1999; Ingenieurs Bureau Amsterdam, 1996).

The obstruction of this transport has the consequence of reducing sediment gains in the beaches and loss of sediment and erosion processes predominace. This effect is well illustrated by the obstruction of this sediment transport caused by the drainage Palmeiras delta and the beaches erosion between Palmeiras and Ponta-Gea.

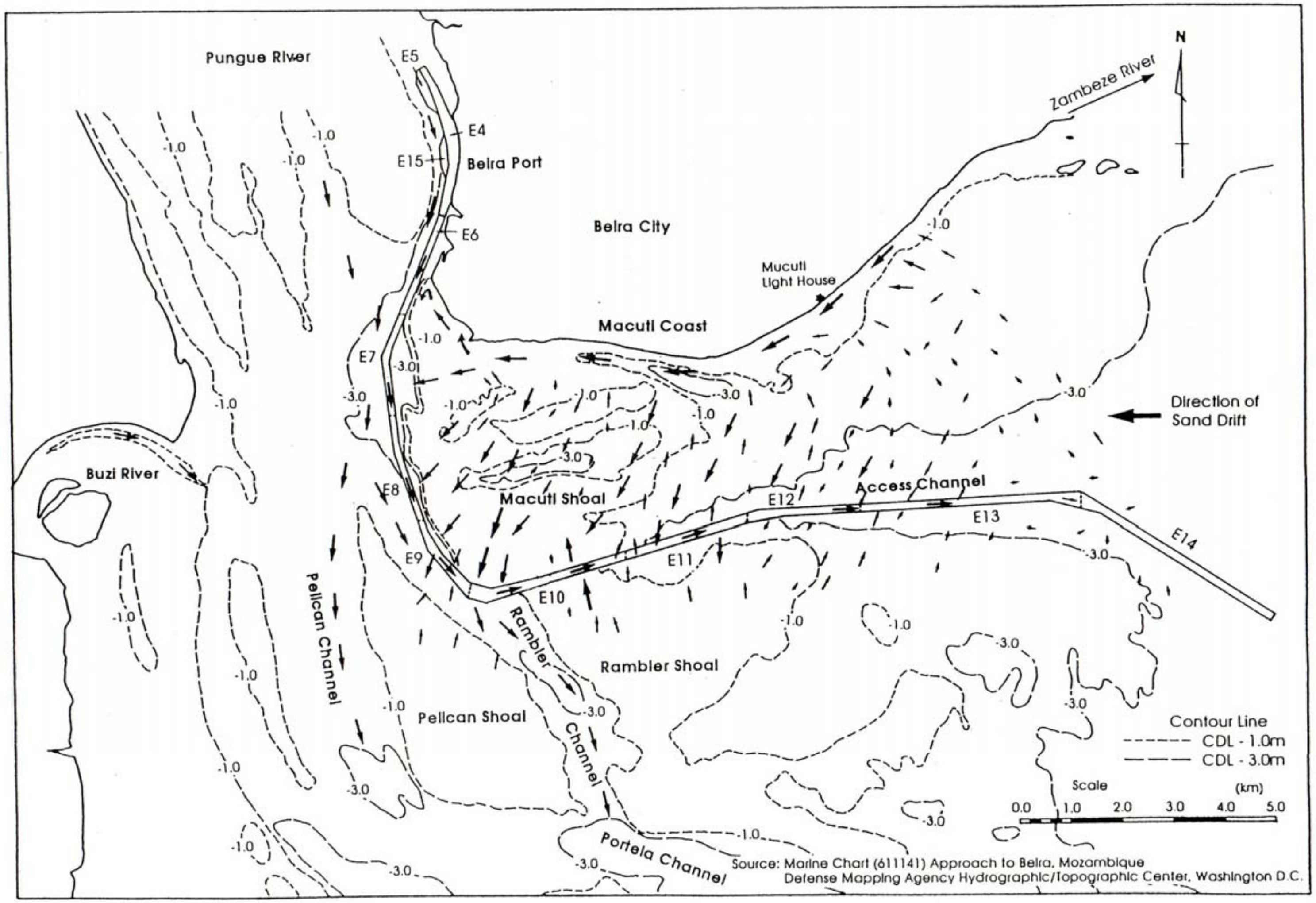


Figure 4.14 – Main residual circulation routes of water mass and sediments in the Beira Estuary. *Source: Doxiadis associates, 1992*

4.4.4 Types of sediments present in the channel

According to the study conducted by JICA (1998) the distribution of sediments in Sofala Bay along the Port Access Channel, in particular, is in accordance with current patterns, and sediment transport.

Regarding the Port Access Channel sediment characteristics, there is a tendency for sandy sediments for almost the entire length of the Channel. However, as can be seen in Figure 4.15, muddy sediment is predominantly found in the section of the Macuti curve located to the side of the Port, and in proximity of region E14 (JICA, 1998).

The fine sediments observed in Macuti curve are believed to come from the Pungue River, since analysis of the mineral content in the Access Channel sediments and nearby areas conducted by JICA (1998) show a correlation with the samples collected in the Gorongosa region, upstream of the Pungue River.

Generally, the sediment analysis showed that, apart from this exception the tendency is for sandy sediment to be predominant in the channels and in the open sea region, while the fine sediments predominate in the northern region of the Access Channel, in the Pungue estuary and the coastal regions to the south of the Buzi River mouth (JICA, 1998).

Chemical analyses were also conducted on ten samples of these sediments collected along the Access Channel, the upstream of the Pungue River and in the Sofala Bay, between the Access Channel and the coast, to determine the levels of metals, nutrients and organochlorines. The results obtained (see Annex 3) showed very low levels, without a clear distinction between areas with sediments constituted of sand or those of clay. According to JICA (1998) the concentrations obtained present acceptable levels, comparable with those coastal sediments found in the South African coast.

It should be refered that after this study, a sediments transport study along the Pungue River was made in the scope of the *Development of the Joint Integrated Management of the Hydro Resources in the Pungue Basin* (SWECO *et al* , 2004); this has revealed some gold exploration activities along the Pungue River mainly in the High Pungue (Nyamakwarara River), along the Zimbabwe border, that has generated a high release of sediment. The study concluded nevertheless that the gold mining operations in the Nyamakwarara River area probably did not significantly affect the average load of sediments transported in the system.

No further sediment analysis was identified, neither in Sofala Bay, nor in the rivers that run into it.

4.4.5 Water Quality in Sofala Bay

Since 2003, CHAIM (Centre of Hygiene, Environment and Medical Exams) has been doing analyses of the Sofala Bay water quality, namely temperature, pH, salinity, oxygen levels, turbidity, electric conductivity, alkalinity, and organic (faecal coliform) and bacterial contamination. These analyses have shown that these last six parameters have high values, showing some form of organic contamination, certainly as a result of untreated domestic effluent dischrage from the city. No analyses have been conducted relating to nutrients, metals, or organochlorides.

During the JICA (1998) study, water quality analyses were conducted in Sofala Bay in 1997 (in February and July) measuring a number of parameters, namely: physical parameters (temperature, salinity, oxygen, pH, turbidity and suspended solids), nutrients (nitrogen, phosphorus and lack of oxygen), total metal traces (mercury, cadmium, lead, arsenic, copper, zinc and hexavalent chromium) and organ chlorides (including PCB and DDT). The results are presented in Annex 3 of this report.

In regards to turbidity, it was observed that it is high between the outflowing tide and during spring tides the turning point, whilst also generally experiencing higher turbidity in the outflowing tide than in the incoming tide. This is explained by the more intense currents that are felt during the outflowing tide, which translates into an increased lifting of sediment from the sea bottom due to the substantial turbulence associated with the strong currents.

During neap tides, on the other hand, there is no clear pattern of turbidity variance during tide phases. Similarly, no patterns are observed in the turbidity variation in the bay during different seasons, maintaining a comparable turbidity in both the dry season and the wet season. One common aspect observed in all of the bay areas and tide phases was the increase of turbidity from the bottom to the surface.

Table 4.6 – Turbidity of the Beira Estuary water during the different tide phases and seasons of the year. The testing points from 1 to 10 are found on the coast (from Ponta-Gea to the lighthouse) and points 11, 12 and 13 are parallel to the external Channel access, around the sand banks. *Source: JICA, 1998.*

Observation Station	Turbidity in Spring tide (Max)		Turbidity in Neap tides	
	Rainy Season	Dry Season	Rainy Season	Dry Season
1	1,020	1,719	225	84
2	1,230	1,726	230	105
3	1,512	1,692	335	142
4	761	739	190	80
5	1,685	1,651	305	336
6	1,443	1,820	332	661
7	1,624	1,132	65	73
8	1,420	802	103	166
9	1,523	1,089	154	96
10	1,220	1,247	90	74
11	1,284	1,158	278	173
12	1,388	669	202	146
13	1,220	524	185	28

The related analyses with the organic and bacterial contamination conducted by JICA (1998) identified high levels of faecal coliform in the shallow water areas close to the city, mainly in the rainy season, a fact that could be attributed to weaker river current, and the disposal of untreated effluents from resident areas (namely latrines, wastes and domestic effluents) that during this time of the year begin to reach the water table.

The values obtained for parameters related to the presence of nutrients also show a reduction in the dry season, even taking into account that the aquatic environment is relatively rich with nutrients in both the dry and raining season.

In what regards the analysed metals, the results obtained are generally low, in most cases being below the instrument detection limits, as established in Mozambican standards (Annex V of Decree nº 18/2004), along with the standards of Japan and South Africa. Only in the testing stations located near the Port of Beira are there relatively high registers of copper, zinc and hexavalent chromium, mainly in the rainy season. Analyses conducted on filtered water samples showed lower values, indicating that these metals are essentially suspended particles. According to JICA (1998) these metals fill the Pungue River basin and probably are of geological origin.

During the study by SWECO e Associados (2004) analyses were conducted on the Pungue River basin water quality, including only combined sections of the estuary. In the study the following were identified as sources of river pollution: commercial and subsistence agriculture, rural and urban settlements, salinity, deforestation, the prospecting for gold in the Nyamakwarara River, along with other sources. The water quality analysis only included a few physical parameters (turbidity, pH, conductivity, dissolved oxygen and chlorides), except in the gold mining area of the Nyamakwarara River (in Zimbabwe), where analyses also tested the grade of mercury, where it was shown the grade of mercury was higher than allowed for in South African Water Quality Standards for domestic use. The analyses conducted on the Lower Pungue, namely on E67 located at the Pungue River Bridge, did not allow for the water quality to be evaluated, only showing a high turbidity and the presence of chlorides.

There were no studies identified that had analysed water quality measuring metals in the past in the Pungue River and Sofala Bay. There is no information about eventual contamination of the river by mercury released by mineral exploration in Zimbabwe or Mozambique despite that in the last few years there is evidence of an expansion in the mining of gold in sections of the Pungue River. Therefore, despite being possible, it is not probable given the large distance from the point of main mining activities.

4.4.6 Sediment Dynamic

Estuaries are complex hydrodynamic and sediment movement systems. Processes such as water flow, tides, saline intrusion, and waves and currents, all perform an important role in erosion, sediment transport and disposal of sedimentation in water body basins.

Important factors in the sediment dynamic:

Tide currents, resulting from variations in the level of the waters, constitute one of the most important factors in sediment transport. These currents can transport sediment from the bottom, and cause the suspension of sediment, as maintaining the sediment suspended through associated turbulence. The intensity reduction results in the reduction of turbulence, and consequently the sedimentation of suspended particles.

The Beira Estuary currents are intense mainly due tides. There is a special dominance during outflowing tides, sometimes reaching velocities above 1m/s. This dominance is attributed to the Estuary's geographic orientation, especially its mouth in relation to the sea waves that propagate in a Southeast direction (Doxiadis associates, 1992).

Maritime waves cause orbital or circular movement amongst the particles at depth, causing, therefore, erosion at the bottom. The stress caused by waves on the sea bottom is bigger when the waves are larger and when the depth is shallower.

As mentioned earlier, the Beira Estuary waves come from the SE and are intercepted by various banks before they meet the estuary. These regions create areas of large agitation by the breaking of the waves that, in theory based on the characteristics of the most common waves, extend up til 4m isobars. However, due to the existence of a very irregular bathymetry generated by many banks, channels and an undulated topography at depth, a wave breaking area typically observed in open seacoasts is not observed. Instead, the waves are disorganised, by refraction, diffraction, and depth friction, breaking irregularly on an individual basis on the Portela, Rambler, Pelicano and Macuti Banks on the estuary mouth.

The wave breaking action on the material at the bottom is more intense during low tide. Material lifted by the wave action is transported by coastal drift caused by waves even though the magnitude of the removed sediment transport by wave action on the beaches is not so important when you compare it with the strong tide currents (Doxiadis associates, 1992)

Currents caused by the variation in water density can serve an important role in the movement of sediment, mainly when the salinity gradient is significant.
However data indicates that these currents are not relevant in the sediment movement in the Beira Estuary (Doxiadis associates, 1992), as this estuary is very mixed during the entire year according to the data obtained between 1957 and 1959, in the stations between Utanha and the Beira Estuary mouth (Doxiadis associates, 1992).

The estuary becomes partially mixed during the rainy season's neap tides. In these conditions currents induced by the density could cause sedimentation in the regions that are salt intruded Still, this occurs upstream of the Port, not having any influence on the sedimentation of the Beira estuary.

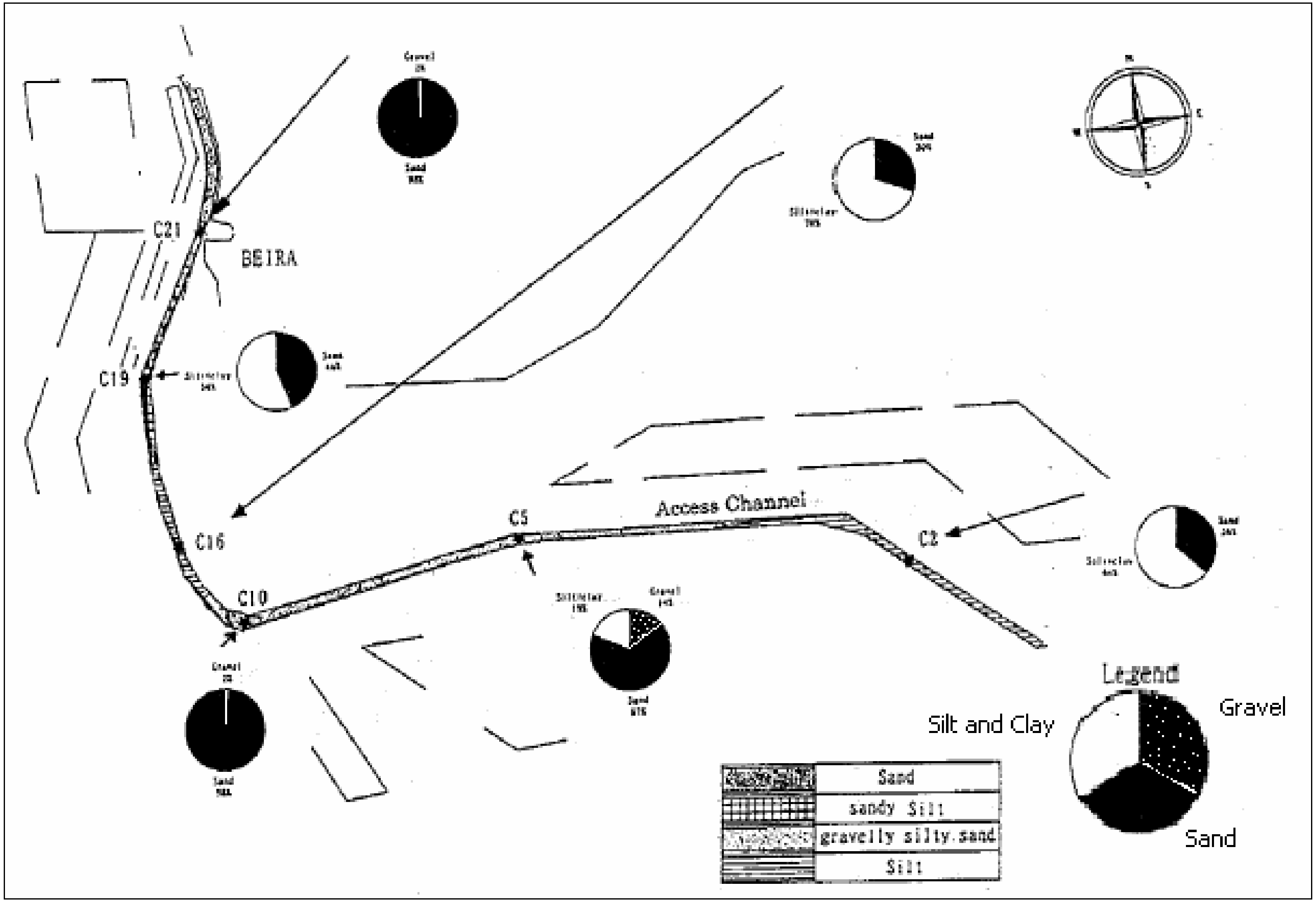


Figure 4.15 – Types of most common sediments in the Port of Beira Access Channel. *Adaptation by JICA, 1998.*

Other factors can also play an important role in the erosion and movement of sediment, in this case they include activities that result in the re-suspension of sediments, as the acquisition and disposal of dredged materials during dredging operations and the disturbance caused by ships.

Sediment Sources

Sediments are brought to, or lost to the system through:

i) River flow, those that contain suspended sediment
ii) Coastal transport induced by waves or tides that contain beach sediment, and
iii) Coastal and open sea currents.

Historically it is considered that the sandy sediment that feeds the beaches along the entire coastal length south of the Zambezi comes mostly from the Zambezi River outflow, and is transported along the coast through longshore drift currents caused by waves that in this region reach the coast typically from the SE. These findings are supported by the high correlation that exists between the sediment's chemical composition that is in evidence along the section of the coast and the sediment from the Zambezi River (JICA, 1998). It is thought that the construction of the Cahora Bassa dam decreased the transport and feeding of beaches to the south of this river with the essential sediment required for the maintaining of its natural condition.

It is estimated that the annual volume of sand transported along the coast by the marine current comes to a total of 80,000 m^3. This volume of sand is deposited along the coast, being interrupted by the Palmeiras spillway, situated in the city of Beira, which retains part of this sand that finally totals 45,000 m^3.

These values are the consequence of the gradient of the longshore drift and the losses resulting from the transversal losses of sand, that cause, on average, an annual coastal regression in the order of 10m.

The beach erosion in the Beira Estuary, especially to the estuary's southeast, is majorly attributed to the reduction in the sediment gaining that used to come from the Zambezi River (JICA 1998).

As previously stated, there is evidence that the fine and muddy sandy sediment that is predominant in the section to the north of the Access Channel, before the Macuti curve and the regions by the open sea (section C2 of the access channel shown in Figure 4.1) comes from the Pungue River outflows.

This data are also substantiated by high correlations observed between the sediment's mineral composition in these regions and the sediments collected at the joining of the river in the JICA studies from 1998.

The Beira Estuary Region is also characterised by a high tidal current in the direction of the coast (Doxiadis Associates, 1992). This current transports sediments from the open sea to the bay and as such is responsible for returning some of the dredged material from the Access Channel that was deposited in the local deposing zones outside of the bay (D4, D2).

Annual and inter-annual variations in the sediment dynamic

Direct measurements of annual and inter-annual variations of measurements of sediment dynamic in the Beira Estuary are very scarce. However sediment volumes removed from the fishing port and commercial port between 1964 and 1976 statistics (Figure 4.16), during maintenance of the depth of the Port, provide a good indication of the variations in the levels of sedimentation that occurred through these years. They also provide a good indication of the climatologically magnitude of the inter-annual variations of the dynamic of the sediments. Unfortunately the reported volume of dredged materials is presented in annual terms, therefore not offering details about the seasonal variations throughout the year.

The dredged sediment volume statistics show the existence of a very significant inter-annual variation, which would infer a significant inter-annual variation of rates of deposits. This inter-annual variation standards when compared with the variation standards of the River Pungue rapids in the same period (Figure 4.17), shows a very strong correlation.

In drought years low levels of sedimentation occur, while in flood year's high levels of sedimentation are felt, clearly showing that the sediment deposited in the Beira Estuary section where the Port is located is mainly resulting from the Pungue River. In these regions the levels of sedimentation can effectively be estimated on the basis of the variations of the Pungue River rapids.

In other regions of the estuary, especially those whose amount of sediment depends little on the sources of the Pungue River, such as the sections of the northern coast between Ponta-Gea and the lighthouse, a different inter-annual deposit level variation pattern can be seen. It is in these areas the transport and disposal is better regulated by the coastal currents caused by the waves, who themselves depend upon wind patterns.

In terms of annual variations, it is expected that for regions in which the expected amount of sediment depends upon the river, as in the case of the section north of the estuary and the beaches located to the south of the Buzi River, the levels of sedimentation or sediment disposal will be higher in the rainy season or in flood times (November to April), and that they will be lower in the dry season (May to October).

It is expected that on the northern coast beaches that the sedimentation dominates the calm times and that erosion dominates times of high winds due to the fact that sediment disposal occurs more acutely during times of lesser wave activity Still, as in this region there is no specific time associated with bad weather and that these cases can happen throughout the year (Doxiadis Associates, 1992), the sedimentation and erosion occurs irrespective of the season or time of the year.

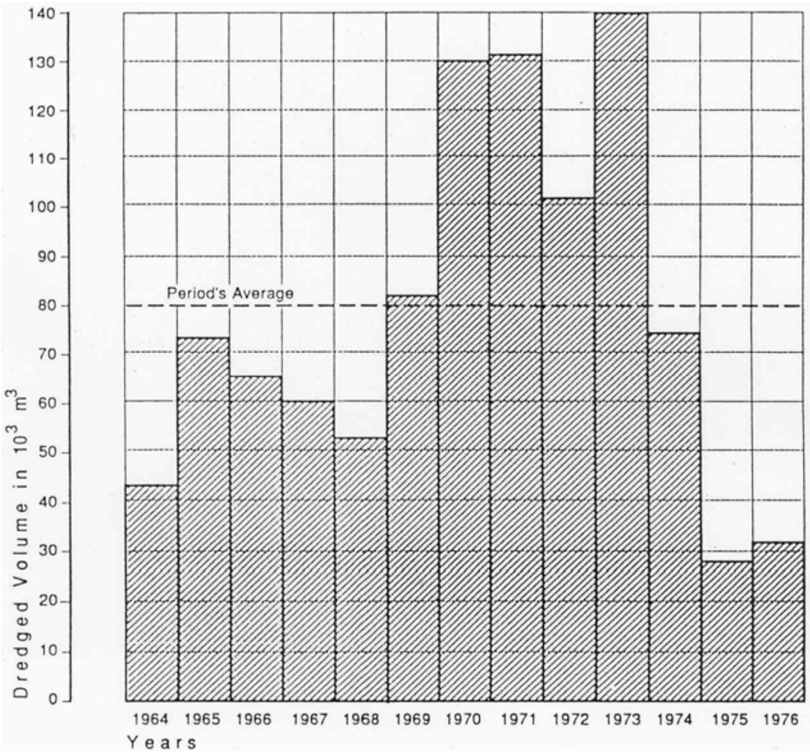


Figure 4.16 – History of dredging on the Beira Port docks between 1964 and 1976. *Source: Doxiadis Associates, 1992*

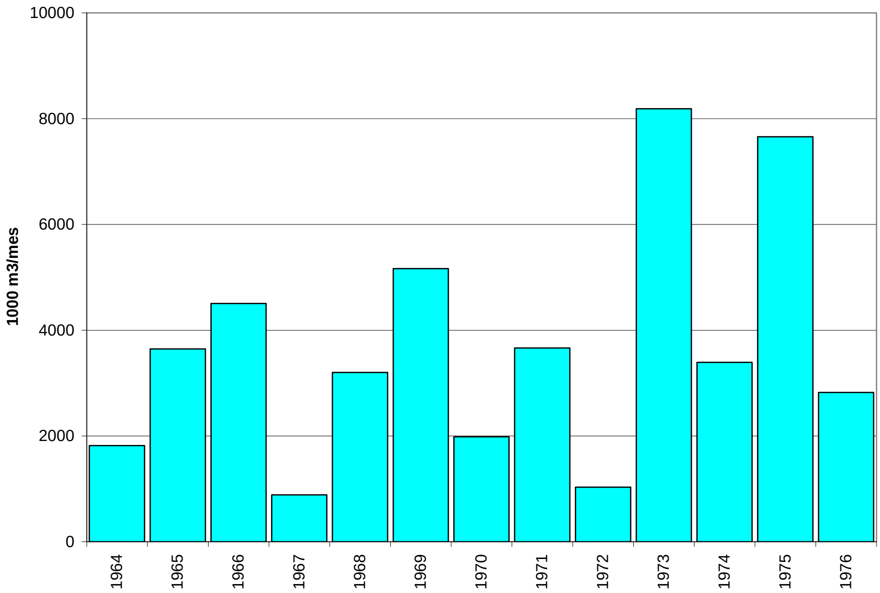


Figure 4.17 – Variation of the Pungue rapids *Source: Doxiadis Associates, 1992*

Sediment Movement in Sofala Bay

Tidal currents in the principal mode of sediment movement in Sofala Bay.. Two important sources of sediment and subsequent movement in this bay can be identified:

a) The erosion along the existing banks in the estuary supplemented with fluvial sediment coming from the upstream river and the recycled sediments from the dredging deposits D5 and D1 areas and erosion of the sea bottom, especially from the Pungue River sand banks.

The main sediment movement is orientated in the plain North-South of the estuary and it is constituted mainly by silt and clay particles, occurring during the ouflowing tide. This sediment movement is considered the main source responsible for sedimentation of finer clay and silt particles from the region of the fishing port docks or from the Chiveve river.

b) The erosion along the coast in the Northeast direction (NE) from Beira resulting from the coastal drift orientated towards the southwest (SW). This drift transports mainly sands in a westerly direction until the main channel of the port entrance.
Disposal zone D4 contributes much of this sediment mainly through its western region.

The combination of the these sediment movements a) and b), as illustrated below in Figure 4.18, are taken as the main movements responsible for the creation of extensive disposal areas that occur on the beaches to the south of the Buzi River in the port region, the development of the sandbanks (Ingenieurs Bureau Amsterdam, 1996) in the Ponta-Gea region, and erosion of the beach section between Palmeiras and Ponta Gea.

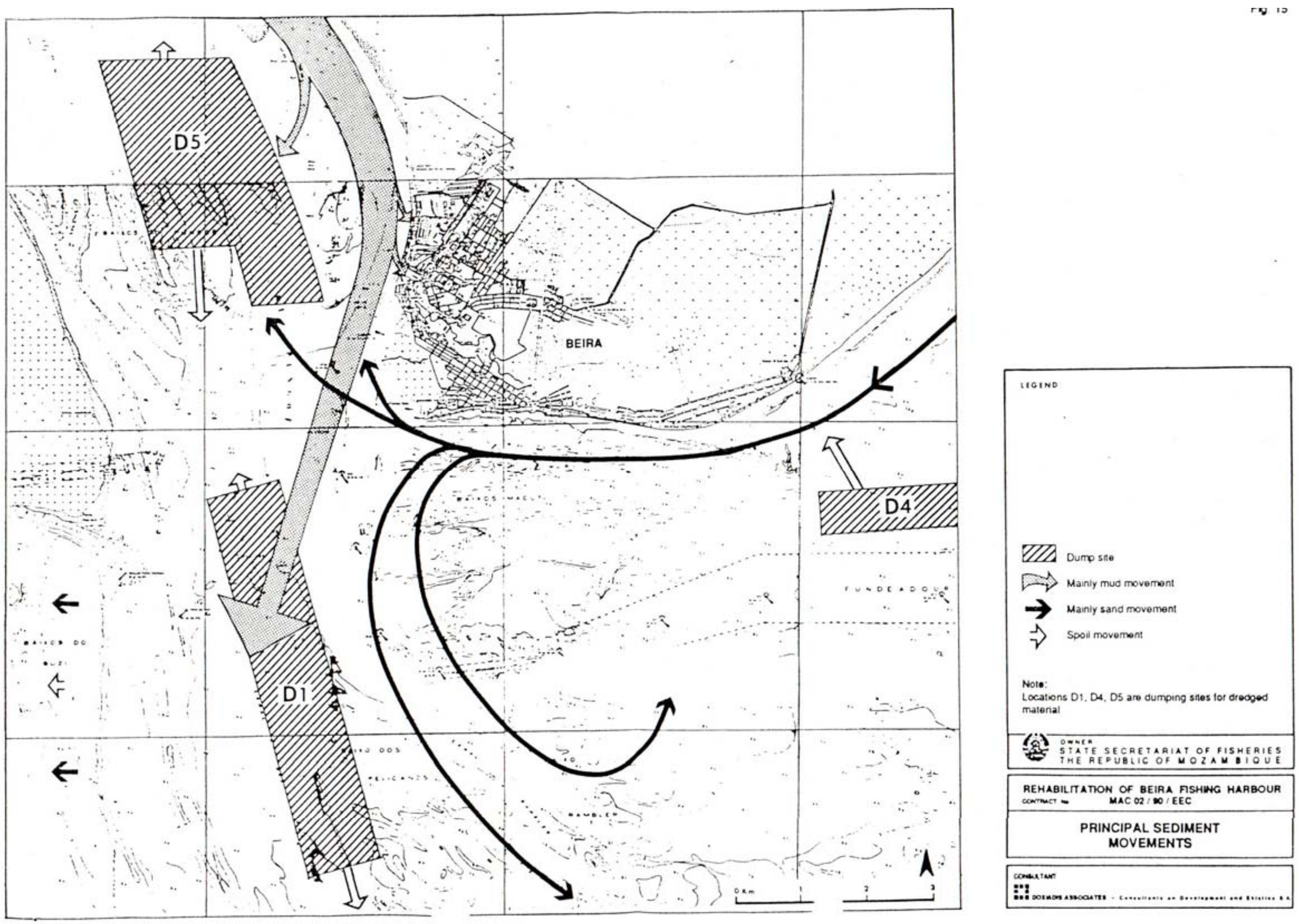


Figure 4.18 – Principal sediment movement route in the Beira Estuaries. *Source: Doxiadis associates, 1992*

4.5 Ecology

According with the Pritchard definition, an estuary is a semi-enclosed coastal water mass that has a free link with the sea, in this way it is strongly influenced by the tides. In its centre, the sea water mixes with the fresh water originating from land drainage. For example, river mouths, coastal bays, marshes and water masses retained by stretches of sand. Estuaries can be considered as transition zones between freshwater and marine habitats, even though many of their most important physical and biological characteristics are not those of transition, but indeed specific.

It is characterised by its fresh water patterns. The salinity variations are continual and give the estuary dynamic environment characteristics with varying populations in both space and time but geographically limited and, furthermore, there are substantial nurseries of larva and recently born fish that within these waters have access to an abundant food source and dynamic protection from predators.

This aquatic environment of the sandy and muddy beaches in the Pungue River estuary are characterised by high biodiversity. It is an ecosystem largely dominated by mangrove species and aquatic animals that support a large part of the economic activities of the urban population of Beira and its outskirts.

4.5.1 Flora

Terrestrial Flora

There is a low dunes system located along the Beira seafront that reach up to 150-200m of the coastal strip from the Praia Nova to the Macuti Lighthouse. The predominant vegetation in many of the dune crests is beef trees. Beef trees *(casuarinas)* is specie that was introduced and does not appear to have any natural abilities of regeneration. Lower in the dunes there is grass and weeds. Many of the stable dunes have creeping plants and weeds such as *Canavalia maritima, Cucumis sp., Ipoamea pescapre, Sporobolus virginicus* e *Cyperus spp* (Sereuca e DNA, 2005) on their front side.

Aquatic and Transitional Flora

The most prominent flora on coasts adjacent to the Pungue River estuary are Mangrove trees and cane that require a large quantity of water in their lower parts for their development.

Due to the high level of natural turbidity in the water that characterises the estuary, there is no aquatic vegetation. Some areas with lower turbidity, located in Regulo Luís, have appropriate conditions for the growth of marine weeds.

The mangroves develop in muddy plains, streams, and estuary islands (these islands found in the Pungue River estuary – figure 4.19) with soils that possess heavy fluvial-maritime alluvium. In the streams close to Savane and Nhangau mangroves grow in large numbers and in a small number on the southern coast of the Pungue River estuary. In the interior banks of the mangrove very few can be found on the extensive highly saline muddy plains, free of vegetation (Sereuca and DNA, 2005)

Figure 4.19 – Mangrove Forest on the interior islands of the Pungue estuary. Artisanal fishing can be noted being done around the mangroves. *Consultec, 2006.*

<u>Mangrove coverage and deforestation rate</u>

The mangrove coverage situation in the Beira area is seen as good and reasonable even though the rate of deforestation was 5% between 1972 and 1990, which is the second highest rate in the country (Anon, 2004).

In the past, the mangroves of the Beira urban zone extended in an area of 100 hectares, in a zone situated between the Ponta Gêa pier and Praia Nova This zone is presently covered by a mosaic of fresh water and brackish swamps and bambu (Sereuca e DNA, 2005). At present the mangroves cover a relatively small area in the urban zones with close to 8 hectares in the inlets around Praia Nova and close to 10 – 20 hectares along the Chiveve river and drainage channels. All of the estuary islands have vast mangrove forest even though some of them have been exploited by people collecting firewood to sell in the market in Beira.

In the mangrove area situated between the mouths of the Búzi and Pungue Rivers, commonly known as Malawi, it can me seen that the devastation of these resources is increasing day by day. Hassan suggested, (cited by Kulima 1999) that the most evident areas of mangrove devastation in Beira are in the following: Maria River, Praia Nova and the Pungue River delta. According to Muchangos (cited by Kulima 1999), these actions are certainly those that cause the most concern in relation to coastal protection. A recent study (Pereira, 2006) confirms the reduction in the coverage of mangrove forests as a result from these intense deforestation activities by the local communities.

In general terms, there are five main mangrove tree species registered in the Beira area, namely: *Avicennia marina, Sonneratia alba, Hieritiera littoralis, Rhizophora mucronata* and *Lumnitzera racemosa*. However, there exists three other mangrove species growing amongst the main species (Table 7). The most abundant mangrove specie by far is *Avicennia marina*. Tree species such as *Hibiscus tiliaceus* and *Peltophorum pterocapum* are common, along with bushes such as *Pluchea sp.*

Table 4.7 – Mangrove species, their location and state of conservation (State of Conservation legend:** Good **= well developed plants can be seen with other small ones growing and no signs of cuttting;** Reasonable **= generally small plants and evidence of some clearings and signs of cutting;** Bad **= Large expanses of the area showing cut trunks, only a few plants left)

Scientific Name	Common Name	Location	State of Conservation
Avicennia marina	Mpedje	Dama and Dingue-Dingue, Maria and Ndjalane River	Good in Dama Reasonable in the other areas
Ceriops tagal	Mucandala	Maria River, Ndjalane	Bad
Rizophora mucronata	Mucorongo	Maria River, Ndjalane	Reasonable
Brugueira gymnorrhiza	Nfinge	Maria River, Ndjalane	Reasonable
Lumnitzera racemosa	Mpiripih	Maria River	Reasonable
Xylocarpus granatum	Ntumbu-Ntumbu	Maria River, Ndjalane	Reasonable
Sonneratia alba	Mutuanguazi	Maria River, Ndjalane	Reasonable
Heritiera littoralis	Nhantazera	Ndjalane	Reasonable

Source of Information: UP – Pereira, 2006

A large area located behind the coastal dunes and mangroves has a mosaic of brackish or freshwater swamps, with cane or rice fields. The mosaic of freshwater and brackish swamps could be important for conservation, as they provide an attractive habitat for amphibious, birds, fish and plants.

4.5.2 Fauna

<u>Terrestrial Fauna</u>

The relevant terrestrial fauna is associated with the mangroves and dune areas. Due to hunting, the large species of mammals are no longer common in this area. According to Sereuca and DNA (2005), within the urban perimeter the diversity of birds reduces to just the domestic sparrow (*Passer motitensis*) and the freckled raven (*Corvus albus*). The numerous swamps, mangroves and the areas influenced by tides that encircle the city provide, therefore, an adequate habitat for bird diversity including long-legged birds and sea swallows. The most common species are the *Euplectes orix* (red bishop), the *Egretta garzeta* (little egret) and the *Chilodonas hybrida* (whiskered tern).

The mangrove forest also shelters reptiles and anuran amphibians, although they are not very well documented. Various invertebrate species (insects, gastropods) associated with the vegetation and a few mangrove birds are also present.

Intertidal Fauna

The most predominant intertidal fauna with the most commercial value are clams. According with the Bata study (2006), the most important species, *Meretrix meretrix,* can be found along the sand banks at the Pungue mouth in front of the Commercial Port.

Other species that are found in smaller quantities and that are of less commercial value are *Mactra sp.* and *Donax incarnatus.* The species *Eumarcia paupercula* and *Donax madagascariensis*, can be found but do not have commercial value. Given the environmental conditions of each area, the occurrence and distribution of the species varies. In Estoril, in the sandy layer of open beach the species *D. incarnatus* and *Mactra sp*. can be found.

In the Maria River mouth, a sandy-muddy layer estuarine zone, all of the cited species can be found with the most prominent being *M. meretrix*. On the sand banks of the Pungue, that has a sandy-muddy layer, only *M. Meretrix* can be found.

Aquatic fauna

In the project area various species of osseous fish (mainly small pelagic fish from the Engraulidae family, also catfish and sea bass), echinoderms (mainly the sea-urchin diadema), crustaceans (mainly white prawns, the brown prawn, giant tiger prawn, mangrove crabs and the fine prawn (mundehe), bivalves (clams) and cnidarians (medusas) can be found.

Non-confirmed local reports refer to an area of the Pungue Estuary that could be used for the local passage of green tortoises and by at least one dolphin specie.

Fishing Resources

In the estuary area various activities take place with the most notable being fishing and maritime transport, noting that the beaches serve as much as boat disembarking centres, transport and for fishing. The Pungue River estuary is the stage to intense artisanal fishing whose most captured species are presented in Table 4.8.

Table 4.8 – Artisanal Fishing resources of high commercial value in the Beira area.

Taxonomic Group	Specie
Fish	*Thryssa vitrirostris*
	Arius dussumieri
	Hilsa kelee
	Jhonius dussumieri
	Acetes erythraeus
	Sardinella gibbosa
	Mugil cephalus
	Trichiurus lepturus
	Otolithes ruber
	Himantura gerrardi
	Pellona ditchela
	Jhonius amblycephalus
	Other fish
Crustaceans	*Penaeus indicus*
	Metapenaeus monoceros
	P. monodon
	Scylla serrata
Cephalopods	*Sepia sp.*
Bivalves	*Meretrix meretrix*
	Donax incarnatus
	Mactra sp
	Donax madagascariensis
	Eumarcia paupercula

Source: IIP-Santana Afonso 2004;IIP- Bata, 2006; IIP- Brito, 2005; Fischer et al. 1990

4.5.3 Biological Sensibility

Occurrence of *Meretrix meretrix* clam stock in the banks

The Pungue River mouth sand banks are the areas most prominent with clams (Bata, 2006) with a high commercial value that flows into the city of Beira, with catches estimated at more than 400 tonnes annually. These molluscs are captured by artisanal fishermen who depend upon this activity for their subsistence. This zone is accessible at low tides, when the bank becomes exposed.

The clams, like other bivalves, filter sediment and by way of which are very susceptible to bioaccumulation of heavy metals and other chemical and microbiological elements. For this reason, in countries where there exists industrial extraction of clams and other bivalves, purification factories are required that allow for the detoxification for the animals before their selling.

In Mozambique and especially in Beira, these procedures do not exist therefore any activity that causes an increase in the exposure of this bivalve stock to the aforementioned contaminants will increase the risk to the health of those people who consume clams.

Occurrence of Giant Tiger Prawn *(P. Monodon)* in the Régulo Luís

Various species of prawn can be found in the area in front of the Régulo Luís fishing centre just like in other parts of the Pungue estuary and adjacent areas. However, a particularity of note in this area is the specific habitat required for the prawn *P. monodon.* There is no other area where this prawn is concentrated around the Pungue River estuary and its surrounds.
Therefore, this species is not distributed along the entire length of the coast. It appears to have different growth characteristics from other prawns that are present in this area; the Penaeidio prawn being considered the largest. Presently, it grows very rapidly, reaching close to 337mm in total length, or 100mm more than the next largest prawn (the species *F. indicus*) (Fischer *et al*., 1990). Its lifecycle is between one and one and a half years.

In the Beira region, the *P. Monodon* habitat is usually found in the Régulo Luís area where the species probably finds the best saline conditions, levels of turbidity, and other factors that for it are favourable. This species is active as much during that day as during the night and has the ability to bury itself in the sand, unlike the other species mentioned, but may not be able to bury itself in very turbid conditions (Palha de Sousa *et al.* 2006), like those that could be caused by different phases of the dredging.

Breeding and migration of prawns in the estuary

The species *Fenneropenaeus indicus* and *Metapenaeus monoceros* constitute 99% of the number of prawns in the Pungue estuary. This estuary plays a very important role in the life cycle of this species. Usually these prawns have a marine adult phase and a coastal or estuary juvenile phase and this cycle is completed in one year.

The juvenile *M. Monoceros*, use areas of the Pungue River estuary located from the suburb of Palmeiras until the mouth of the Búzi River for the breeding of offspring in the rainy season when the salinity is less than 25 (*practical units*). For *F. indicus,* there are favourable areas for both adult development (areas with salinity permanently above 30), and juvenile development however in lower quantities (Table 4.9). Figure 4.20 shows the location of some of these areas, almost all occupied by fishing centres.

Table 4.9 – Species of prawns found in the Pungue estuary, and their location

Especies / Fases	Régulo Luis	Estoril	Palmeiras	Grande Hotel	Foz do Pungoe	Foz do Buzi	Dingue - Dingue
F. indicus							
Juvenile	0.19	0.44	0.22	0.10	0.11	0.15	0.21
Adults	0.81	0.56	0.78	0.90	0.89	0.85	0.79
M. monoceros							
Juveniles	0.34	0.30	0.75	0.83	0.85	0.90	0.32
Adults	0.66	0.70	0.25	0.17	0.15	0.10	0.68

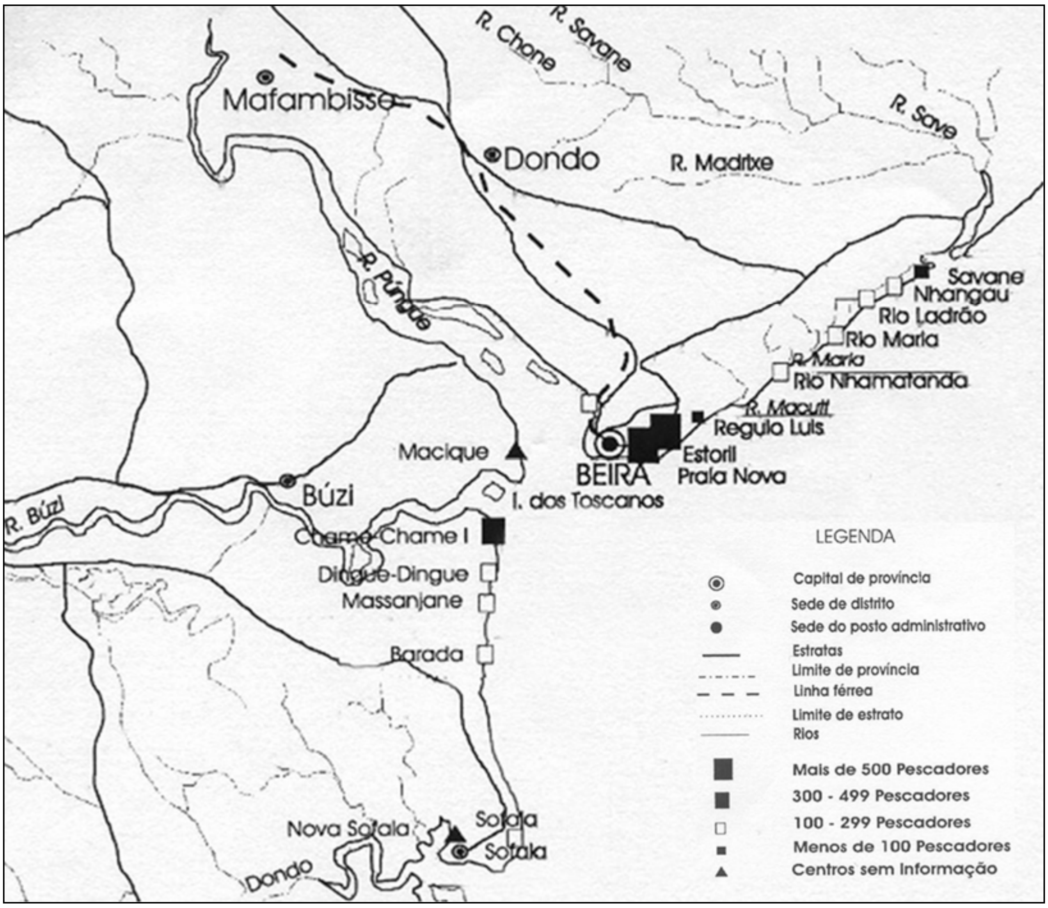


Figure 4.20 – Map with the main fishing centres in the Sofala Bay region. The larger squares represent more then 500 fishermen. *Source: Perreira et all, 2005*

The immigrant prawns (juveniles in migration) that migrate from the estuary to deeper areas (where the industrial fishing takes place) require between 1-2 months to complete the migration (Brito, 2005) which is a locomotive process using thoracic claws at the bottom of the sea or by "surfing" in the water columns helped by currents.

This important process occurs during the rainy period, between November and March of each year (figure 4.21) (Brito, 2005). As its importance is recognised for the Mozambican fishing industry, the process of breeding and the migration is protected by laws during this period through ministerial fishing despatch that determine the closed season for prawn fishing for the entire Mozambican coast,. These closed seasons are defined by the general regulations of maritime fishing.

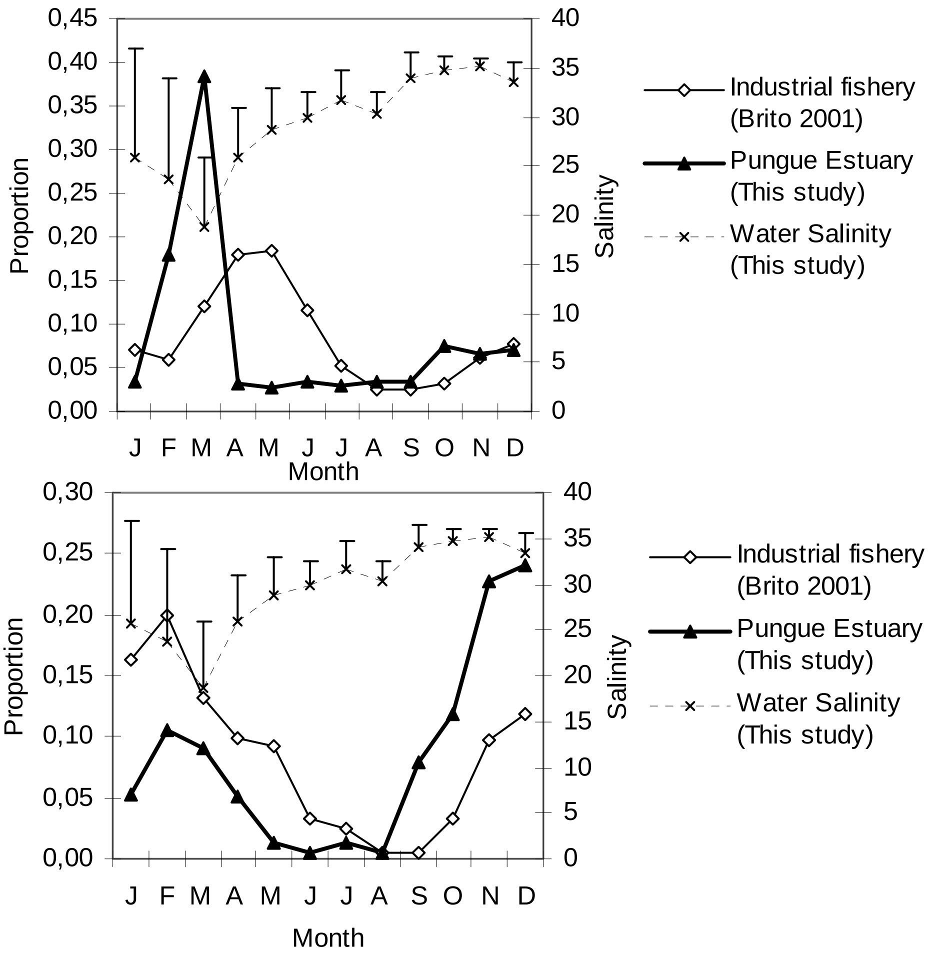


Figure 4.21 – Monthly migration patterns (-▲-), of the Pungue estuary and the deeper adjacent areas (-◊-) for the F. indicus (left) prawns and M. monoceros (right) and salinity values of the estuary water (---) *(Source: IIP-Brito, 2005.)*

The planned dredging of the Port Access Channel could interfere with this natural process of breeding and migration if mitigation measures are not taken. These are indicated later in this report.

<u>Ecological Importance of the Mangrove Ecosystem</u>

As is widely known, the marine component of the mangrove is largely dominated by various molluscs, crustaceans and fish. The complex root system serves as coverage for much invertebrate marine life. Their falling leaves, branches and trunks and consequent decomposition offer the adjacent sea organic and dissolved inorganic material. As the mangroves contribute to the recycling of nutrients, they support important species, in this way contributing to positive coastal artisanal fishing amongst other things.

The mangroves are a primary biological component for the environment. They remove phosphorous and nitrogen from the sediment and break down the carbon. They are important also for the retention of toxins and bad substances for some marine species.

In a general way, mangroves protect the soil against marine erosion and retain part of the sediments released by the rivers and local currents that would otherwise be carried to the sea; this sediment is the main source of sedimentation for the port access channel and of other areas where the marine and estuary ecosystem would otherwise consequently be altered.

Ecological Importance of the Estuary Ecosystem

Despite the lack of any concrete studies about the contribution of the Pungue River estuary for the natural breeding of young fish, there are signs of this contribution through samples taken in “chicocota” and net fishermen’s mosquito nets at the beach at Palmeira’s outflow that show high fish larva catches (data from the Institute of Fishing Research - *Instituto de Investigação Pesqueira*).

The fish species and crustaceans’ larvae and young fish mentioned above also migrate to the open sea like older animals. These movements, generally, are driven by various environmental factors. Generally, the higher the precipitation, the higher the water drainage of the rainwater by water currents from the river and consequently the water salinity of the estuaries and coast tends to decrease. In these conditions, many already mature animals can not tolerate low salinities and immigrate to deeper areas and areas with high salinity (open sea).

4.6 Socio-economic Description

4.6.1 City's Evolution and Importance

Beira has a history strongly influenced by its location and geographic attributes (natural physical) – the favourable location alongside the Buzi and Pungue River estuaries (meaning access to the Muenemutapa Empire) gave Sofala Bay a commercial importance for the region ever since the pre-colonial times.

Located on a strip of sand, Beira was constructed alongside the sea, along the coastal line constantly modified by tides, and its development and use of the land were always influenced by its topography. A barrier against the sea was constructed, initially using stakes and later was substituted by a brick and stone wall. This "*fight*" against the sea continually characterised the city's development. To complete the construction of habitation infrastructures, it was needed to put in place landfill in the swamplands..,

Beira's development has always been linked with the geostrategic condition of the port installation. The development of its infrastructures (habitation and storehouse), with particular attention on the centre of the city, provided a measure of how the Port was developing,

The importance of this port-city reached a considerable position at a regional level through the creation, in 1975, of the Beira Corridor and the consequent modernisation of the Port. Despite the current levels of sedimentation, the capacity to handle port markets shows Beira's unquestionable position in terms of national and international importance in the development of the central region of the country and surrounding countries.

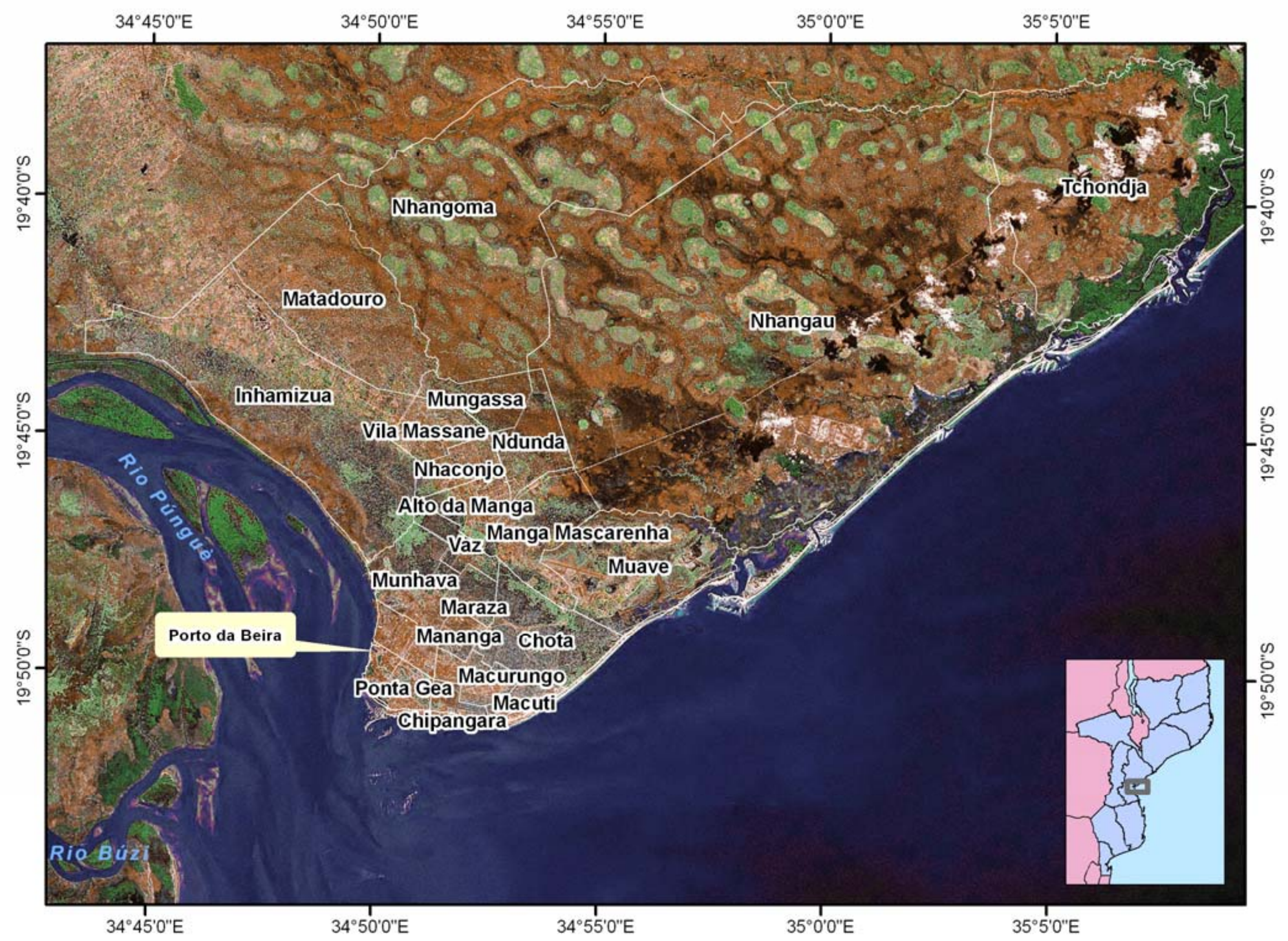


Figure 4.22 – Administrative Division of the Municipality of Beira

4.6.2 Demographic Conditions

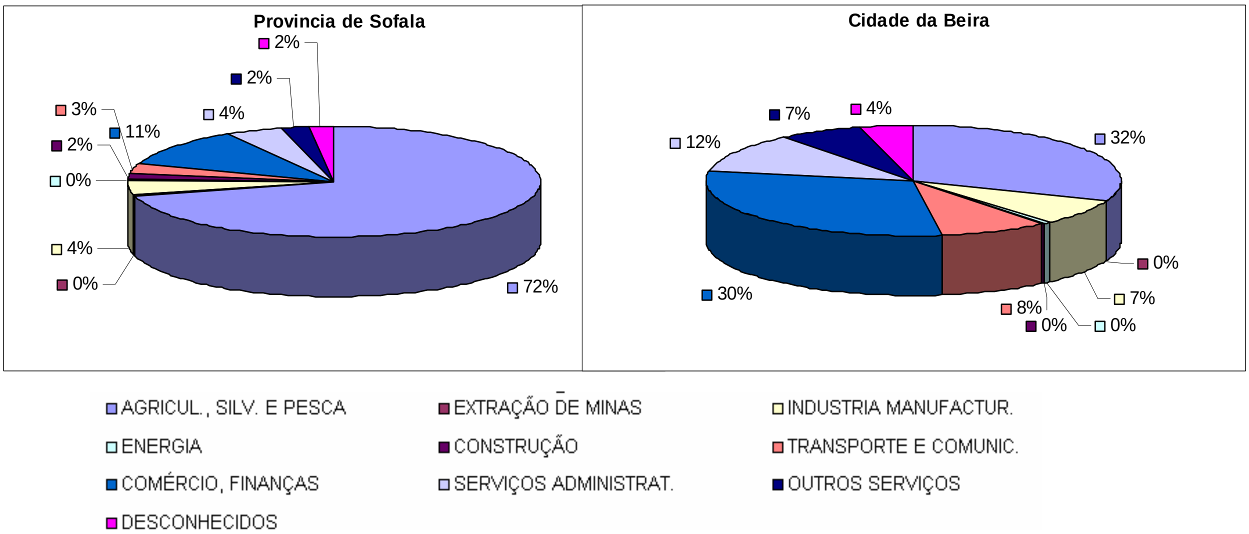
During the Second General Population and Habitation Census, completed in 1997, Sofala province registered 1,289,390 habitants, of which 397,368 reside in Beira. The National Institute of Statistics' (INE) projections indicate that in 2005 the population increased to 1,637,821 and 561,255 inhabitants, in the province and city respectively. It can be seen that Beira, the largest city of the province, contains, in 1997, 30.8% of the total population of the province, with an increase to 34.3% in 2005 (INE, 2004).

In relation to population density, the 1997 Census showed Sofala's population density to be the highest in the country, along with the province of Nampula and Maputo. In 1997 Sofala Province had a population density in the order of 19 inhab/km^2, predicting that in 2005 it would be 24.1 inhabit /km^2, In Beira the densities were 553.4 and 781.7 inhab/km^2, in 1997 and 2005 respectively.

Occupational structure of the Sofala province population

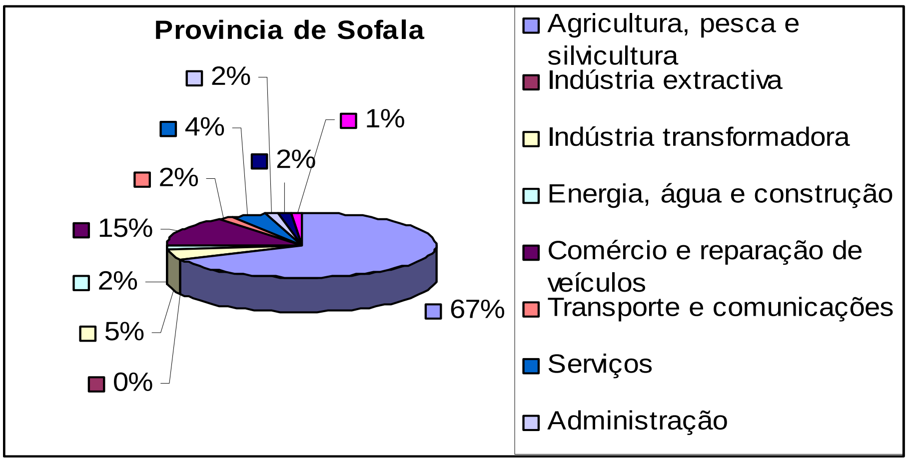
According to definitive data from the Second General Population and Habitation Census (INE, 1999), in 1997, Sofala province has 442,838 inhabitants of 15 or more years of age doing a productive activity – Population Economically Active (PEA) – of which 115,734 are found in Beira.

The graphics below show the distribution of this population (PEA) by different activities and it can easily be seen that most of these people are working in agriculture, forestry and fishing, both in the province (72%) as well as in the city (32%). In the city it can be seen that commerce is very close (30%) to these other activities.



Graphic 4.1 – PEA by different activities in Sofala Province (left) and city of Beira (right).

According to the Integrated Enquiry of the Workforce (IFTRAB), in Sofala province, in 2005, the PEA sectors of agriculture, forestry and fishing dropped 67.3%, which can be seen in graphic 4.2. Even though data does not exist about the occupational structure of the city of Beira for the year 2005 it is believed that commerce continues as the second most practiced activity, just like in the census year.



Graphic 2 – IFTRAB in Sofala province in 2005. *Source: INE, 2006*

Land use

During the scope of Beira environmental diagnosis, Bene (1996) showed the spatial division of the city in accordance with the urban structure and defined three areas: urban, suburban, and peripheral.

According with this author, the predominant types of space occupation in the centre of the city throughout the history of its development reflects a spatial plain where the natural conditions and space demand for different human activities played an integral role for its configuration.

Located in unfavourable areas and swamps, the suburban areas have precarious structures that do not obey any spatial planning. The concentrated occupation of this space motivated by overpopulation provokes various socio-environmental problems like the deficient functioning of sanitary infrastructure, providing of water and other social infrastructures. Apart from this, these swamplands harbour sickness, like malaria-carrying mosquitoes.

In the suburban areas and surrounds, the sketch of the arteries is unorganised and the soil generally sandy or clayey, which results in movement being impractical in the rainy seasons.

In some urban areas there are precarious constructions made in part from mangroves and other non-conventional material, nevertheless, they are more spacious and constructed on the coastal plane that borders the terrace – land appropriate for construction – as such presenting fewer environmental problems compared to the suburban area.

It is also in the coastal plain where agriculture/harvesting and cattle activities are conducted, creating the green zone of the city that is home to important infrastructures for the breeding of animals and horticulture and vegetable production.

4.6.3 Economic Activities

Given its geostrategic location at the mouth of the Buzi and Pungue rivers, and the politics of development followed since the colonial period, the socio-economic development of Beira is strongly related to the development of the Port and the Beira Corridor.

According to the State Administration Ministry, apart from consolidating a rail-port system, Beira possesses the country's second largest industrial park and fishing units. The potential for professional development of the fishing resources by industry is a strong element of attraction for work in the region.

Subsistence agriculture, artisanal fishing, and informal commerce, along with the exploitation of local natural resources, notably wood and coal, still represents a majority of the Population Economically Active (PEA) as much in the rural areas as well as in the urban areas. In general, the rural population from the District of Beira, is found distributed in the following way:

- Populations located on the coast, where the main activity is fishing and informal commerce.
- Populations located along the communications channels. The main economic activity is the selling of products, with high levels of informal commerce. There are also areas where coal, firewood and timber posts are sold.
- Small populations at the forest edge. The main activity is the cutting of firewood, production of coal, and agriculture. In these groupings the main type of activities are family type agriculture
- The most secluded peoples whose inhabitants concentrate on artisanal fishing. They have fishing camps.

4.6.4 Agricultural Activities

It is important to note that nearly 39% of the population that live in the urban areas in Sofala province is involved in forest, fishing and agriculture. In a majority of cases, these are people who live in cities, whose main occupation is the agriculture practiced in the lands that exist in the cities' green zones and in the districts situated in the Beira corridor and the Pungue River Basin. On the other hand, there are also groups of tenant farmer families in Beira that have "machambas" (small farm plots) in the more distant rural areas.

The most commonly produced products in Beira District are: rice, sweet potato and some horticulture. The agricultural activity is produced in the most fertile strips located in the low areas (rice production) or in the higher fertile zones, close to the hills, where groups of forests exist.

The agriculture is basically subsistence and self-consumption. The products that generate a small family income generally prove to be other types of products such as: firewood, coal, production of drink, timber posts, cane and in the coastal zones there is also fishing.

Fruit trees constitute an important source of family income. Around the houses and machambas there are orchards: mango trees, cashew trees, banana trees, coconut trees, and income generating citrus trees inherited from their ancestors**.**

The breeding of small weight animals (coop birds and goats) is also a contributor to means of survival for the local communities. It is common to come across fishing activities, crops of *mapira*, cassava, fruit trees, beans and sweet potato developed by a collection of tenant farmer families in a cooperative (CVRD, 2006).

4.6.5 Fishing resources and activity

In area of the Pungue River estuary (where the port is located) various activities take place with the most notable being fishing and maritime transport, noting that the central beaches serve as much as boat disembarking transport centres than as for fishing.

The exploitation of fishing resources involves as much industrial fishing as artisanal. Despite commercial fishing contributing greatly to the country's economy, small-scale fishing, composed of semi-industrial and artisanal fishing, also significantly contributes to exportations, the informal economy (especially at a local level), and is a large source of protein for the coastal populations.

Artisanal fishing is the most represented type of fishing – in 1998 Sofala province emitted 613 fishing licences, 534 of those artisanal, 41 industrial and 38 semi-industrial. In figure 4.23 the artisanal fishing in the interior of Sofala Bay can be seen.

Figure 4.23 – Artisanal fishing practised around the estuary islands. *Consultec, 2006.*

Artisanal Fishing

The estuary is the stage to intense artisanal fishing that captures various species of fish, cephalopods and crustaceans, including Penaeidio prawns of a high commercial value as shown in Table 4.10. The total captures are estimated to be in the range of 2000 tonnes per year (Santana Afonso et al., 2004). The fishing activity is done by about 3,000 artisanal fishermen that operate 2,145 different fishing methods; amongst the highlights of these are land and boat seine, gill netting, line fishing and others (table 4.10) in more than twelve fishing centres in the district of Beira.

On the southern margin of the Pungue delta there are some spread out fishing centres that are part of the Barada strip, part of Búzi district, that catch 140 tonnes of fish on average per month (data from the Institute of Fishing Research). This area constitutes one of the main fishing areas of that district.

Table 4.11 shows that beach netting is the method that is responsible for the most catches, representing 40% of the daily production, followed by cast netting (23%). The Praia Nova fishing centre is the main unloading centre with more than 38% of the daily load of the Beira city artisanal fish passing through there.

Beach net fishing is evenly distributed throughout different fishing centres however cast netting takes place mainly at Ndjalane whilst at a lesser extent it also takes place at Praia Nova (table 4.12).

Table 4.10 – Main species, their habitats, average quantities caught in the Pungue estuary and surrounding areas and fishing methods used.

Taxonomic Group	Specie	Common Name	Average Annual Catch (tonne)	Methods	Habitat
Fish	*Thryssa vitrirostris*	Orange mouth Anchovy	532	Seine and gill net	Pelagic coast and estuaries. Entire study area.
	Arius dussumieri	Catfish	430	Seine and line	Demersal coast, marine waters and turbid estuaries. Entire study area.
	Hilsa kelee	Kelee Shad	315	Beach Seine and gill nets	Pelagic coast. Entire study area.
	Jhonius dussumieri	Sin Croaker	280	Seine and line	Bento-pelagic coast. Entire study area
	Acetes erythraeus	Tsivakihini Paste Shrimp	212	Mosquito nets and seine	Benthic: depths of mud and sand, brackish waters, fish in the intertidal zones of Praia Nova at Régulo Luis
	Sardinella gibbosa	Sardine	109	Seine and gill net	Pelagic coast. Entire study area.
	Mugil cephalus	Flathead mullet	96	Seine and gill net	Bento-pelagic coast, estuaries and rivers. Pungue and Búzi river mouths.
	Trichiurus lepturus	Cutlass fish	80	Seine	Bento-pelagic coast. Entire study area
	Otolithes ruber	Tiger-toothed Croakers	75	Seine, gill net and line	Bento-pelagic coast. Entire study area
	Himantura gerrardi	Sharp-nosed Stingray	55	Line, Seine	Bento-pelagic coast. Entire study area
	Pellona ditchela	Indian Pellona	51	Seine and gill net	Pelagic coast, estuaries and rivers. Entire study area.
	Jhonius amblycephalus	Bellfish	48	Seine and line	Bento-pelagic coast. Entire study area.
	Other fish		98		
Sub-total fish			***2380***		
Crustaceans	*Penaeus indicus*	White Prawn	26	Seine	Benthic, depths of mud and sand: Young estuaries, adult marine. Entire study area.
	Metapenaeus monoceros	Brown Prawn	8,6	Seine	Benthic, muddy-sandy depths: Young estuaries (Buzi and Pungue River mouth), adult marine. Entire study area.

Taxonomic Group	Specie	Common Name	Average Annual Catch (tonne)	Methods	Habitat
	P. monodon	Giant Tiger Prawn	NA	Seine	Benthic, muddy-sandy depths: young estuaries, mangroves or coastal, adult marine. Present at Régulo Luís.
	Scylla serrata	Mangrove crab	NA	Captured by hand and lines	Benthic: muddy depths, mainly in the Maria and Savane River and river mouths of the Buzi and Pungue. In estuaries and rivers. Live in mud holes beneath roots.
Cephalopods	*Sepia sp.*	Cuttle fish	4,9	Seine	Pelagic, demersal, epipelagic. Entire study area
Bivalves	*Meretrix meretrix*	Hard Clams	424	Caught by hand	Intertidal-Benthic: buried in sand banks and muddy sand, in the Macuti bank and Maria River.
	Donax incarnatus		NA	Caught by hand	Intertidal-Benthic on exposed sandy beaches. In Estoril and Maria River.
	Mactra sp		NA	Caught by hand	Intertidal-Benthic on exposed sandy beaches. In Estoril and Maria River.
	Donax madagascariensis		NA	Caught by hand but without commercial value	Intertidal-Benthic on exposed sandy beaches of Maria River.
	Eumarcia paupercula	Soft Clams	NA	Caught by hand but without commercial value	Intertidal-Benthic: buried in sand banks and muddy sand, in the Macuti bank and Maria River.

Source of Data: IIP-Santana Afonso 2004; IIP- Bata, 2006;IIP- Brito, 2005; Fischer et al. 1990, NA=not available

Table 4.11 – Average catches and fishing effort per area in the Pungue estuary and surrounds

		Daily Average		
	Location	**Catch (tonne)**	**Active in each method**	**Catches/methods (kg)**
Beach Seine	Praia Nova	1,8	15	109,3
	Estoril	0,6	10	53,2
	Njalane	0,6	9	86,5
Chicocota	Praia Nova	0,1	3	41,1
	Estoril	0,9	30	28,2
	Njalane	0,2	15	11,3
Gill net	Praia Nova	0,7	4	115,0
	Estoril	0,1	9	13,9
	Njalane	0,9	47	20,8

	Location	Daily Average Catch (tonne)	Active in each method	Catches/methods (kg)
Line*	Praia Nova	0,2	15	15,1
	Estoril	0,3	26	11,6
	Njalane	0,9	60	12,1

Source: IIP- Tânia Pereira, Personal Communication; * line force measured with active canoes

Table 4.12 – Types of fishing per location

Location	Boat Seine	Beach Seine	Surface Gill net	Palangre	line Fishing**
Ndjalane and surrounds	0	36	1445	17	173
Maria River and surrounds	0	33	6	17	81
Praia Nova and surrounds	25	29	168	0	115
Total	**25**	**98**	**1619**	**34**	**369**

*Data Source: Sofala Provincial Government-Beira Fishing Community Council, 2006 **Number of fishermen who use fishing lines.*

Between the Ndjanlene Fishing Centre and Ladrão River a Chinese company, Sol e Mar Prawn Aqua culture project, can be found breeding prawns. The company buys live prawns, tiger prawns, from the fisherman and uses them for breeding. The bred prawns are processed and exported.

Industrial and Semi-industrial Fishing

For many years offshore industrial prawn fishing has been one of the main components of exports and national income (Volstad et al. 2004).

The most important resources in terms of volumes caught and of exports and national income are surface and deep-sea prawns, and fish (Table 4.13) (Ministério das Pescas, 2005).

Table 4.13 –Semi-industrial and Industrial catches and exportation of fishing products (including kapenta – freshwater fish) in Mozambique

Description	Value USD 10^3 current prices	Catches (tonnes)
	2003	**2004**
Surface Prawns	61.520,00	8106
Deepwater Prawns	7.125,00	993
Fish	2.687,50	484
Langoustines	1240	132
Squid and Octopus	327,50	195
Prawns	243,00	184
Lobsters	-	2
By catch	804,00	-
Kapenta	13.173,60	18760
Others	-	1354
Total	**87.121,00**	**30210**

Source: Ministério das Pescas, 2005.

The Sofala bank (figure 4.24), located between the coordinates 16° 05' and 21° 00' (whose southern border is included in the area of study), is the highest contributor to national fish catches with prawns being responsible for the most exports and income.

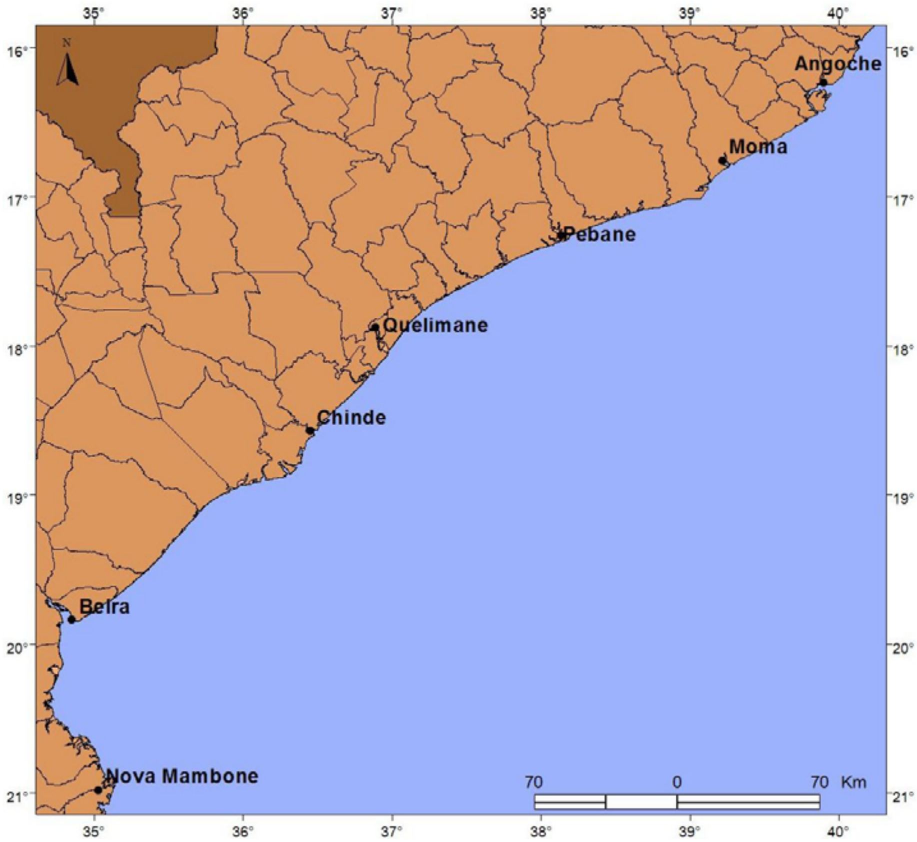


Figure 4.24 – Location of the Sofala Bank

Semi-industrial fishing is done in coastal areas with vessels of between ten and twenty metres of length, propelled by motor and using ice or mechanical refrigeration to conserve the catches on board. Sometimes the fishing is supported mechanically.

Industrial fishing is done in maritime waters, with motor propelled vessels larger than 20 metres of length, generally with means of freezing products onboard and using mechanical assistance in fishing (Figure 4.25).

According with the National Fishing Administration, there were close to 29 industrial ships licensed in the country in 2006.

Figure 4.25 – Semi-Industrial fishing vessel in Sofala Bay. *Consultec, 2006*

<u>*Prawn and by-catch fauna fishing*</u>

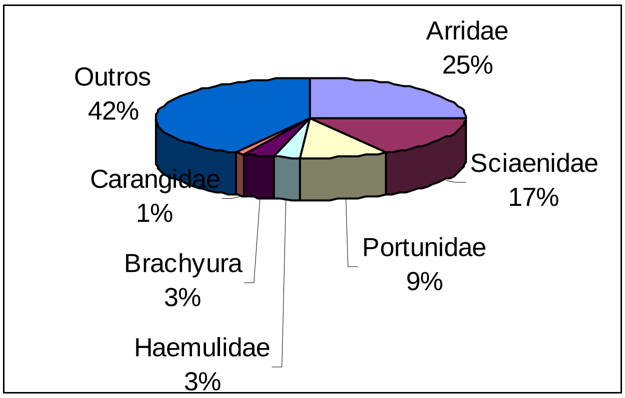
Commercial fishing in Sofala bank essentially revolves around prawns. In 2003, 61 industrial vessels and 17 semi-industrial vessels operated around the Sofala bank, capturing a total of 7117 tonnes of prawns (Sousa & Brito, 2004). In 2005 the catches increased to 7715 tonnes, equating to a 3% increase on the previous year (Sousa et all, 2006).

The catches are mostly comprised of prawns belonging to the Penaeidio family, namely the *Fenneropenaeus indicus* (white prawn) and *Metapenaeus monoceros* (brown prawn) species. According with Brinca and Sousa (1984), the best catches are obtained during the months of January and July, which corresponds with the highest migrating periods of the aforementioned species.

In the last few years there has been an increase in the amount of fishing, the result of this is that the variation in annual catchments is mainly due to environmental factors related to migration (IIP, 2006).

During this activity a significant proportion of the catch is composed of by-product fauna (crustaceans, cephalopods and fish) despite the main target of industrial and semi-industrial fishing on the Sofala bank being prawn,

A study conducted by IIP (Sousa, 2004) shows that the most dominant species of by-product fish caught in company “Pescamar’s” vessels are: Arridae (catfish), Sciaenidae (sea bass and croaker), Portunidae (crab), Haemulidae (grunts) and Brachyura (crab) (graphic 3).



Graphic 4.3 – Specific composition of catches by the company “Pescamar” in 2004. *Source: Sousa, 2004*

The specific composition of by-product fauna varies from vessel to vessel and area to area. There are areas where the proportion of prawn to by-product fauna is very high, and others where this proportion is very low.

In general, the percentage of prawn in the total catch in Sofala bank is believed to be around 50%, followed by the Sciaenidae (sea bass and croaker) and Portunidae (prawn) families (Sousa, 2004).

Semi-industrial and industrial line fishing

Despite the greatest income generator of fishing in Mozambique comes from crustacean resources, such as prawn, the importance of line fishing resources should not be underestimated. The rich ictiofauna contributes to the line fishing potential, with more than 200 cacheable species (Fischer *et al* 1990).

The industrial and semi-industrial line-fishing fleets are constructed using wood or steel, and can be between 10 and 30 metres in length. According to the National Office of Fishing Administration, 13 semi-industrial and 4 industrial line-fishing vessels operated up the entire coast in 2005 in depths that varied between 30 and 250 metres.

Despite receiving little information about daily catches from fishing companies along the coast, it is still possible to get an idea of the industrial and semi-industrial fishing activities in the area of study. Figure 4.26 shows a summary of the routes followed by line-fishing ships, leaving the Port of Maputo, close to Beira, during the period between 2001 and 2005.

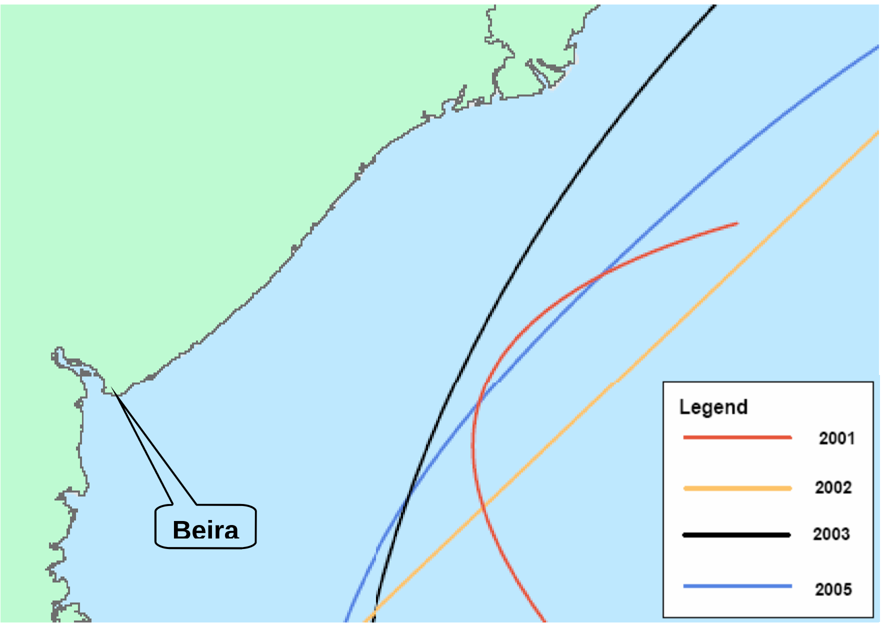


Figure 4.26 – Geographic location of the circulation of fishing ships between 2001 and 2005 on the Sofala bank. The information from 2004 was not available.

Industrial deep-sea prawn fishing (Deep water Rose Shrimp)

Industrial deep water rose shrimp fishing is conducted using dragnets at depths between 200 and 800 metres, between the parallels 17° 00'S and 26° 30'S. According to the National Office of Fishing Administration 12 industrial vessels operated in 2004 the total haul in 2003 was estimated at 1500 tonnes with an estimated 3000 days of fishing conducted.

However, this type of fishing is not of great importance to the Sofala bank, with the most important fishing areas in the country being found in the Boa Paz area (24º 30'- 25º 40'), Inhaca (25º 40'- 26º 50'), Bazaruto-A (21º 00' a 23º 00') and Bazaruto B (23º 00'S a 24º 30'S).

4.6.6 Port Activities

The Port of Beira is located in the southern part of the city, on the northern margin of the Pungue estuary, in the suburb of Pioneiros, surrounded by the suburbs of Esurro, Matope and Ponta-Gêa, at the Chiveve river mouth. It is a low-lying area in a flood zone characterised by swamps in the areas furthest from the river mouth.

The current port was constructed after the First World War coinciding with the industrial development of the city, and has been subject to enlargements throughout the decades.

In being responsible for the movement of various products, the Port of Beira constitutes a vital element in the Beira Corridor that is the spine of the country's central region. Apart from the port, the Beira Corridor is constituted by a highway, a pipeline and two railway lines that link the port and Zimbabwe and Malawi. It represents the hub of imports/exports of the country's central region and of neighbouring countries such as Zimbabwe, Malawi, Zambia, Botswana and Congo.

The Machipanda line that directly links the Port to Zimbabwe stretches nearly 317 km in length, while the Sena line, 331km in length, links the Port of Beira, through Dondo, to Malawi (CFM, 1999a), passing by Moatize. The Machipanda Line is presently operational, however it needs improvements, whilst the Sena Line has been not operational since 1984, as a result of the civil war that devastated the country, but it is presently being rehabilitated by the "Companhia de Caminhos de Ferro da Beira (CCFB) (Beira Railway Company), in an investment that includes Indian capital. At present, the products arriving into the port are directed mainly by land routes to both Malawi and Zimbabwe.

The armed conflict caused a significant reduction in the movement of products from the Port of Beira, which only recently has recovered (see figure 4.27). The type of transit of the products was also influenced by the resultant instability on the highways during this period, causing an increase in maritime national transit of products.

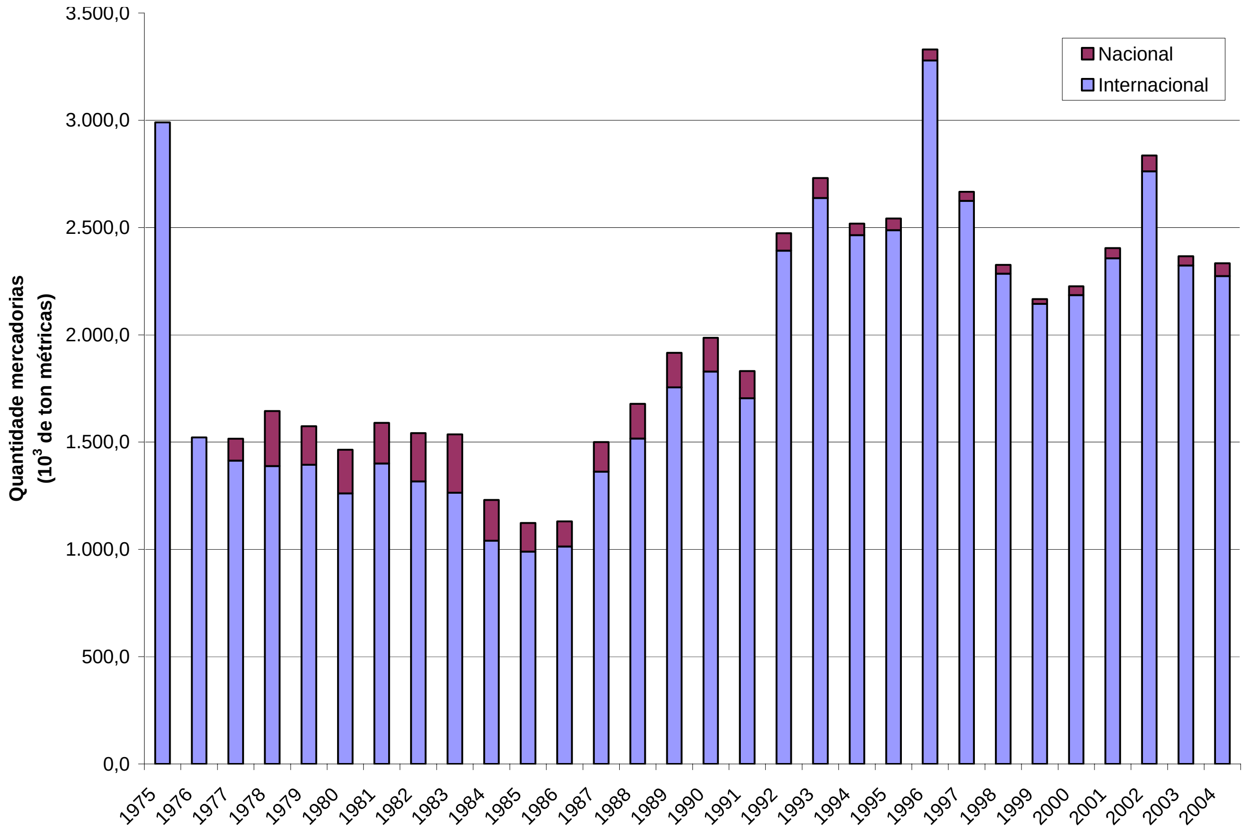


Figure 4.27 – Variation of the usage of port products between the years 1975 and 2004. For this study, the years of the conflict in Mozambique are considered to be those between 1976 and 1992.

Capacity and Cargo types

The annual capacity of the Port of Beira is close to 2.3 M tonnes of cargo, without including the fuel terminals (close to 2.0 M tonnes) and coal (close to 3,000 tonnes). The current storage capacity of the tanks is 18,000 tonnes/year. The container area has an annual capacity of 4.7 M tonnes (CFM, 2006).

The hydrographical characteristics of the Port access channel are similar for the river mouths and rivers, with low depth, and many banks and sandbanks. However, the sedimentation in the access channel to the port is the main limitation, as only ships with a maximum of 25,000 tonnes can reach the port.

The Port can currently be considered to be, essentially, a transit port – load and unload – for products, as much for neighbouring countries than as for national commerce.

Included amongst the products handled in the Port are cereals, cotton, citrus products, tea and coffee, prawns, vegetable oils, tobacco, cement, ornamental rocks such as granite, wood, metals (copper, iron rods, chrome), various types of containers and vehicles (CFM, 2006)

In the 1990s the transit of cargo was mainly international and more than 50% of the products where derived from oils (JICA, 1999).

The table below shows values relating to the cargo in the Port of Beira in June 2006 (CFM, 2006). As can be seen, despite the economic crisis in Zimbabwe the highest proportion of the cargo is still goes there, followed by products for national commerce.

Imports and Exports	Zimbabwe	Mozambique	Malawi	Zambia	Other countries
Quantities (10^3 metric tonnes)	78.4	38.6	19.3	6.5	9.5

In figure 4.28 a sketch of the distribution of terminals and structures within the Port of Beira can be seen.

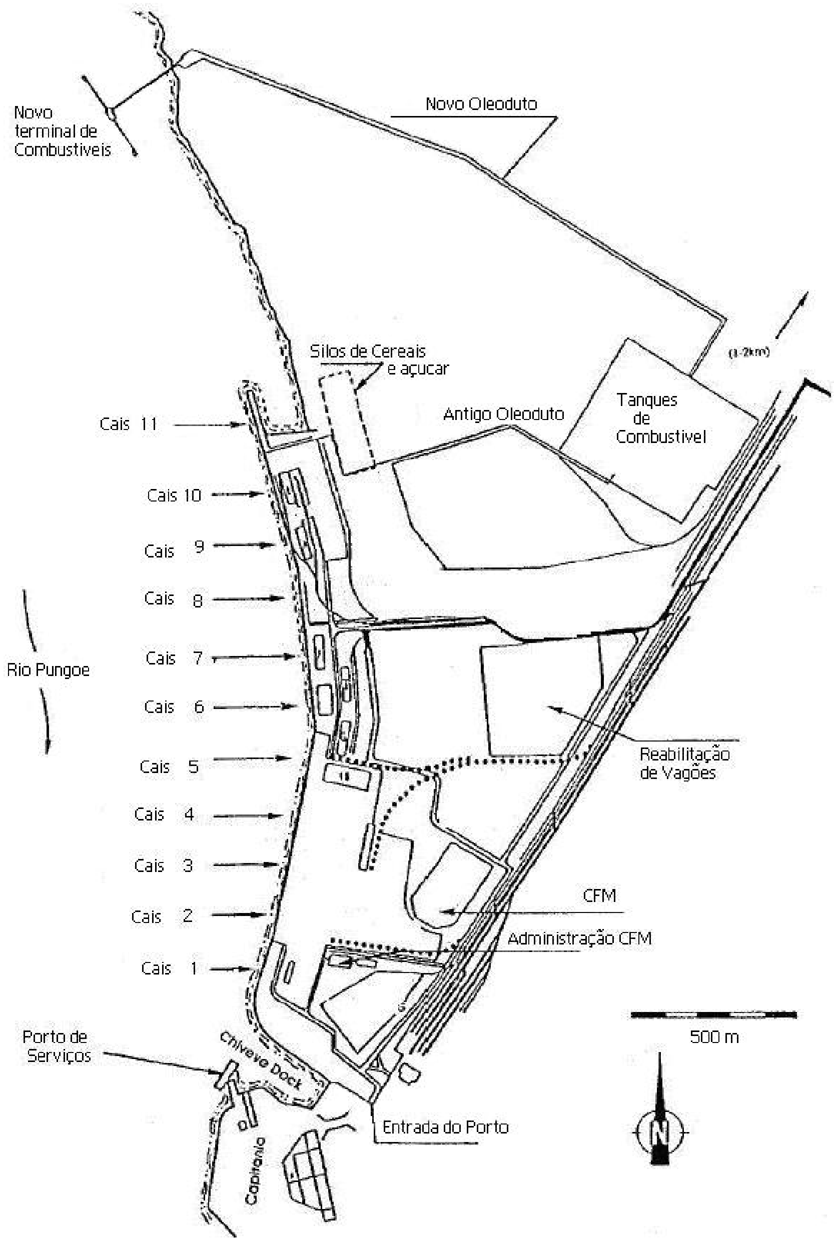


***Figure 4.28 – Port of Beira** (Adapted by CFM, 1999b)*

The loading and unloading of materials, controls, and hours of operation, are defined by CFM.

<u>The Economic Importance of the Port of Beira</u>

In different parts of the socio-economic situation the importance of the port is mentioned and its impact on the city of Beira, the province of Sofala, the Central Region of the country, the rest of the country, and for neighbouring countries of the hinterland.

The location of the Port of Beira gained notable economic importance as far back as the 12th century, for being easily accessible by boats to the gold producing lands that in the past was commercialised by the Arabs. In the 15th century, with the progress of the

Portuguese, the area also acquired political-military importance by allowing the control of the interior lands.

Presently the port continues with this formerly acquired importance, especially from a commercial perspective.

Despite the environmental constraints (low topographical area, susceptible to floods and swamp characteristics) Beira was established at the mouth of the Pungue River with the objective of maximising the opportunities made available by the port.

The indisputable economic importance of the port also is felt in the neighbouring provinces and countries. This regional importance was reinforced with the construction of the Beira Development Corridor – comprised of the port, National Highway Nº 6, by the gas line and railway that links Zimbabwe.

With this complex system of transport, the port constitutes the entry and exit gate of products and raw material, especially for the provinces of Sofala, Manica, Tete and Zambezia, and to neighbouring countries such as Zimbabwe, Malawi, Zambia, Botswana and Congo.

At present, the volume of the port traffic has registered some delays due to the sedimentation in the navigation channel that allows the entrance of ships into the port. The sedimentation puts limits on the port's capacity, making impossible the entrance of large ships. This in turn causes an obstacle to the socio-economic development of Mozambique and the other countries that benefit from the port.

5 Description and Assessment of the Environmental and Social Impacts

In this chapter the possible impacts caused by the activities conducted during the dredging cycle of the Port of Beira Access Channel will be analysed. In the following chapter, proposals of control, mitigation, and prevention measures are presented. The dredging activities are well-established practices, therefore the potential impacts of dredging operations on ecosystems and the marine environment are well known.

This analysis is the result of various research studies conducted to assess the nature and magnitude of the impacts relating to dredging. The identification of issues associated with the project operations were based on:

- Questions raised in the Terms of Reference;
- A revision and understanding of the affected environment;
- Revision of the nature of proposed activities, and revision of the results of published studies;
- The professional opinion of the specialist team; and
- Stakeholders' consultation.

The impacts associated with the dredging process and disposal of dredged material could be characterised by direct or indirect effects on habitats and organisms, like those attributed with alterations to the circulation of the channel, the quality of the water, and the effects on the activities and socio-economic development of the area.

Direct effects are those associated with the process of removal of channel sediment (dredging), discharge of water collected along with the sediment (overflow) and the disposal of dredge material in the marine deposit areas (deposits). Indirect effects considered in this report are those resulting from sediment ressuspention or noise generation.

5.1 Impacts on the marine and coastal environment

5.1.1 Direct Impacts of the Dredging and the Disposal of Dredge Material

<u>Impacts on the Bay Bathymetry and Circulation</u>

As previously mentioned, the objective of this emergency dredging is to return the Access Channel to its original dimensions. The process of channel sediment removal and disposal of dredge materials in the deposit areas will result in changes of present depths, both in the dredging locations and in the deposit locations. The current depth will increase in the areas where the dredge materials are collected (the Access Channel) and the areas where the material is deposited will experience formation of banks and a decrease of depth.

The intended depth established for this dredging project is 8m below the hydrographic zero. Despite this goal not representing a movement of large volumes of sediment in the channel's lesser filled sections (such as the sections located to the east of the Macuti curve and the northern section before this curve to the region of the Macuti curve), it is expected that along section E10 large quantities of sediment will be moved, which could mean a bathymetric alteration, although without potentially large influences on the estuary's general circulation.

Regarding the circulation of water masses in bays and water bodies, the bathymetry of this basin, i.e. the configuration and composition of the topographical attributes such as channels, reefs, banks, etc., plays a very important role in the definition of the circulation pattern of this bay. The channels constitute the main avenues where the water flow occurs. The main effect of the dredging on this circulation pattern will result from the creation of artificial channels and banks that will result in the alteration of the course and direction of the main water currents in this bay.

There will therefore be an increase in the volume water mass that will flow through the channel, as well as the intensity of the flow in relation to the current situation. The outgoing tide currents have the tendency to be confined to this channel (JICA 1998). With the dredging this current will intensify increasing the existing difference between the outgoing and incoming tides.

On the other hand, the disposal of dredge material could result in the formation of the banks that could constrain the course of the water masses, as well as the waves. Here it is important to emphasize that the choice of adequate disposal areas for the sediment is crucial to minimise the alteration to the bathymetry avoiding the formation of banks.

Impacts on coastal erosion

Tidal currents constitute one of the ways in which the beaches gain or lose sediment. In Sofala Bay the incoming tidal current in combination with the erosive action of the waves play an important role in the transport and redistribution of the sediment removed by waves (parallel to the coast) along the coast in the direction of the Pungue River. Tidal currents in the Beira Estuary are high and according to JICA (1998) are about 1m/s.

Those waves that are relatively larger than the average wave that usually break on the beaches (swell) regularly reach the estuary coming from the open sea (Doxiadis associados, 1992; Ascadis Euroconsult, 1999). When they break (relatively far from the coast) on the existing banks of the estuary, they create currents in the direction of the coast that carry sediment from the open sea and from the various existing banks in the estuary to the beaches. It is possible that this transport is one of the most important for sediment in maintaining the coastal line, as sediment carried by these currents are considered as new additions to the coastal sediment.

The Port of Beira Access Channel will create an effective barrier for the transportation of this sediment from the open sea to the coast, as there will be a larger accumulation in the channel. The resultant sedimentation in the channel from the disposal of sediment brought by these currents was observed in the bathymetric samples conducted by JICA (1998) between 1990 and 1997 especially in the section E10 (10,700 m) from the access channel in the region of the Macuti curve.

This effect could result in the progressive decrease in the gains of sediment from the beach erosion coming from the estuary's north.

On the other hand the channel dredging could increase the wave activity on the beaches causing the larger waves to break closer to the coast, and in consequence, increase beach erosion, and therefore resulting in an increase in the depth close to the coastal line (Torres, 2000). Still, the relatively distant location from the channel, in relation to the beach line, could make this erosive effect of the waves insignificant.

Nevertheless, it is important to highlight that up until this date there is no data that confirms an increase in wave activity on the Macuti beaches, and consequently an increase in coastal erosion as a result of the large dredging projects that deepened the Access Channel in 1988.

In the scope of JICA (1998) study, a hydrodynamic model of Sofala Bay was made, where the dredging of the Access Channel was simulated. According to this study, no significant impacts are expected to the coastal dynamic, but just a slight alteration in the transportation of sand is expected without significant consequences on coastal erosion.

5.1.2 Indirect Impacts

During the dredging cycle, using suction technology, there is a lifting of the sediment during the suction of dredged material and overflow phases, as also during the disposal of the sediments (Figure 5.1).

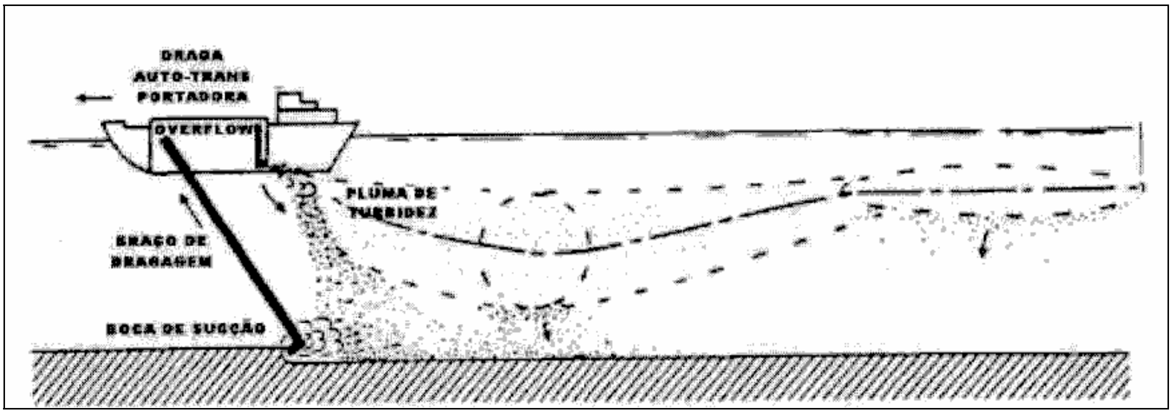


Figure 5.1 – Dredging operation conducted by a self-propelled dredge, showing the plume of turbidity caused by the suction mouth and overflow *Source: Torres, 2000*

In general, the disturbance of sediment in the water column results in the alteration of some water quality aspects such as:

i) Increase in water turbidity;
ii) Increase of nutrients in the water column;
iii) Disturbance of chemical contaminants; and
iv) Dispersion of sediment

These impacts on the water quality are directly dependent upon the dredging technology utilised and the present situation of both the quality level of the sediment and the quality level of the water.

Dispersion of disturbed sediment

Sediments disturbed during the dredging operation, depending upon their physical and granular characteristics, could be deposited in the dredging area or transported by currents and deposited in other areas.

Slender sediment, mainly clays and fine sand, tend to stay suspended in the water column for a longer time and, consequentially, are subject to a higher rate of dispersion with the effects of the currents. The time in which the sediment stays suspended depends upon the size of the particles and the intensity of the current turbulence. The higher the turbulence the more time the particles remain suspended, and the larger the size of the particles the less time they will remain in suspension.

The length of the access channel is predominantly composed of sand except for the sections north of the Macuti curve where there is an abundance of fine sediment and clay. During the dredging of this section of the channel there will be a large dispersion of sediment due to the fact that this sediment is so fine and the currents, especially that of the outgoing tide, are intense.

The areas susceptible to this dispersion will depend upon the tidal phases when the dredging is being conducted. In general, the areas located along the north-south axis will be more susceptible to being affected by disturbed sediments, and the region to the east of the estuary could be affected by dredging activities that are conducted during the outgoing tide.

The risk of dispersion presented by the predominance of sandy sediment in the other areas of the channel is much less, as this type of sediment falls more quickly than clay and this reduces the extent of the area susceptible to the dispersion of sediment. While the sediment remains suspended in the water column it will contribute to the turbidity of the water. In a system where the water is usually turbid and localised an increase in the turbidity would not cause a significant impact.

Increase in turbidity and alteration of the estuary water quality

As can be seen in Figure 5.1, there is disturbance of sediment during the dredging operations as overflow is deposited resulting in large quantities of sediment becoming suspended in the water column.

This could result in an increase in water turbidity, reducing in this way the water clarity and light penetration in the water column. Even though this does not have any physically relevant implications, biologically it could be important considering that increased turbidity would reduce the level of biological productivity due to the reduction of light to allow photosynthesis.

The effect of the increased turbidity is, however, temporary and localised as the plumes of disturbed sediment can dissipate with the current action and with the fall of suspended sediment.

Having said this, along with the fact that these disturbances will be localised to dredging locations, the relevance of increased turbidity caused by the Port of Beira Access Channel dredging operations would be insignificant considering that the system is naturally characterised by high turbidity due to the large amounts of sediment that come from the

Buzi and Pungue Rivers, as well as the turbidity that is presently being caused by the maintenance dredging that are being continuously conducted.

As was previously mentioned, the analyses conducted on the Access Channel's sediments during the JICA (1998) study indicated that they do not contain organic pollutants or heavy metal contamination. More recent data regarding sediment quality was not found but it is assumed that there is unlikely to be any large variations.

The available results from the analyses conducted by JICA lead one to believe that the quality of the water column is not significantly affected by toxic substances. However, as soon as water analyses detect the presence of metals in the Port area, suspended in the water column, it is recommended that caution be heeded. There therefore exists the possibility, however improbable, of a temporary and localised increase of imported metals and/or bacteria in the water column, which in terms of the physical environment could be considered of little relevance, but relevant when assessing the ecological and socio-economic effects.

5.2 Impacts on the Ecology

According to Shelford's law of tolerance "*survival of an organism depends on the completeness of a complex of conditions. Failure of the captive propagation and release of an organism can be controlled by the qualitative or quantitative deficiency or excess with respect to any one of several factors which may approach the limits of tolerance for that organism*" (Odum, 1997).

The environmental impacts associated with the dredging process and disposal of dredged material can be characterised by the direct effects on the habitats and organisms, or the indirect effects regarding alterations to water quality (Kennish, cited by Torres, 2000).

Physical disturbances associated with the removal and reallocation of sediment could cause the destruction of benthonic habitats, increasing the mortality of these organisms through injuries caused by mechanical action during the dredging, or by suffocation as they are sucked by the dredge. In terms of the indirect effects, the disturbance of the at-depth sediment could remobilise contaminants and nutrients affecting the water quality and the overall chemistry of the estuary.

According with Davis *et al*. and Bray *et al*., cited by Torres, (2000) these impacts can be divided into the following categories: Dispersion and disposal of disturbed sediments, loss of at-depth habitats and fishing resources, sound generated by dredging operations.

5.2.1 Direct dredging impacts and material dredged

<u>Impacts resulting from the dispersion and disposal of sediments</u>

The breaking and disaggregating of bottom sediments and their disposal could cause a large variety of environmental impacts that could result from the increase of turbidity and the covering of the sea floor of dredged sediments.

Regarding the increase of turbidity, if the disturbed sediments are highly concentrated, well above the natural levels in the area, and persist for a long period (which is generally the time predicted for a dredging operation), the light penetration in the water column could decrease, causing damage to the weeds, photosynthetic algae and other aquatic organisms.

If a large quantity of dredged material were to be deposited in deposit area D4, which is in the proximity of the fishing centre of Régulo Luís, there could be an increase in water turbidity above natural levels that could affect the prawn *P. Monodon*'s ability to bury itself.

The disposal of sediments, them being those in suspension resettling, or dredged materials in the deposit areas, could have an effect on the benthonic animals living in the area, suffocating them, or forcing them to migrate to other regions.

The deposited materials could stifle the clams *M. Meretrix* (who filter water), as well as juvenile prawns by covering the bank where the clams live and the migrating areas of the prawns *M. monoceros,* in areas that overlap D1, D2 and D5 (Figure 5.2).

In the case of the prawns, the disposal of dredge materials in those areas could constitute a physical barrier that could impede the movement of these individuals from the mangroves to the open sea even though they have the ability to "surf" the water column.

However, given the natural conditions of the system, with high turbidity levels, and given that maintenance dredging has been continually conducted in the Channel and surrounds, it is believed that the impacts resulting from the disposal of sediments will be of low significance, as long as the mitigations methods recommended in Chapter 6 are applied.

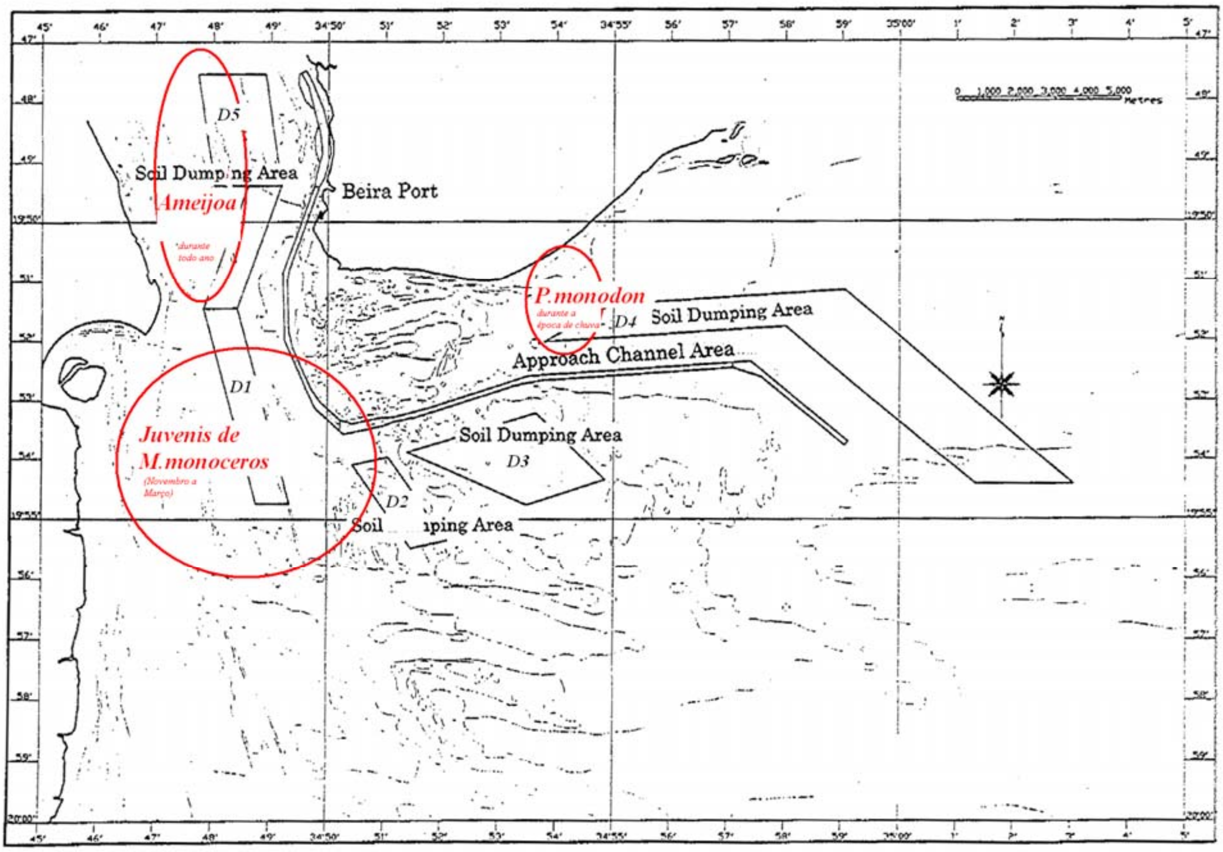


Figure 5.2 – Map of the Pungue River estuary area showing the access channel to the port, potential deposit areas (D1 to D5) and biologically sensitive areas (in the circles) for clams and prawns according to those referred to in the text *(map modified by JICA, 1998).*

On the other hand, some positive impacts could result from the sediment movement.

The excavation of sandy sediments removes the organisms that live in the sediment. However, as the rate of sedimentation in this area is high, the recently deposited sediments at the bottom can form and restore these habitats when the work has finished.

Furthermore, the dumping of more muddy sediments in the sandy zones such as D4 could serve to feed certain species of fish and to develop certain species of prawns. Fishermen consulted from various fishing centres in Beira during the present study indicated that this type of phenomena occurred with some species after other large dredging conducted in the past, namely 1988/89.

Impacts resulting from the noise generated by the dredging operations

All mechanical equipment generates noise but most of the dredging operations are relatively silent when compared with many other construction activities.

However, some types of dredging produce a high level of noise when working in the more cohesive clays, or when working with compressors and drill bits used to break rocks.

Problems associated with noise are more significant at night when environmental sound levels are lower. This impact however, can be considered to be of small relevance, due to the fact that hydraulic suction dredges that will be used in this dredging operation are quieter relative to mechanic dredges.

5.2.2 Indirect Impacts

Impacts on the water quality resulting from the increase in nutrients and contaminants

The disturbance of sediment in the water column results in the remobilisation of nutrients and pollutant chemical compounds that could be already present in the sediment (nitrogen and phosphorous, organic pollutants or heavy metals) in the water column, altering the quality and chemistry of the water. These toxic products and contaminants that could be released by disturbed soils could be dissolved or become suspended and contaminate or cause high mortality of estuarine and marine species of high fishing importance directly and/or indirectly to the region where the dredging is being conducted.

The increase in nutrients concentration in the water column could result in stimulating productivity. This could be seen as a positive impact as it could eventually convert into an improvement in fish production.

If the quantity of nutrients absorbed is higher than the absorption capacity of the estuary, eutrophication conditions could occur in the system which could cause low secondary productivity and impact fishing conditions.

The increase in the pollutants concentration in the water column could have negative impacts on the estuary's biological productivity and on public health as the contamination on fishing products could eventually result in the contamination of the consumers of these products. Some of these contaminants could inhibit the reproductive ability of the species and that could result in a reduction of the fish production in the estuary.

More specifically, the disturbance and disposal of large quantities of dredge materials on top of fauna in the deposit areas D1 and D5 (figure 5.2), where there are large amounts of *M. Meretrix* clams (who filter water), could lead to them consuming heavy metals or available coliform bacteria which in turn consumed by humans could enter into their system.

As previously mentioned, sediment analyses conducted in 1997 during the JICA (1998) study showed that the nutrient, metals and organochloride levels are in general very low. No other previous sediment studies were identified. In the last 10 years there have been no significant developments that could lead to significant alterations in the sediment quality. It should be noted, however, that CHAEM has noted bacteriological contamination in the water in the last few years and an increase in the exploration for gold at the mouth of the Pungue River that could eventually be shown in the chemical composition of the estuary water.

This is a sensitive issue as the collection area for the *M. Meretrix* clams is located in the Pungue River estuary area, the area involving the port. In the event that the sediment is contaminated there is risk of a temporary deterioration in water quality, which would lead to adverse affects on the *M. Meretrix* species which would lead to a risk to public health, this constituting a very significant negative impact. Despite being improbable this impact requires particular attention, requiring the implementation of mitigation measures and monitoring as indicated in the Environmental Management Plan.

5.3 Socio-economic Impacts

The socio-economic activities of Beira and the Province in general could be negatively or positively affected by the dredging activities, with direct impacts on maritime activities, the fishing and on the port.

5.3.1 Negative Impacts

Impacts on Maritime Traffic

The presence of dredging vessels could cause disturbances by interfering with the movement of other vessels and the access traffic to the Port, or by tangling with fishing nets on the way to the deposit zones for dredged materials.

However, this impact is temporary and localised and applicable only to large vessels that have difficulties in changing direction quickly. This impact can be mitigated with a good communication system between the Port of Beira, ships in transit, and the dredging company.

Impacts on Fishing

The dredging activities, and all actions associated with it, could cause impacts on the ecosystem, and consequently on the fishing resources. This impact is most likely to affect the artisanal fishing that not only contributes to the region's informal economy, especially at the local level, but also is the largest source of protein for coastal populations.

The impact on the fishing activities would be considerably more acute if there were a large ecological impact on fishing recourses and if its duration were not well defined. This would depend upon the regeneration capacity of the ecosystem.

Despite industrial and semi-industrial fishing considerable contribution to the country and province's economy, these vessels that work in the Sofala Bank travel far from the study area, and are not directly under the influence of the project area. Furthermore, the percentages of the catches made by these vessels are very low when compared with the country's total annual values. Therefore, it can be assumed that the industrial and semi-industrial fishing activities in the study area are of little relevance when compared with the total values caught in the Sofala bank.

As previously stated, significant negative impacts could be felt by the prawns and clams in Sofala Bay, that could result in impacts on fishing. Mitigation measures (see chapter 6) should be implemented to reduce these possible impacts.

5.3.2 Positive Impacts

Impacts on Fishing

The disposal of muddy dredge materials close to the artisanal fishing zone could increase the amount of fish species and certain species of prawn, leading to an increase in the volume of catches by nets in this area.

Impacts on the rehabilitation of city structures

The volume of potentially usable dredge material, remaining from the port expansion, could be put to use for civil works, the construction of ramps, filling of swamplands, or in beach refilling projects in an attempt to reduce erosion to coastal zones.

The use of dredge material to fill swamplands would not only improve public health problems, by eliminating rates of illnesses, but by also allowing for an increase in the areas of the Municipality being developed.

If the dredged sediments prove to be of similar characteristics to those of the Beira coastal sands, the dredged material could be considered in supporting these areas, stabilising the beach areas and protecting adjacent infrastructures.

Impacts on Port Activities

In the short term the enlarging and deepening of the Access Channel will increase the number of vessels that can reach the port reducing the waiting time. This will allow for more Port economic activity.

This energising of activities and increase in tributary levies and commercialisation of goods and consequently the fees paid relative to exports, will also help drive the city's economy.

Despite the dredging operations not contributing directly to the reduction in unemployment, as the activity requires very specialised labour that is already being used by the company, indirectly there will be an increase in the demand for labour, and indirectly there will be a higher demand for labour, services, equipment, and goods associated with the port development.

In the medium to long term it is hoped that this economic vitalisation will improve economic activities in the entire Municipality, linked directly or indirectly to the port, and therefore leading to an improvement in economic activities in the Province.

The opening of the channel will also allow for new entrepreneurial undertakings in the port and the Beira Corridor, like new port terminals for the Moatize Coal Project and the rehabilitation of the Sena Railway Line.

6 Mitigation Measures

In this chapter mitigation measures will be presented with the intent of minimising the negative impacts and to enhance the positive impacts resulting from the dredging activities discussed in the previous chapter.

These measures are focussed on the impacts identified in relation to the most relevant and long-lasting physical, biological and social sensitivities described above. Other potential impacts identified in the previous section are of less relevance, reversible, and are restricted to the immediate dredging area and therefore not constituting large concerns from an environmental point of view.

The recommended mitigation measures on the physical, biotic and socio-economic impacts are presented in three levels, namely:

- spatial mitigation – when they apply to a determined area;
- temporal mitigation – when they apply to a certain time period; and
- Operational mitigation – when they relate to an operational mode.

6.1 Impacts on the physical environment

6.1.1 Spatial Mitigation

To reduce any alteration to the bathymetry, and therefore an alteration to the patterns of circulation, it is recommended that the disposal of dredged materials not be restricted to just small surfaces in the deposit zones, but instead distributed throughout the surface, in an attempt to avoid significant alterations to the depths in the deposit areas.

To minimise the susceptibility of coastal erosion the following measures are recommended:

- As the channel depth increase will constitute a physical barrier to the transportation of sediments from the open sea to the coastal beaches to the north of the estuary, resulting in a deficit in sediment for these beaches, it is recommended that there be a priority in disposal the dredges in deposit area D4 and other deposit areas in the proximity of this area as shown in Figure 6.1.

  In this way, through tidal and coastal currents, this sediment will be redistributed on the beaches balancing the deficit that will be caused by the reduction of sediment transportation caused by the open sea.

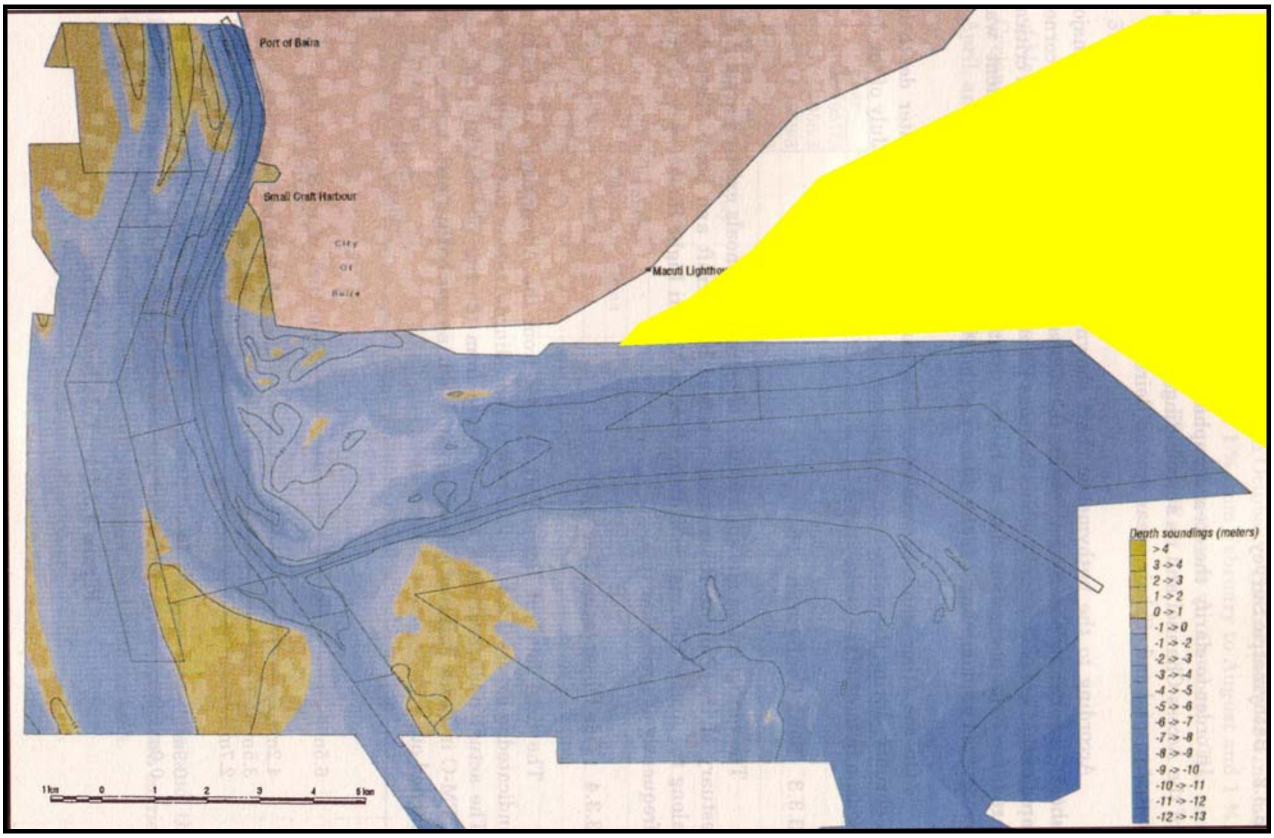


Figure 6.1 – Bathymetric Map of the Beira Estuary. The area highlighted in yellow and D4 represent recommended deposit areas. *Source: JICA 1998*

- Alternatively the disposal of the dredged material can be done directly on the beaches on the northern coast of the Beira Estuary resulting in a more immediate mitigation of this impact, along with reducing wave activity due to the reduction of the water depths. This measure, however, could only be implemented after verifying that there is compatibility between the dredged materials and those existing along the coast. If this is not the case, the feeding of these beaches could create negative effects on the coastal dynamic.

6.1.2 Operational Mitigation

As coastal erosion is a current concern on the Beira coast and one of the Municipality's worst problems it is extremely important that mitigation measures be implemented despite the likelihood that the dredging will not cause any significant increased damage.

The use of sandy dredged materials from the channel to refill beaches could be considered a mitigation measure against the susceptibility to erosion, lessening potential negative impacts, and in turn creating a positive impact.

To reduce the impacts on coastal erosion it is also recommenced that the Municipality of Beira fixes the barriers that regulate the flow of the Palmeiras spillway. Furthermore, the delta of sediment located in front of the structure should also be removed to allow a normal flow of the coastal flow and the sediments that it carries. If this does not happen a significant portion of the dredge materials that should be deposited on the beaches, instead of being deposited on the areas recommended above, could end up being transported to the open sea as suggested by Ingenieurs Bureau Amsterdam (1996).

6.2 Ecological and Socio-Economic Impacts

6.2.1 Temporal and Spatial Mitigation

Avoid the disposal of dredge materials in the deposit areas **D1 and D5** and surrounding areas during **the entire year** given the presence of the *M. Meretrix* **clam** species is in this area that have the tendency to bio-accumulate toxic substances present in the water column, transmitting these on to man through its consumption.

Avoid putting large volumes of dredge materials in deposit areas close to the mouth of the **Pungue River (D1 and D2)** and the **first 2 miles of D4** (from Régulo Luís) during the rainy season (**November and March**) to try to avoid interfering with the migration of the **young prawns** *M. Monoceros* in the case of D1 and D2 and to help the survival of the **prawn** population *P. Monodon* in area D4.

6.2.2 Operational Mitigation

It is recommended that hydraulic dredge vessels be regulated and calibrated so they are as close as possible to the sea bottom, to avoid the risk of injuries to marine animals caused by the dredging operation, and that they have a net in the sucking mouth so as few organisms as possible are removed from their habitat along with the dredge materials.

There should be preference given to the disposing of sandy sediments on land, so it could be used for both the port expansion and for civil construction. Should there be leftover materials from the port expansion that could be used for civil works, there should be cooperation with the Municipality of Beira that should decide what the best use for this material is.

A good communication plan should be established between the dredging vessels and the Port of Beira to improve the marine traffic to and from the port, reducing the probability of accidents or high waiting times for vessels entering the channel.

In the case of the dredge materials removed from the Port's docking area and adjacent area where certain levels of heavy metals and products coming from ships could exist in the sediment, it is recommended that these dredge materials are not deposited in the sea. And to avoid these materials contaminating the soils in the land disposal areas or the existing water, it is recommended that these sediments should be deposited and confined to the Port area.

As analyses of the sediment quality have only be done once in every ten years, it is recommended that CFM jointly with sanitary authorities (CHAEM) and the Sofala Provincial Office for the Coordination of Environmental Affairs (DPCA-S), should conduct analyses on samples taken from the Pungue River, in the area of the Port.

Furthermore, analyses of the water quality should be conducted before, during and after the dredging operations to verify the presence of any heavy metals and/or bacterial contamination in the water column. In the case that there is evidence of a level of heavy materials passing acceptable standards the sanitary authorities should assess the need to conduct analyses on clams and if necessary temporarily ban their collection.

7 Summary and Conclusions of the Environmental and Social Impacts

This chapter presents a summary in matrix form of the impacts assessed in previous sections. Impact analysis using a matrix constitutes an important method of Environmental Impacts Studies, contributing to decision-making in projects with environmental aspects.

An assessment of the impacts in matrix form can be done in a qualitative and quantitative form; in this case the qualitative form was used. This method has the advantage of allowing an easy visualisation in weighing up the different impacts.

The matrix that follows (Table 7.1), classifies each impact, with the parameters used in the assessment below:

Character:	Positive (+) Negative (-)
Area of Influence:	Immediate Local
Probability:	Certain Very probable Probable Slightly probable
Time Frame:	Immediate Short term Medium and long term
Relevance:	Slightly relevant Relevant Very relevant
Duration:	Permanent Temporary

The impact, whether mitigated or enhanced, is identified, with an assessment of its significance before or after the implementation of the relevant mitigation measure.

Table 7.1 – Analysis Matrix of the Impacts of the Project

Environment	Impact	Operation Phase	Character (+/-)	Probability	Time frame	Area of Influence	Relevance	Duration	Can be Mitigated?
Physical Environment	Change in bathymetry and hydrodynamics	**Dredging**	-	Probable	Immediate	Local	Relevant	Permanent	Yes
	Increase in the volume of inflow from the Pungue River passing through the Channel		-	Probable	Immediate	Local	Slightly relevant	Permanent	
	Increase of the disturbance and raising of sediment		-	Certain	Immediate	Immediate	Slightly relevant	Temporary	
	Increase in Coastal Erosion		-	Probable	Immediate	Local	Relevant	Permanent	Yes
	Decrease in the transport of sediment from the open sea to the coast		-	Probable	Immediate	Local	Relevant	Permanent	Yes
	Increase in the volume of sea sediment being deposited in the coastal estuary – open sea		-	Very Probable	Immediate	Local	Slightly Relevant	Permanent	
	Raising and dispersion of ressuspended sediment	**Overflow**	-	Certain	Immediate	Immediate	Slightly relevant	Temporary	
	Increase in water turbidity		-	Very Probable	Immediate	Immediate	Slightly relevant	Temporary	
	Increase of nutrients and pollutant in the water column		-	Very Probable	Immediate	Immediate	Slightly relevant	Temporary	
	Increase in water turbidity	**Transport**	-	Probable	Immediate	Immediate	Slightly relevant	Temporary	
	Raising of sediment		-	Probable	Immediate	Immediate	Slightly relevant	Temporary	
	Change in ocean bathymetry	**Disposal**	-	Very Probable	Immediate	Immediate	Slightly relevant	Permanent	
	Increase in the raising of sediment		-	Certain	Immediate	Immediate	Slightly relevant	Temporary	

Environment	Impact	Operation Phase	Character (+/-)	Probability	Time frame	Area of Influence	Relevance	Duration	Can be Mitigated?
	Dispersion of lifted sediment		-	Probable	Immediate	Local	Slightly relevant	Temporary	
	Increase in the turbidity of water due to the disposal of a large volume of dredged materials		-	Certain	Immediate	Immediate	Slightly relevant	Temporary	
Biological Environment	Reduction in the rates of photosynthesis, as a result of an increase in turbidity	**Dredging, Overflow and Deposit**	-	Probable	Immediate	Immediate	Relevant	Temporary	
	Reduction in the capacity of the *P. Monodon* prawn to bury itself, as a result of the increase of turbidity		-	Slightly Probable	Immediate	Immediate	Relevant	Temporary	Yes
	Increase in productivity, due to the increase availability of nutrients		+	Probable	Short term	Local	Relevant	Temporary	
	Contamination of aquatic fauna, namely *M. Meretrix* clams, as a result of the raising of toxic materials in the water flow		-	Slightly Probable	Short term	Local	Very relevant	Temporary	
	Suffocating of benthonic organisms and young *M. Monoceros* prawns, as a result of deposing dredged materials	**Deposit**	-	Very Probable	Immediate	Immediate	Relevant	Temporary	Yes
	Difficulty in the movement of the *M. Monooceros* prawn as a result of the creation of barriers created by the disposal of dredged materials		-	Slightly Probable	Short term	Immediate	Relevant	Temporary	Yes
Socio-economic Environment	Restriction of the physical space used for fishing	**Dredging, Overflow and transport**	-	Slightly Probable	Immediate	Immediate	Slightly relevant	Temporary	
	Disturbances in maritime traffic		-	Slightly Probable	Immediate	Local	Slightly relevant	Temporary	Yes
	Increase of nutrients in the water increases the productivity of the system and consequently the amount of catches		+	Probable	Immediate	Immediate	Slightly relevant	Temporary	

Environment	Impact	Operation Phase	Character (+/-)	Probability	Time frame	Area of Influence	Relevance	Duration	Can be Mitigated?
	Impacts on the ecosystem could affect the resources and consequently affect the catches		-	Probable	Immediate	Local	Relevant	Temporary	
	Improvement of structures and establishment of sensitive zones with dredged materials deposited on land	**Deposit**	+	Certain	Immediate	Local	Relevant	Permanent	
	Revitalisation of Port activities		+	Certain	Immediate	Local	Relevant	Permanent	
	Revitalisation of the Municipal economy, and that of the Province, Central Zone, and country	**Post operations**	+	Very Probable	Short & Medium Term	Local	Relevant	Permanent	

8 Conclusions and Recommendations

The Port of Beira Access Channel Emergency Dredging would, in general, have a significant positive impact on Port activities and for the population of Beira as it will allow improved (and faster) access for maritime traffic which will progressively stimulate port activities, contributing to an increase economic activity in the medium to long term for the city, the Province and for the country’s entire central region.

In direct terms, the dredged materials could possibly be used in Beira for; civil construction, landfill of swamplands, or the refilling of sand on the beaches. All of these alternatives bring additional benefits for the development of the city. Standing out is the fact that the utilisation of these dredge materials to fill swamplands would contribute to the improvement of health conditions, reducing the rates of illnesses related to water, whilst also creating spaces for the expansion of the city.

During this study some potential negative impacts were identified, namely those related to coastal erosion, aquatic fauna, and negative consequences to artisanal fishing. However, the relevance of each was not considered significant.

In relation to coastal erosion, according with the conclusions reached by JICA (1998), based on hydrodynamic models at that time developed, the deepening of the Access Channel would not cause any significant alterations to the levels of erosion currently being experienced.

In ecological terms, the fact that Sofala Bay already has high turbidity levels and is continually subject to maintenance dredging reduces the risk of potential ecological impacts. Furthermore, the available information about the sediment quality in Beira indicates that they are not contaminated, and therefore reducing the risk of marine organisms being affected. However, as each dredging presents a degree of sensibility to all areas, it is recommended that caution be heeded during the collection of clams in the area around the Port.

This Simplified Environmental Study includes measures that will minimise these impacts, including recommendations relating to the disposal of dredge materials and additional measures to reduce the susceptibility of coastal erosion, also recommending the conducting of analyses to determine the quality of sediments as well as the monitoring of water quality around the port.

To ensure that these measures are effective it is very important that CFM work jointly with other institutions, namely the Municipality of Beira and the Sofala Provincial Office of Environmental Coordination Affairs, mainly to determine the potential uses for the dredged materials used for on-land deposits and the possible deposit areas.

It is concluded that the Emergency Dredging of the Port of Beira Access Channel would have a very significant positive socio economic impact and that the impacts on the biophysical environment could be mitigated through the implementation of mitigation measures contained in the Environmental Management Plan.

9 Environmental Management Plan

The Simplified Environmental Study (SES) identified and assessed environmental impacts that would result from a Maintenance Dredging of the Port of Beira Access Channel. To reduce and avoid the negative environmental impacts of the project activities a list was prepared containing mitigation and compensation measures.

In the current Environmental Management Plan (EMP) these measures are listed according with the project's sequence of activities, to facilitate their identification they have indicated the person or body responsible for the implementation of each measure.

The EMP instructions are defined for the different phases of the project, according to their impacts and mitigation measures. The effective implementation of these measures will ensure that the project is conducted and managed in a responsible and sustainable way.

The EMP is a dynamic document subject to revisions according to changes/variations in the project.

To guarantee the effective implementation of the EMP it is necessary to define the measures that will be taken and the entities responsible for them.

9.1 Objectives of the EMP

The objective of this EMP is to control the potential negative environmental impacts of the project and improve any possible positive environmental impact. The effective implementation of the EMP will ensure that the project is conducted and managed in an environmentally reasonable and responsible way.

It is hoped that the EMP will:

- Guarantee continual observance to Mozambican legislation;
- Provide the initial mechanisms that will ensure that the measures identified in the EMP, aimed at mitigating potential adverse effects, are implemented;
- Provide an action matrix for the mitigation of impacts that could not have been predicted or identified before the dredging activities actually began; and
- Provide a guarantee to the regulators and stakeholders about the completion of required responsibilities in relation to environmental and social expectations.

9.2 Roles and Responsibilities

In a way to ensure the correct development and effective implementation of the EMP identifying and defining the responsibilities and abilities of various people and organisations involved with the project will be necessary.

The following entities will be involved in this EMP:

- CFM
- The company(s) contracted to conduct the dredging (Contractor)
- The Beira Municipal Council (BMC)

* The Sofala Provincial Office of Environmental Coordination (DPCA-S)
* Institute of Navigation and Hydrographic (INAHINA), and
* Institute of Maritime Navigation (INAMAR).

9.2.1 The Role of CFM

CFM, being responsible for subjects relating to the Port, will guarantee that all project operations (sampling, dredging and the disposal of sediment) will be conducted in compliance with the EMP. CFM and the company contracted to conduct the dredging will guarantee that the EMP is implemented in full.

CFM should accompany the contracted company during the initial and final survey and verify whether the dredging is being done in the correct area and if the dredged materials are being deposited in the established areas.

The relevant details relating to the dredging operations should be presented to the regulating agencies (INAHINA and INAMAR) for their approval before the beginning of activities.

9.2.2 The Role of the Contracted Company (Contractor)

CFM should guarantee, after having completed a careful selection, that the contracted company will fulfil the EMP requirements during their operations. Special attention should be given the company's credibility at an international level, qualifications, accreditations, experience, and to their local knowledge.

The contracted company will be responsible for the relevant training of their staff, ensuring that they are able to complete the project activities in an efficient and appropriate way according with the contractual requisites with CFM for the agreed work.

The contracted company will be responsible for the project's initial and final survey, for the correct dredging of the Access Channel and for the completion of daily activity reports that should include meteorological conditions, dredging locations, the volume dredged, and the disposal location.

9.2.3 Role and Responsibilities of Other Entities

Beira Municipal Council:

* Will work in conjunction with CFM to define on-land disposal zones for the dredged materials and a definition of its use.

Provincial Office the Coordination of Environmental Affairs:

* Support the implementation of the Environmental Management Plan
* Support the monitoring of water and sediment quality in conjunction with health and fish authorities should this prove necessary

Institute of Navigation and Hydrographic (INAHINA) and the Institute of Maritime Navigation (INAMAR):

- Accompany the dredging process and the implementation of the Environmental Management Plan

9.3 Implementation

The EMP will be implemented during the dredging activities. The details about the necessary actions for the implementation of the mitigation measures are presented below in a table in the form of action plans.

9.3.1 Project Planning Phase

Environment	Potential Impact to be Minimised/Enhanced	Mitigation Measure	Responsible Entity
Physical Environment	• Alterations in the bathymetry and the Bay's circulation • Impact on coastal erosion • Reduction in the transport of sediment from the open sea to the coast	• Prioritise area D4 for the disposal of dredge materials or in other favourable deposit areas so that the materials can be transported towards the beaches. • Plan for the disposal of dredge materials on land to increase their usefulness, in conjunction with the Port of Beira and the Beira Municipal Council	CFM Contractor BMC
Ecology	• Interference with the creation and migration of prawns, fish and other species. • Impacts on marine life and water quality. • Bioaccumulation of pollutants in bivalves and risks to public health.	• Plan for dredging activities and the disposal of dredged materials in the areas close to the mouth of the Pungue river and the first miles in the D4 area during the rainy period (November to March) to avoid interference in the migration and survival of the prawn population. • Plan for the disposal of dredged material from the Port area or surrounds in industrial areas or in other Port areas where there already exists a level of contamination in the soil and where there could be treatment.	
Socio-Economic	• Improvement of structures the establishment of sensitive and swamplands.	• It is recommended that the remaining sediment volume after the port expansion be made available for civil construction, in conjunction with the Beira Municipal Council	

<u>**Implementation Phase of the Project**</u>

Environment	Potential Impact to be Minimised/Enhanced	Mitigation Measure	Responsible Entity
Physical Environment	• Alterations in the bathymetry and the Bay's circulation	• Deposit the dredge materials in the most even manner possible in the deposit areas to avoid significant alterations to water depths.	Contractor
Ecology	• Interference with the creation and migration of prawns, fish and other species. • Removal of benthonic habitats through suction of sediments • Noise interference to marine life	• Maintain hydraulic dredge vessels regulated and calibrated so they remain as close as possible to the sea floor and minimise the risk of injuries to marine animals, and with a net on the sucking mouth to reduce the number of organisms being collected with the sediments. • Avoid dredging operations at night in the areas of the Channel closest to the ecologically sensitive areas (Figure 5.2).	Contractor
Socio-Economic	• Disturbances to marine traffic • Restrictions to the physical space used for fishing	• It is recommended that the chosen deposit areas be adequately marked with buoys and lights, especially at night. • Maintain good lines of communication with the Port of Beira and other vessels to ensure as little interference as possible to Channel traffic.	Contractor

10 Bibliography

- Anon (2004) - *Apresentação sobre a situação dos mangais na Beira* in the Fishing Forum that took place in Hotel Embaixador, July of 2004, Beira.
- Arco Mozambique (1998). Environmental Impact Assessment of Sofala Bay and M-10 Seismic Exploration and Sofala Bay Exploration Drilling. Maputo.
- Ascadis Euroconsult. (1999) - *Integrated Coastal Zone Management Programme for Beira, Mozambique – Final report,* The Royal Netherland Embassy, Maputo
- Bata, O. (2006) - *Estudo preliminar de exploração de bivalves no distrito da Beira.* Thesis Work. Universidade Pedagógica da Beira. 98 pages
- Bene P., (1996) - *Traços Ambientais da Cidade da Beira.* Provinvial Office of Environmental Date unknown.
- Brito, A. (2005) - R*ecrutamento de Juvenis de Fenneropenaeus indicus e Metapenaeus monoceros. (Decapoda:Penaeidae) no Estuário do Rio Pungue, Moçambique.* National Institute of Fishing Research 26 pages
- CFM, (1999a) – *Environmental Audit & Management Plan for the Rail and Port Restructuring Project*. Financing from the World Bank. Report produced by *Impacto*, Maputo, 1999
- CFM, (1999b) – *Beira Port Handbook*. Beira, 1999
- CFM (2006) – Personal Information
- CVRD, 2006 – Estudo de Pré Viabilidade Ambiental do Transbordo Marítimo de Carvão na Baía de Sofala, ERM-CONSULTEC-Diagonal.
- De SOUSA, Lizete. Et al (2006) - *O Camarão do Banco de sofala 2006.* Maputo, July.
- De SOUSA, Bárbara (2004) - *Fauna Acompanhante do Camarão (Banco de Sofala).* In IIP Annual Report 2004. 10-12pp, Maputo.
- De SOUSA, Lizete. and Brito, Atanásio (2004). *O Camarão do Banco de sofala*. In IIP Annual Report 2004. 7-9pp, Maputo.
- De SOUSA, Lizete. Et al (2006) - *O Camarão do Banco de sofala 2006*. Maputo
- Doxiadis Associates (1992) – *Consultants on Development and Ekistics SA,. Rehabilitation of Beira Fishing Harbor – Sedimentation report*. Greece. 104 pp
- EMODRAGA, 2006 – Personal Information.
- Fischer, W, Sousa, I, Silva, C., de Freitas, A., Poutiers, J.M., Schneider, W., Borges, T.C.,Feral,J.P. and Massinga, A.. (1990) - *Guia de campo das espécies comerciais marinhas e de águas salobras de Moçambique*. FAO-424p
- GOVE, et all (2001) - *Impacto da pesca do Camarão de superfície no Banco de Sofala (Região Centro de Moçambique) sobre as tartarugas marinhas e efeitos da introdução do TED (DISPOSITIVO DE EXCLUSÃO DE TARTARUGAS) na pescaria do camarão*. Study financed by the WWF Weest African Marine Eco-region programme. Maputo, 2001
- Ingenieurs Bureau Amsterdam. (1996) - *Combate a Erosão. Beira, Moçambique.* Commission for Development Amsterdam Cooperation 57 pages

- INE, National Institute of Statistics (1999) - *Censo 97 Resultados Definitivos* ("97 Census Definitive Results") (CD and book). Maputo, 1999.
- IIP (2003) - *Pesca Artesanal em Moçambique* – Maputo.
- IIP (2004) – *Annual Report*. Maputo, 2004
- IIP (2006) – Prawns on the Sofala Bank-2006. Maputo, 2006
- National Institute of Small Scale Fishing, Sofala Delegation (2003) – Census of Artisanal Fishing in Interior Waters 2003 Preliminary Data, 2003. Report on the National Census of artisanal Fishing in Maritime waters.
- Japan International Cooperation Agency (JICA) 1998. *The Study for the Maintenance and Improvement Plan of Access Channel of Beira Port in the Republic of the Mozambique*. Tetra Co., Ltd.
- Kulima (1999). *Reconstituição do Mangal. Ilusão ou Realidade?* Moçambique, Maputo, 60pp.
- Ministry of State Administration (MAE) (2003) – III National Meeting of Municipalities. DNDA, Maputo, 2003.
- MAE (2002) – Municipality Information page, 2002.
- Odum, E. P. (1997).*Fundamentos de Ecologia*. 5ª. ed., Caloustre Gulbenkian Foundation, Lisbon, 927p.
- Palha de Sousa , L., Brito, A., Abdula, S., Penn, J., Howell, D. (2006). *The shallow water shrimp at Sofala Bank, Mozambique.* National Institute of Fishing Research 26p
- Projecta Arquitetura e Urbanismo (1998) - Plano de Estrutura da Beira – Dondo Relatório das Propostas, Dezembro 1998.
- Santana Afonso, P., Pereira, T., Baltazar, L. (2004). A pesca artesanal na Beira 2003. Relatório do Instituto Nacional de Investigação Pesqueira. Maputo. 47p.
- Pereira, Tânia et al (2005). Pesca Artesanal em Sofala – 2004. IIP. Beira.
- Pereira, M. (2006). *Estudo da influência antropogênica nas características dos mangais da Beira.* Thesis Work. Universidade Pedagógica da Beira. 95pp
- Plano de Estrutura das cidades Beira-Dondo (1998) – *Relatório de Propostas para a Ministério da Administração Estatal, República de Moçambique.* Report produced by Palmar Associates and Scott Wilson
- Relatório dos CCPs ao *fórum provincial de gestão participativa das pescas de Sofala,* organizado pela Direcção Provincial de Pescas de Sofala em Outubro de 2006.
- Santana Afonso, P., Pereira, T., Baltazar, L. (2004) - A pesca artesanal na Beira 2003. Relatório do Instituto Nacional de Investigação Pesqueira. Maputo. 47p.
- Seureca e DNA (2005). Relatório do estudo de avaliação do impacto ambiental do projecto de reabilitação da rede de saneamento da cidade da Beira. Project 7ACP.MOZ.20. Preliminary Version.
- SWECO e Associados, (2004) – *"DESENVOLVIMENTO DA ESTRATÉGIA CONJUNTA DE GESTÃO INTEGRADA DOS RECURSOS HÍDRICOS DA BACIA DO RIO PUNGUÉ – Anexo VI, Estudo Sectorial: Qualidade da Água e Transporte de Sedimentos"* Report conducted for the Government of the Republic of

Mozambique, Government of the Republic of Zimbabwe and Agency for International Development (Asdi). Maputo, April 2004.

- Torres, R.J. (2000) - Uma Análise Preliminar dos Processos de Dragagem do Porto de Rio Grande, RS. Dissertação apresentada para a obtenção do título de mestre em Engenharia Oceânica. Fundação Universidade Federal do Rio Grande, Brazil
- UCGIS, (2006) - *University Consortium for Geographic Information Science*, http://www.cobblestoneconcepts.com/ucgis2hud/WVURptCityofBeira.htm Alexandria, USA.

Annex 1

MOZAMBIQUE PORTS AND RAILWAYS
PORTOS E CAMINHOS DE FERRO DE MOÇAMBIQUE, E.P.

Conselho de Administração

Exmº. Senhor
Dr. FELÍCIO FERNANDO
DIRECTOR NACIONAL DO IMPACTO AMBIENTAL (DNAIA)
<u>MAPUTO</u>

Ref.: 23/DB-ADM/CFM/2006 — Maputo, 27 de Abril de 2006

Assunto: **<u>DRAGAGEM DO CANAL DE ACESSO AO PORTO DA BEIRA E AQUISIÇÃO DUMA DRAGA DE GRANDE CAPACIDADE</u>**

Exmº. Senhor,

Nos finais da década de 80 e princípios da década de 90, foram levados a cabo um conjunto de projectos no Porto da Beira, nomeadamente a construção de modernos Terminais de Contentores e de Combustíveis e o aprofundamento dos canais de acesso ao referido Porto, numa extensão de cerca de 28 kms.

A profundidade dos canais de acesso acima referidos passaram da cota de -6m em relação ao Plano do Zero Hidrográfico (ZH) para à cota -8m (ZH) e larguras entre 150 a 250 m, permitindo a entrada de navios até 80.000 DWT.

Houve nessa altura um compromisso de financiamento de uma draga com capacidade para manter os canais de acesso com aquelas características. A não efectivação do respectivo financiamento fez com que esses canais estejam hoje à cotas de cerca de -5m (ZH) e largura de 50m, inviabilizando o retorno dos investimentos feitos e originando reclamações dos utilizadores do Porto da Beira, pois só podem entrar navios até 30.000 DWT.

É neste cenário que o Governo de Moçambique priorizou duas acções tendentes a sair desta delicada situação:

- Fazer uma dragagem de emergência, de forma a ter os canais de acesso na sua cota original de -8m (ZH). Isto vai ser possível com o financiamento do Governo holandês;

- Aquisição duma draga oceânica com a capacidade para dragar 2.500 m3/ano, de forma a manter o canal original estável, o que será possível com o financiamento do Governo dinamarquês.

Para a implementação destes dois projectos a decorrerem em simultâneo, foi já lançado o primeiro concurso, relativo às dragagens de emergência e cuja abertura das propostas está agendada para o próximo dia 25 de Maio.

Porque a Lei moçambicana e os financiadores assim o exigem, vimos pela presente submeter a V.Exª. a ficha de informação ambiental preliminar e a descrição dos projectos para vossa apreciação e aprovação.

Gostaríamos no entanto de informar V.Exª. que foram feitos para aquele Porto, vários estudos, incluindo os de impacto ambiental, financiados pela União Europeia e o Banco Mundial, pelo que e em nossa opinião estaremos perante uma actualização ou programa de gestão ambiental, que V.Exª. decidirá como fazer dentro do curto espaço de tempo à nossa frente.

Queremos deixar bem patente que não se trata de abrir novos canais, nem aprofundá-los, mas sim repô-los à sua cota original e que as dificuldades em meios conduziram-nos a actual situação constrangedora à navegação. Salienta-se também que o troço designado por "Curva do Macuti" com cerca de 6 kms é o que se apresenta mais problemático.

Ciente de que V.Exª. nos orientará no caminho correcto e curto para que não percamos os financiamentos, subscrevemo-nos com elevada consideração,

O ADMINISTRADOR PARA A ÁREA DE ENGENHARIA

DOMINGOS BAINHA, Engº.

Anexo:

- Fichas de informação ambiental
- Cronograma dos Projectos

ANEXO IV

FICHA DE INFORMAÇÃO AMBIENTAL PRÉLIMINAR

1. Nome da Actividade:
SUBSTITUIÇÃO DE UMA DRAGA DE SUCÇÃO ANTIGA POR UMA NOVA.

2. Tipo de actividade:

a) Turistica ☐ Industrial ☐ Agro-pecuária ☐ Outro ☐

Especifique SUBSTITUIÇÃO DE UMA DRAGA DE SUCÇÃO EXISTENTE POR UMA NOVA COM CAPACIDADE SUFICIENTE PARA MANTER O CANAL DE ACESSO AO PORTO DA BEIRA, A PROFUNDIDADE E LARGURA DESENHADA.

b) Novo ☐ Reabilitação ☐ Expansão ☐

3. Identificação do(s) proponente(s):
PORTOS E CAMINHOS DE FERRO DE MOÇAMBIQUE, E.P.

5.Endereço/contacto:
PRAÇA DOS TRABALHADORES C.P. Nº 2158

5. Localização da actividade:

5.1 Localização administrativa:

Bairro de________ Vila________
Cidade BEIRA

Localidade________ Distrito de________

Província de SOFALA

Coordenadas Geográficas
(GPS)________

5.2 Meio de inserção:

Urbano ☐ Rural ☐ MARITIMO ☒

6. Enquadramento no zoneamento:

Espaço habitacional Verde ☐ Industrial ☐ Serviço ☐ MARITIMO ☒

7. Descrição da actividade:

7.1 Infra-estruturas da actividade, suas dimensões e capacidade instalada (juntar sempre que possível as peças desenhadas e escritas da actividade):

DRAGA COM PORÃO DE 2500 m^3 COM UMA CAPACIDADE DE CARGA DE 3900 TONELADAS

7.2 Actividades associadas:

7.3 Breve descrição da tecnologia de construção e de operação:

A DRAGA SERÁ CONSTRUIDA NA EUROPA E ENTREGUE A MOÇAMBIQUE PARA SER OPERADA PELA EMODRAGA.

7.4 Actividades principais e complementares:

REMOÇÃO DE AREIAS NA ORDEM DE 3 000 000 m^3/ano; e COMO ACTIVIDADE COMPLEMENTAR SERÁ A COLOCAÇÃO DE UMA PARTE DAS AREIAS DRAGADAS NA COSTA BEIRENSE PARA A PROTECÇÃO COSTEIRA.

7.5 Tipo , origem e quantidade da mão-de-obra:

CONSTRUÇÃO – MÃO DE OBRA ESTRANGEIRA

OPERAÇÃO – MÃO DE OBRA DA EMPRESA, EP

7.6 Tipo, origem e quantidades de matéria-prima :

//

7.7 Produtos químicos citados cientificamente a serem usados: (caso a lista seja longa deverá produzir-se em anexo)

//

.8 Tipo, origem e quantidade de consumo de água e energia:

//

7.9 Origem e quantidade de combustiveis e lubrificantes a serem usados:

COMBUSTÍVEIS PARA A DRAGA EM GRANDES QUANTIDADES

SERÃO COMPRADOS NA BEIRA.

7.10 Outros recursos necessários:

8. **Posse de terra (situação legal sobre a aquisição do espaço físico):**

9. **Alternativas de localização da actividade:**

(Motivo da escolha do local de implantação da actividade e indicando pelo menos dois locais alternativos)

10. **Breve informação sobre a situação ambiental de referência local e regional:**

10.1 Características físicas do local de implantação da actividade:

Planície ☐ Planalto ☐ Vale ☐ Montanha ☐

10.2 Ecossistemas predominantes:

Rio ☒ Lago ☐ Mar ☒ Terrestre ☐

10.3 Zona de localização:

Zona Costeira ☒ Zona do interior ☐ Ilha ☐

10.4 Tipo de vegetação predominante:

Floresta ☐ Savana ☐ Outros ☐
(especifique)__________

10.5 Uso do solo de acordo com o plano de estrutura ou outra política vigente:

Machamba ☐ Habitacional ☐ Industrial ☐

☐ ☐

Protecção Outros
(Especifique)______________________

10.6 Infra-estruturas principais existentes ao redor da área da actividade ______
____
____
____
____

11. Informação complementar através de mapas

- Mapa de localização (a escala conveniente)
- Mapa de enquadramento da actividade na zona de localização (a escala conveniente)
- Outra informação relevante que julgar relevante.

Maputo, ____ de ____________________ de 200____

MINISTÉRIO DO INTERIOR

Diploma Ministerial nº 189/2004

de 29 de Setembro

O Ministro do Interior, verificando ter sido dado cumprimento ao disposto no artigo 14 do Decreto nº 3/75, de 16 de Agosto, e no uso da faculdade que lhe é concedida pelo artigo 12 da Lei da Nacionalidade, determina:

É concedida a nacionalidade moçambicana, por naturalização, a Agostinho António Gonçalves, nascido a 27 de Novembro de 1945, em Portugal.

Ministério do Interior, em Maputo, 16 de Agosto de 2004. — O Ministro do Interior e para Assuntos de Defesa e Segurança na Presidência da República, *Almerino da Cruz Marcos Manhenje.*

COMISSÃO NACIONAL DE ELEIÇÕES

Deliberação nº 29/2004

de 2 de Setembro

Concluído o processamento dos dados finais da actualização do recenseamento eleitoral, o Secretariado Técnico da Administração Eleitoral procedeu ao cálculo do número de mandatos pelo círculos eleitorais, cuidando da eventualidade de realizar ou não o recesseamento no estrangeiro.

Ao abrigo do disposto no artigo 38 da Lei nº 18/2002, de 10 de Outubro, a Comissão Nacional de Eleições, reunida em sessão plenária, delibera:

1. Aprovar os seguintes mandatos por círculo eleitoral, realizando-se o acto eleitoral no estrangeiro:

Círculo Eleitoral	Nº de mandatos
Niassa	12
Cabo Delgado	22
Nampula	50
Zambézia	48
Tete	18
Manica	14
Sofala	22
Inhambane	16
Gaza	17
Maputo	13
Maputo Cidade	16
África	1
Resto do Mundo	1

URGENTE

Exmos Senhores
- Dr Marília Aere
- Eng. Miguel Ratabel

Preparar os ToR para um concurso restrito entre empresas moçambicanas p/ este estudo que é MUITO URGENTE

REPÚBLICA DE MOÇAMBIQUE
GOVERNO DA PROVINCIA DE SOFALA

DIRECÇÃO PROVINCIAL PARA A COORDENAÇÃO DA ACÇÃO AMBIENTAL

p/ PCA
19/05/06

Ao
C.F.M
Beira

Nota nº 334/DGA/DPCA/06

De 15 de Maio de 2006

Assunto: Parecer Sobre a Dragagem do Canal de Acesso ao Porto da Beira e Aquisição duma Draga de Grande Capacidade

Em resposta a nota de V. Excia nº 29/DB–ADM/CFM/2006 de 11/05/06, na qual solicitava-se parecer sobre o assunto em epigrafe, temos a comunicar o seguinte:

1. A luz do Regulamento sobre o Processo de Avaliação do Impacto Ambiental, Decreto 45/2004, de 29 de Setembro, projectos de dragagem de novos canais de acesso aos portos, carecem da elaboração de um Estudo de Impacto Ambiental (EIA) para a sua implementação.

2. No presente projecto não se irá fazer a abertura de um novo canais, mais sim, a reposição da cota original do canal. Ainda de acordo com Regulamento sobre o Processo de Avaliação do Impacto Ambiental, Decreto 45/2004, de 29 de Setembro, esta actividade de reposição da cota original é classificada como sendo de categoria B, o que significa que a sua implementação está sujeita a elaboração e aprovação do Estudo Ambiental Simplificado (EAS).

3. Para a elaboração do EAS, V. Excia deverá contratar um consultor ou empresa de consultoria devidamente registada no MICOA.

4. A elaboração do EAS é antecedida pela submissão dos Termos de Referencia nesta Direcção para aprovação.

Com os melhores cumprimentos.

Direcção Executiva dos C.F.M. – Centro
SECRETARIA
17-05-06
ENTRADA Nº 1067

O Director Provincial

Mauricio Xerinda
/Técnico superior N1/

Rua Serpa Pinto nº 580, 7º Andar, Telefone 23325525, 23329175 Fax. 324071, 23324092, E-mail: dpcasofala@teledata.mz

MOZAMBIQUE PORTS AND RAILWAYS
PORTOS E CAMINHOS DE FERRO DE MOÇAMBIQUE, E. P.

Conselho de Administração

Exmº. Senhor

DIRECTOR PROVINCIAL PARA A COORDENAÇÃO AMBIENTAL DE SOFALA

BEIRA

N/ Ref.34ADM-DB/CFM/2006 Maputo,05de Junho de 2006

Assunto: **SOLICITAÇÃO PARA APROVAÇÃO DOS TERMOS DE REFERÊNCIA PARA DRAGAGEM DO CANAL DE ACESSO AO PORTO DA BEIRA**

Em resposta a nota de V. Excia nº 334/DGA/DPCA/06 de 15/05/06 sobre o parecer do assunto em epígrafe, em anexo se remetem os Termos de Referência para a vossa apreciação e aprovação.

Os melhores cumprimentos,

O ADMINISTRADOR PARA A ÁREA DE ENGENHARIA

Domingos Lopes Bainha, Engº.

Sede: Praça dos Trabalhadores Maputo República de Moçambique
Caixa Postal 2158 Telefone 427[illegible] Fax [illegible] Telex 6.208 CFMS-MO

Para. Engº Bainha

REPÚBLICA DE MOÇAMBIQUE
GOVERNO DA PROVINCIA DE SOFALA

DIRECÇÃO PROVINCIAL PARA A COORDENAÇÃO DA ACÇÃO AMBIENTAL

Ao
C.F.M
Beira

Nota nº 512/DGA/DPCA/06

De 03 de Julho de 2006

Assunto: TOR's para EAS para a Dragagem do Canal de Acesso ao Porto da Beira

Em resposta a nota de V. Excia nº 39/ ADM-DB/CFM/2006 de 22/06/06, na qual submete a aprovação o assunto em epigrafe, temos a comunicar o seguinte:

- Foram apresentados aspectos chave para a elaboração de Estudo do Impacto Ambiental Simplificado para a dragagem do canal de acesso ao Porto da Beira.
- A equipe de trabalho deverá dar um reparo especifico ao fenómeno de erosão costeira na costa da cidade da Beira, associado ao processo de dragagem

Assim sendo, aprova os termos de referência propostos para o EAS.

Com os melhores cumprimentos.

O Director Provincial.

Mauricio Xerinda
/Técnico superior N1/

Direcção Executiva dos C.F.M. - Centro
SECRETARIA
03-07-06
ENT. 1380

MOZAMBIQUE PORTS AND RAILWAYS
PORTOS E CAMINHOS DE FERRO DE MOÇAMBIQUE, E.P.

Conselho de Administração

Exmº. Senhor
MAURÍCIO XERINDA
DIRECTOR PROVINCIAL PARA A COORDENAÇÃO DA ACÇÃO AMBIENTAL
Rua Major Serpa Pinto, nº. 850, 7º. Andar
BEIRA

Refª.: 39/ADM-DB/CFM/2006

Maputo, 22/06/2006

Assunto: *Termos de Referência para o EAS da dragagem dos Canais de Acesso ao Porto da Beira*

Exmº. Senhor,

Em resposta à sua nota nº. 499/DGA/DPCA/2006, de 9 do corrente, remetemos em anexo, a carta da Impacto – Projectos e Estudos Ambientais, com refª. Impacto C.337/06, desta data, capeando os Termos de Referência para EAS da Dragagem dos canais de acesso ao Porto da Beira, solicitando a sua aprovação.

Logo tenhamos a v/aprovação, procederemos a contratação duma empresa licenciada para efectuar o referido EAS.

Antecipadamente gratos, pela sua habitual atenção no atendimento deste nosso pedido, subscrevemo-nos com consideração,

O ADMINISTRADOR PARA A ÁREA DE ENGENHARIA

DOMINGOS BAINHA, ENGº.

Anexos: - Carta da Impacto
- Termos de Referência

Impacto

Projectos e Estudos Ambientais

Ref. Impacto C.337/06
Maputo, 22.06.2006

Para:

Portos e Caminhos de Ferro de Moçambique, E.P.
Att: Engº. Domingos Bainha
Administrador Executivo
Maputo

Assunto: Termos de referência para EAS da Dragagem dos canais de Acesso ao Porto da Baira.

Acusamos recepção da vossa carta Ref. 38/ADM-DB/CFM/2006 referente aos Termos de referência para Estudo Ambiental Simplificado para Dragagem do Canal do Porto da Beira.
Assim, enviamos três originais da Proposta de Termos de Referência conforme a vossa solicitação.

Os melhores cumprimentos,

IMPACTO, LDA.
PROJECTOS E ESTUDOS AMBIENTAIS
MAPUTO

António Mia Couto
Director Geral

Av. Mártires da Machava, 968 • Tel. 21-499636/7 • Fax 21-493019 • E-mail: impacto@impacto.co.mz
• Maputo - Moçambique

Impacto
Projectos e Estudos Ambientais

PROPOSTA DE TERMOS DE REFERÊNCIA PARA ESTUDO AMBIENTAL SIMPLIFICADO PARA DRAGAGEM DO CANAL DO PORTO DA BEIRA

1. Antecedentes

Localizado na foz do Púnguè e do Búzi, o Porto da Beira é sujeito a processos de sedimentação das vias de acesso o que constitui constrangimentos significativos ao seu bom funcionamento.

Obras de dragagem são necessárias de forma periódica para viabilizar e maximizar a utilização da referida porto, sabendo-se que esta unidade portuária contribui para um manuseamento de um volume total de 8 000 milhões de toneladas, a maior parte das quais se destinam ao países vizinhos de Moçambique.

A Empresa Portos e Caminhos de Ferro de Moçambique pretende efectuar uma dragagem de emergência para a remoção de 8 000 000 m^3 de materiais cujo destino será a deposição e locais identificados e o aproveitamento de parte deles para a construção civil. Este último destino integra-se num plano de expandir e alargar a intervenção de dragagem, plano que inclui a aquisição de um draga oceânica com capacidade para dragar 2500 $m^{3/}$ de dragados. A utilização racional de materiais dragados para reabilitação de terrenos costeiros está sendo projectada com o apoio do Governo Holandês e apenas será viável se as actuais capacidade de dragagem foram redimensionadas.

2. Identificação do proponente

O proponente é a Empresa Portos e Caminho de Ferro de Moçambique CFM com sede na Praça dos Trabalhadores, em Maputo.

3. Descrição da actividade proposta

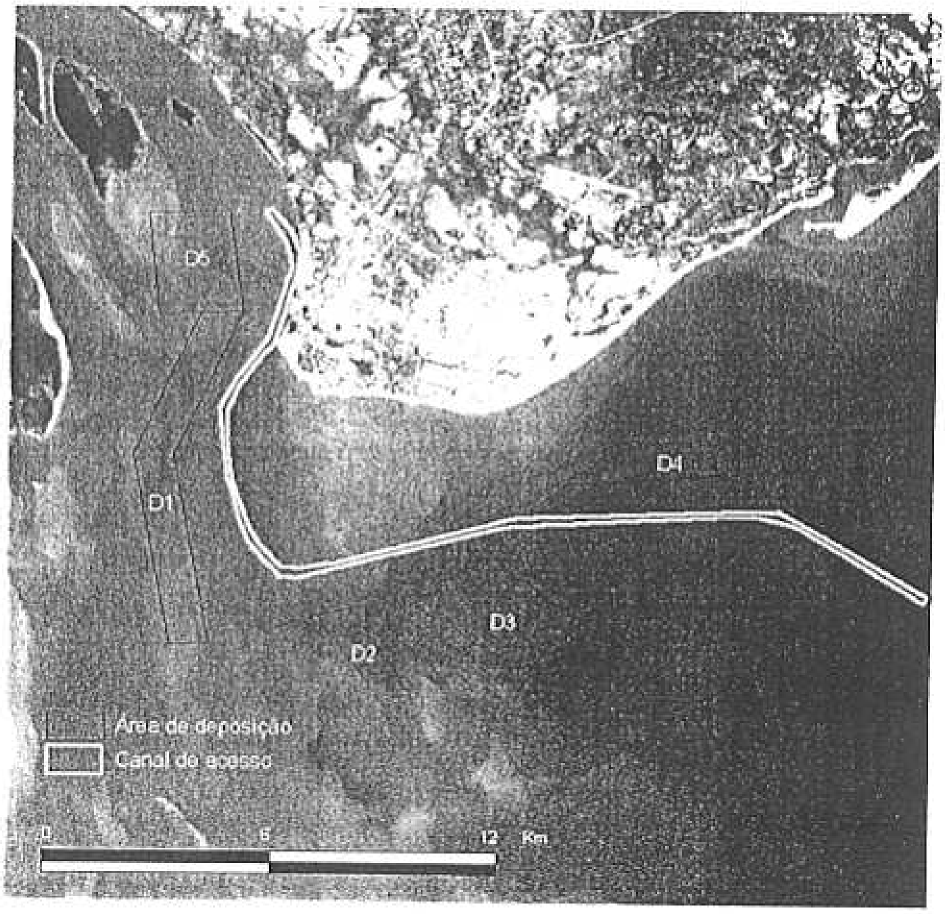
Pretende-se realizar operação de dragagem de manutenção do Canal de Acesso ao porto da Beira para repor à cota original do canal à (-) 8 m (ZH) de profundidade e 200m a 250m de largura numa extensão de 28 Km.

A operação consistirá na remoção da sedimentação acumulada ao longo dos anos, cerca de 8 milhões de m^3 para zona de despejo no mar e tradicionalmente identificada e utilizada, dos quais cerca de um milhão de metros cúbicos de areias serão repulsados para a zona designada por Praia Nova para consumo na construção civil.

Após esta operação, está prevista a utilização duma draga oceânica com capacidade para dragar 2.500 m^3/ano de sedimentos carregados pelos Rios Punguè e Búzi, de modo a permitir a entrada de navios até 80.000 DWT.

4. Localização

As áreas sujeitas a dragagem localizam-se no estuário do Pungué e representa o Canal de acesso para o Porto conforme ilustra a imagem seguinte:



5. Objectivos

O objectivo do estudo é proceder a uma identificação e avaliação dos impactos da dragagem e da deposição de sedimentos na região de influência directa e indirecta do projecto. Medidas de mitigação serão formuladas para minimizar os impactos negativos e um Plano de Gestão será elaborado para aplicação sistemática dessas medidas ao longo do tempo de vigência do projecto e de duração dos impactos.

6. Plano de trabalho

A realização do EAS incluirá entre outras as seguintes tarefas principais:

Tarefa 1. Descrição detalhada do Projecto – Os consultores descreverão com detalhes os processos e actividades relevantes do Projecto, usando mapas e diagramas apropriados para uma melhor compreensão. A descrição incluirá as quantidades e volumes de sedimentos a serem escavados em cada área, os métodos de extracção, transporte e deposição. O calendário e o faseamento do Projecto será descrito.

Tarefa 2. Descrição do Ambiente - Informação de base será colectada sobre as caracteristicas ambientais da área de estudo (incluindo dos locais de deposição previstos). A descrição incluirá ainda os seguintes parâmetros

a) Ambiente físico: geomorfologia, meteorologia (pluviosidade, ventos, ondulação e correntes), batimetria, hidrologia de superfície, qualidade de água.

b) Ambiente biológico: vegetação e fauna marinha e terrestre (linha costeiras adjacente) com referência a habitats sensíveis e espécies de valor biológico e/ou comercial particular

c) Ambiente social: actividades portuárias e transito de navios, uso da terras e actividades planeadas nas regiões envolventes

d) Vulnerabilidade da região para cheias, tempestades, tremores de terra.

Os consultores deverão identificar o rigor e actualidade da informação disponível, indiciando áreas de lacunas ou imprecisão e grau de incerteza para determinação dos impactos.

Tarefa 3. Contexto legal e institucional – Os consultores identificarão a legislação pertinente, incluindo regulamentos e padrões de qualidade em vigor. O enquadramento institucional será igualmente descrito

Tarefa 4. Determinar os Impactos Potenciais do Projecto – Os impactos das actividades previstas serão identificados e avaliados. Os critérios a serem usados para qualificar os impactos podem ser assim esquematizados:

Probabilidade – refere o grau de possibilidade de ocorrência do impacto que pode ser classificada de:

Improvável – a possibilidade da ocorrência se verificar é baixa quer seja pelo desenho do projecto quer pela natureza do projecto.
Provável – existe uma possibilidade distinta do impacto ocorrer.
Altamente provável – quando é quase certo que ocorra.
Definitiva – quando há certeza que o impacto ocorrerá independentemente das medidas preventivas adoptadas.

Extensão – refere o comportamento espacial da actividade que poderá possuir impactos nos limites da região do projecto (localizada), na área envolvente, na região ou a nível nacional.
Duração – o tempo de vida do impacto poderá ser:

> **De curto prazo** – 0 a 1 ano
> **De médio prazo** – 1 a 5 anos
> **De longo prazo** – o impacto cessa quando termina o tempo de vida da actividade a que se refere
> **Permanente** – o impacto prolonga-se mesmo depois de terminar a actividade de mesmo após aplicação de medidas de mitigação.

Intensidade – Neste parâmetro se avalia com que magnitude os impactos infligem normas e regulamentos, atingem populações e processos sociais e afectam o funcionamento dos processos ambientais. Nesse âmbito se classifica a intensidade de:

> **Baixa** – caso o impacto ocorra de forma a que o funcionamento dos processos naturais, culturais e sociais não sejam afectados
> **Média** – caso o impacto altere o funcionamento dos processos naturais, sociais ou culturais.
> **Alta** – quando o funcionamento dos processos naturais, culturais ou sociais seja temporária ou permanentemente interrompido.

Grau de significância – O significado do impacto passa a ser determinável através da síntese dos aspectos anteriores (extensão, duração, intensidade, probabilidade) e pode ser referido como:

> **Baixo** – se o impacto não deve influenciar nas decisões.
> **Médio** – se deve influenciar nas decisões (a não ser que seja mitigável).
> **Alto** – se deve influenciar decisões, qualquer que seja o grau de mitigação.

Especial atenção será concedida aos seguintes aspectos:

- Efeitos das actividades de dragagem e deposição de dragados na qualidade das águas e nos processos ecológicos e dinâmicas costeiras
- Efeitos da dragagem na estabilidade costeira da linha litoral adjacente
- Sugestão de locais de deposição adequados em função das correntes e factores dinâmicos de transporte e redistribuição dos sedimentos

Tarefa 5. Identificação de medidas de mitigação - Para cada um dos impactos identificados serão definidas medidas de mitigação respectivas com determinação de prazos e entidades responsáveis pela sua aplicação.

Tarefa 6. Desenvolvimento de um Plano de Gestão – Os assuntos considerados principais serão listados e a aplicação de medidas de mitigação e monitoria serão integrados num Plano de Gestão Ambiental sumarizado que assegure a aplicação de mecanismos de mitigação de forma atempada e coordenada

7. Equipe de consultoria

A equipe responsável pela elaboração do relatório será composta pelos seguintes elementos:

- Um Coordenador que será simultaneamente um ecologista
- Um oceonografo
- Um hidrologista
- Um biólogo marinho

8. Tarefas dos membros da equipe

Tarefa do coordenador/Ecologista

Dirigirá a equipe, coordenando e integrando as intervenções dos restantes especialistas.

Assegurará a qualidade do relatório e a sua realização nos prazos estipulados

Como ecologista será responsável pelos aspectos ecológicos do trabalho, e assegurará um alto rigor cientifico do conjunto do relatório

O consultor funcionará como elemento de ligação entre as diversas instituições em presença.

Tarefas do oceanografo

O consultor ocupar-se-á da descrição da batimetria, características geológicas e dinâmica de sedimentos na região de dragagem, nas zonas de deposição de dragados e na região envolvente.

O consultor procederá à descrição das variações sazonais da topografia e da configuração costeira, em função da variações diárias de maré e da sazonalidade climática e dos fluxos dos rios

O consultor identificará os impactos no meio físico e desenhará proposta de mitigação, contribuindo ainda com medidas a serem integradas no Plano de Gestão

Tarefas do hidrologista

O Consultor identificará os padrões de correntes, ondulação e marés e como a dinâmica costeira influencia fenómenos de erosão e sedimentação

Em coordenação com o Oceanografo, o hidrologista avaliará os efeitos das actividades propostas na hidrologia de superfície e na estabilidade costeira

Tarefas do biólogo marinho

O Consultor procederá à descrição das comunidade bentónicas e fauna e flora associadas
e determinará a ocorrência de áreas de reprodução, desova ou migração.

O Consultor verificará a existência de áreas de sensibilidade biológica particular na região de influência do projecto

O consultor avaliará a as possíveis interferência com áreas de pesca

O Consultor verificará se a dragagem pode afectar a qualidade da água e os ambientes bentónicos na região de influência

9. Estrutura do Relatório do EAS

O Relatório do EAS será entregue à Direcção Provincial de Coordenação Ambiental em Sofala, em língua portuguesa e num número de cópias a ser estabelecido por esta Direcção. A estrutura do Relatório será a seguinte:

a) Resumo Não Técnico contendo as principais conclusões
b) Localização e descrição da actividade
c) Enquadramento legal e inserção nos planos de desenvolvimento territoriais
d) Descrição ambiental de referência
e) Identificação e avaliação dos impactos ambientais
f) Plano de Gestão Ambiental
g) Identificação da equipe técnica envolvida

Annex 2

EIS Beira - DRAGAGEM DO PORTO DA BEIRA

Lista dos Participantes

Beira, 08/11/06

Nome	Instituição	Cel/Tel/Fax	E-mail
Dilip Ramgi	C.C.P. Nº3. Beira	844282500	
Oliveira Manfe	Assiação P. de Este	823822590	
Ribeiro Maubin	C.C.P. Nº2	844898160	
Alberto mauame machava		Secretaria Praia Nova	
EMÍDIO R. ANDRÉ	IIP	82 4922690	dee@mozilip.org
ATANASIO BRITO	IIP	825338570	mikamba@Hotmail.com

Annex 3

JICA analysed water quality parameters (1998)

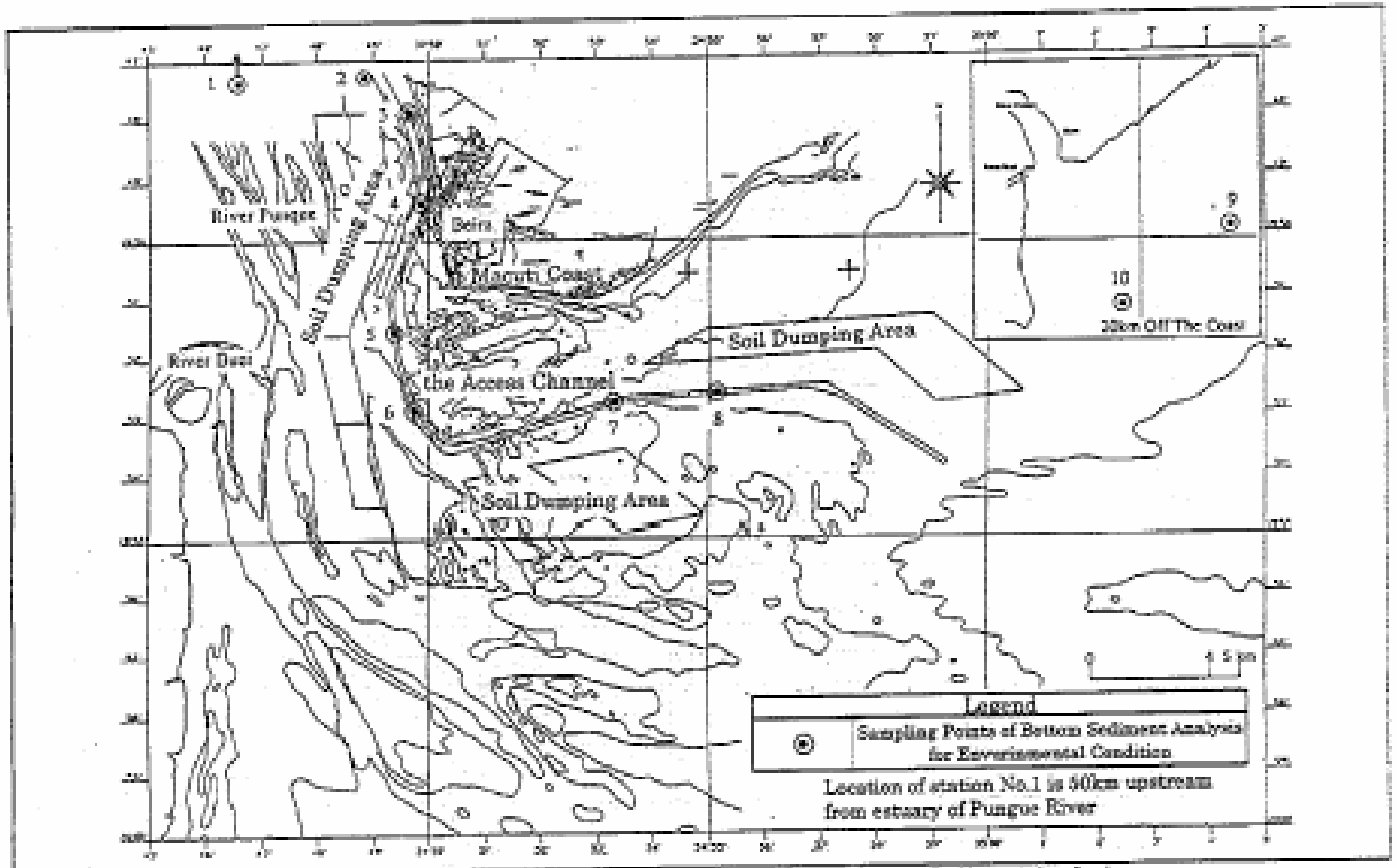


Figure 7.1.5-1 Location of Sampling Stations for Bottom Sediment Analysis

Table 7.1.6-1 Results of CTD* Measurements

CTD* Data (River Area)

Station-Season	Temperature(°C)	Salinity(‰)	O2(ml/l)	pH
St 1:Wet	27.2	0.04	4.95	5.85
Dry	21.3	0.09	7.05	6.49

CTD* Data (Low Tide)

Station-Season	Temperature(°C)	Salinity(‰)	O2(ml/l)	pH
St 2:Wet	28.1	0.29	6.81	8.06
Dry	22.1	16.60	5.41	7.81
St 3:Wet	28.3	0.25	3.13	8.14
Dry	22.2	15.90	6.35	8.21
St 4:Wet	29.1	0.33	2.77	8.18
Dry	22.2	7.30	7.10	8.12
St 5:Wet	29.3	0.85	2.73	8.15
Dry	22.3	5.37	7.19	8.26
St 6:Wet	29.3	8.08	3.04	7.77
Dry	22.2	27.40	5.75	8.45
St 7:Wet	29.4	12.80	3.92	7.82
Dry	22.5	28.60	5.81	8.53
St 8:Wet	28.3	15.60	4.12	7.86
Dry	22.8	25.68	6.73	8.60
St 9:Wet	29.8	29.10	4.44	8.08
Dry	23.0	25.36	7.18	8.59
St 10:Wet	29.5	28.00	4.79	8.12
Dry	23.2	27.01	7.76	8.39

CTD* Data (High Tide)

Station-Season	Temperature(°C)	Salinity(‰)	O2(ml/l)	pH
St 2:Wet	29.4	8.98	3.87	7.72
Dry	22.0	25.00	5.86	8.40
St 3:Wet	29.4	10.30	3.65	7.70
Dry	22.1	26.30	5.43	8.46
St 4:Wet	29.6	15.10	3.86	7.82
Dry	22.0	18.50	6.52	8.21
St 5:Wet	29.7	20.10	4.39	7.91
Dry	22.2	27.50	5.80	8.49
St 6:Wet	29.6	21.90	4.70	7.94
Dry	22.3	25.90	6.20	8.53
St 7:Wet	29.8	28.00	4.60	7.98
Dry	22.4	11.20	7.22	8.43
St 8:Wet	29.8	29.10	4.57	7.97
Dry	22.6	29.99	5.90	8.56
St 9:Wet	30.1	30.50	4.66	7.99
Dry	22.8	31.18	6.41	8.07
St 10:Wet	30.1	29.80	4.61	7.96
Dry	22.8	32.76	5.58	8.60

*CTD is abbreviation of Conductivity, Temperature and Depth.

Table 7.1.6-2 Results of Faecal Coliforms Measurements

Station No/ Sample Description	Date	Tide	Faecal coliforms per 100ml	Salinity (‰)
W 1	1997/2/9	non-tidal	226	0
D 1	1997/7/5	non-tidal	500	0
W 2	1997/2/6	Low	1420	0.3
D 2	1997/7/3	Low	74	19.35
W 3	1997/2/6	Low	6000	0.26
D 3	1997/7/3	Low	42	19.57
W 4	1997/2/6	Low	8200	0.33
D 4	1997/7/3	Low	100	31.45
W 5	1997/2/6	Low	3300	0.84
D 5	1997/7/3	Low	500	24.35
W 6	1997/2/6	Low	600	8.68
D 6	1997/7/3	Low	172	28.19
W 7	1997/2/6	Low	76	12.52
D 7	1997/7/3	Low	Nil	31.23
W 8	1997/2/6	Low	64	15.65
D 8	1997/7/3	Low	Nil	32.03
W 9	1997/2/7	Low	200	29.18
D 9	1997/7/4	Low	Nil	33.48
W 10	1997/2/7	Low	530	27.97
D 10	1997/7/4	Low	Nil	33.46
W 2	1997/2/8	High	5000	8.38
D 2	1997/7/2	High	400	24.57
W 3	1997/2/8	High	700	10.35
D 3	1997/7/2	High	1500	26.81
W 4	1997/2/8	High	6000	15.14
D 4	1997/7/2	High	2700	26.81
W 5	1997/2/8	High	58	20.06
D 5	1997/7/2	High	2	29.2
W 6	1997/2/8	High	2100	21.94
D 6	1997/7/2	High	2	30.58
W 7	1997/2/8	High	26	26.01
D 7	1997/7/2	High	2	31.81
W 8	1997/2/8	High	4 060	29.60
D 8	1997/7/2	High	Nil	32.83
W 9	1997/2/7	High	176	30.47
D 9	1997/7/2	High	2	33.04
W 10	1997/2/7	High	122	29.83
D 10	1997/7/2	High	Nil	33.56
Japanese Environmental Standard (River B)			5000	----

(D: July 1997,W: Feb 1997)

Table 7.1.6-3 Results of Turbidity and Suspended Solids Measurements

Station No.	Tide	Turbidity (NTU*)	Total Suspended Solids (mg/l)
W 1	Non-tidal	19	37
D 1	Non-tidal	210	26
W 2	Low	210	652
D 2	Low	260	1120
W 3	Low	98	294
D 3	Low	270	1020
W 4	Low	150	502
D 4	Low	270	1120
W 5	Low	44	137
D 5	Low	43	115
W 6	Low	88	314
D 6	Low	63	182
W 7	Low	9.5	97
D 7	Low	47	126
W 8	Low	2.7	80
D 8	Low	45	126
W 9	Low	1.7	67
D 9	Low	0.2	57
W 10	Low	1.8	77
D 10	Low	0.7	66
W 2	High	90	271
D 2	High	54	146
W 3	High	27	107
D 3	High	110	300
W 4	High	39	116
D 4	High	79	231
W 5	High	20	95
D 5	High	34	123
W 6	High	5.7	78
D 6	High	11	66
W 7	High	5.3	75
D 7	Low	47	126
W 8	High	2.8	84
D 8	High	4.4	80
W 9	High	1.7	74
D 9	High	0.6	64
W 10	High	1.8	76
D 10	High	0.1	59
Japanese Environmental Standard		(River B)	25

(D: Jully 1997,W: Feb 1997)

*NTU means Standard Nephelometric Turbidity units

Table 7.1.6-4 Results of Organic Measurements

Station No	Tide	Organic Hg(μg/l)	Organic P(mg/l)	Cyanogen(mg/l)	PCB (μg/l)	DDT (μg/l)	BHC (μg/l)
W 1	non-tidal	<0.02	0.02	<0.05	<0.02	0<0.02	<0.02
D 1	non-tidal	<0.02	<0.01	<0.05	<0.15	<0.15	<0.15
W 2	Low	<0.02	0.04	<0.05	<0.02	0<0.02	<0.02
D 2	Low	<0.02	0.47	<0.05	<0.15	<0.15	<0.15
W 3	Low	<0.02	0.21	<0.05	<0.02	0<0.02	<0.02
D 3	Low	<0.02	0.07	<0.05	<0.15	<0.15	<0.15
W 4	Low	<0.02	0.43	<0.05	<0.02	0<0.02	<0.02
D 4	Low	<0.02	0.21	<0.05	<0.15	<0.15	<0.15
W 5	Low	<0.02	0.18	<0.05	<0.02	0<0.02	<0.02
D 5	Low	<0.02	0.1	<0.05	<0.15	<0.15	<0.15
W 6	Low	<0.02	0.15	<0.05	<0.02	0<0.02	<0.02
D 6	Low	<0.02	0.06	<0.05	<0.15	<0.15	<0.15
W 7	Low	<0.02	0.14	<0.05	<0.02	0<0.02	<0.02
D 7	Low	<0.02	0.03	<0.05	<0.15	<0.15	<0.15
W 8	Low	<0.02	0.14	<0.05	<0.02	0<0.02	<0.02
D 8	Low	<0.02	<0.01	<0.05	<0.15	<0.15	<0.15
W 9	Low	<0.02	0.01	<0.05	<0.02	0<0.02	<0.02
D 9	Low	<0.02	<0.01	<0.05	<0.10	<0.15	<0.15
W 10	Low	<0.02	0.01	<0.05	<0.02	0<0.02	<0.02
D 10	Low	<0.02	<0.01	<0.05	<0.10	<0.10	<0.15
W 2	High	<0.02	0.17	<0.05	<0.02	0<0.02	<0.02
D 2	High	<0.02	0.15	<0.05	<0.15	<0.15	<0.15
W 3	High	<0.02	0.25	<0.05	<0.02	0<0.02	<0.02
D 3	High	<0.02	<0.01	<0.05	<0.15	<0.15	<0.15
W 4	High	<0.02	0.22	<0.05	<0.02	0<0.02	<0.02
D 4	High	<0.02	<0.01	<0.05	<0.15	<0.15	<0.15
W 5	High	<0.02	0.09	<0.05	<0.02	0<0.02	<0.02
D 5	High	<0.02	<0.01	<0.05	<0.15	<0.15	<0.15
W 6	High	<0.02	0.06	<0.05	<0.02	0<0.02	<0.02
D 6	High	<0.02	<0.01	<0.05	<0.15	<0.15	<0.15
W 7	High	<0.02	0.04	<0.05	<0.02	0<0.02	<0.02
D 7	High	<0.02	<0.01	<0.05	<0.15	<0.15	<0.15
W 8	High	<0.02	0.02	<0.05	<0.02	0<0.02	<0.02
D 8	High	<0.02	<0.01	<0.05	<0.15	<0.15	<0.15
W 9	High	<0.02	0.01	<0.05	<0.02	0<0.02	<0.02
D 9	High	<0.02	0.03	<0.05	<0.15	<0.15	<0.15
W 10	High	<0.02	0.01	<0.05	<0.02	0<0.02	<0.02
D 10	High	<0.02	<0.01	<0.05	<0.15	<0.15	<0.15
Japanese Environmental Standard		not detectable	—	not detectable	not detectable	—	—

(D: July 1997, W: Feb 1997)

Table 7.1.6-5 Results of COD,Total Nitrogen and Total Phosphorus Mesurements

Station No.	Tide	COD(mg/l)	Total Nitrogen (μg/l)	Total Phosphorus(μg/l)
D 1	Non-tidal	1.97	322	77
W 1	Non-tidal	4.06	393	29
D 2	Low	3.13	1192	541
W 2	Low	8.01	1120	810
D 3	Low	2.11	589	231
W 3	Low	5.15	1581	681
D 4	Low	2.69	863	363
W 4	Low	8.01	1033	798
D 5	Low	1.38	363	153
W 5	Low	3.35	363	180
D 6	Low	1.38	648	164
W 6	Low	1.67	446	156
D 7	Low	0.58	240	60
W 7	Low	1.76	359	149
D 8	Low	0.53	151	18
W 8	Low	1.53	406	148
D 9	Low	0.8	240	22
W 9	Low	0.15	154	15
D 10	Low	0.67	233	16
W 10	Low	0.44	265	13
D 2	High	1.75	479	205
W 2	High	2.44	329	170
D 3	High	1.24	418	94
W 3	High	3.2	547	257
D 4	High	1.17	205	87
W 4	High	2.26	385	218
D 5	High	1.02	185	68
W 5	High	1.02	244	97
D 6	High	0.8	158	41
W 6	High	0.73	214	60
D 7	High	0.73	185	29
W 7	High	0.44	214	45
D 8	High	0.73	301	22
W 8	High	0.29	180	29
D 9	High	0.8	226	104
W 9	High	0.52	205	9
D 10	High	0.73	240	19
W 10	High	0.22	164	13
Japanese Environmental Standard		3	300	30

(D: July 1997,W: Feb'1997)

Table 7.1.6-6 Results of Trace Metals Measurements (Unfiltered)

Station No.	Tide	Salinity (‰)	Hg	Cd	Pb	As	Cu	Zn	Cr VI
D 1	Non-tidal	0	<0.03	<0.57	<4.00	<0.24	2.6	10.18	<0.6
W 1	Non-tidal	0	<0.02	<0.27	5.52	<0.20	2.7	31.76	18
D 2	Low	19.35	<0.03	0.78	<4.00	1.64	14.88	24.72	<0.6
W 2	Low	0.3	<0.02	0.84	16.42	7	30.42	69.34	42
D 3	Low	19.67	<0.03	<0.57	<4.00	1.84	6.72	1.88	<0.6
W 3	Low	0.35	<0.02	0.8	16.1	5.67	23.14	35.54	40
D 4	Low	21.45	0.04	0.6	<4.00	2.98	10.62	18.5	<0.6
W 4	Low	0.33	<0.02	0.84	16.3	7.57	27.5	63.74	38
D 5	Low	24.25	<0.03	<0.57	<4.00	1.88	3.54	6.04	<0.6
W 5	Low	0.81	<0.02	<0.27	3.53	1.63	3.76	6.84	1
D 6	Low	28.19	0.06	<0.57	<4.00	2.06	8.36	13.1	<0.6
W 6	Low	8.08	<0.02	0.48	5.56	2.17	5.5	12.62	5
D 7	Low	31.23	<0.03	<0.57	<4.00	1.39	1.78	5.44	<0.6
W 7	Low	12.82	<0.02	<0.27	4.5	2.57	3.78	6.74	1
D 8	Low	32.85	<0.03	<0.57	<4.00	1.06	<1.48	3.84	<0.6
W 8	Low	15.55	<0.02	0.32	3.72	2.03	4.42	6.66	1
D 9	Low	33.48	0.05	<0.57	<4.00	1.06	3.22	1.85	<0.6
W 9	Low	29.13	<0.02	<0.27	0.82	0.67	1.94	5.02	<0.58
D10	Low	33.48	<0.03	<0.57	<4.00	0.63	<1.48	<0.57	<0.6
W10	Low	27.97	<0.02	<0.27	4.02	0.67	2.66	8.44	<0.58
D 2	High	24.57	<0.03	<0.57	<4.00	0.92	7.14	19.3	<0.6
W 2	High	8.98	<0.02	0.32	3.92	1.63	4.88	13.8	1
D 3	High	26.51	<0.03	<0.57	<4.00	3.05	2.72	20.6	<0.6
W 3	High	10.35	<0.02	0.62	6.68	2.7	8.05	18.92	5
D 4	High	28.81	<0.03	<0.57	<4.00	1.53	2.63	16.72	<0.6
W 4	High	15.14	<0.02	0.4	6.66	2.3	6.72	11.3	<0.58
D 5	High	29.2	0.03	<0.57	<4.00	1.24	3	14.62	<0.6
W 5	High	20.06	<0.02	0.42	4.06	1.7	4.6	9.43	1
D 6	High	30.58	<0.03	<0.57	<4.00	1.75	<1.48	11.12	<0.6
W 6	High	21.94	<0.02	<0.27	5.62	2.03	2	4.68	<0.58
D 7	High	31.61	<0.03	<0.57	<4.00	0.54	<1.48	5.76	<0.6
W 7	High	28.01	<0.02	<0.27	6.06	1.9	1.58	4.42	<0.58
D 8	High	32.83	<0.03	<0.57	<4.00	1.15	1.54	<0.57	<0.6
W 8	High	29.09	<0.02	<0.27	5.72	0.8	2	8.78	<0.58
D 9	High	33.04	<0.03	<0.57	<4.00	0.92	<1.48	<0.57	<0.6
W 9	High	30.47	<0.02	<0.27	2.84	0.97	1.66	5.73	<0.58
D10	High	33.55	<0.03	<0.57	<4.00	0.76	<1.48	<0.57	<0.6
W10	High	29.63	<0.02	<0.27	2.96	0.67	1.92	41.16	<0.58
Japanese Environmental Standard			0.5	10	10	10	—	—	50
Recommended Limit for S.A.			0.3	4	12	12	5	25	8
Recommended Limit for S.A. River			0.2	3	30	200	5	100	50

Results expressed in μg/l (D: July 1997, W: Feb 1997)