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Managing Freshwater Ecosystems of International Water Resources – The Case of the Maputo River in Mozambique

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Executive Summary

Freshwater ecosystems form a basis for the natural water circulation, and their maintenance is a prerequisite for a sustainable use of the world's water resources. Furthermore, they provide a multitude of goods and services that benefit humankind and are critical for the conservation of biological diversity. The protection of freshwater ecosystems has to be tackled internationally, where they are associated with transboundary watercourses.

This study reviews the key demands placed on management strategies that provide for the protection of freshwater ecosystems, and it examines whether relevant international agreements can serve as a legal framework for an ecosystem-oriented management of international water resources. Further, three promising examples of transboundary river management are given. The second part of this study is a case study of the Maputo River Basin. The aim is to point out sensitive freshwater ecosystems in Mozambique, the downstream riparian country, and to indicate existing options to integrate their protection into joint river management.

The drainage basin is considered to be an appropriate geographical reference point for an ecosystem-oriented management of transboundary freshwater resources. Other substantial principles designed to promote ecosystem orientation are the concepts of sustainable development, intergenerational equity, as well as the precautionary principle (compare Brunnée & Toope 1994). Procedures of an ecosystem-oriented management should provide for flexibility, participation, and co-operation in order to adapt to new scientific insights in and changes of ecological conditions as well as to new societal interests and concerns.

The most explicit international laws with regard to the management of international rivers are the UN Convention on the Law of the Non-navigational Uses of International Watercourses and, for the sub-Sahara region, the Revised Protocol on Shared Watercourses in the Southern African Development Community (SADC Protocol). They provide a framework in which competing claims for water use can be reconciled and offer a legal basis for the establishment of international agreements and institutions. With the explicit introduction of an environmental use, the SADC Protocol recognises the right to claim water for the protection of ecosystems. Nevertheless their provisions for the protection of freshwater ecosystems have been criticised for being insufficient. Other important international arrangements are the water chapter of Agenda 21, the Convention on Biological Diversity (CBD), and the Ramsar Convention on Wetlands. Although their provisions partly are not legally binding, they offer guidelines on how to put the protection of freshwater ecosystems into practice, and they formulate a range of activities and measures suitable for achieving the goal. The CBD and the Ramsar Convention further provide for a legal framework to put freshwater ecosystems under international protection.

The three cases of management of international rivers discussed show that co-operation in the management of shared water resources is possible and can integrate the common care for freshwater ecosystems integrity. This task is tackled in different ways, depending on the specific conditions, which differ considerably in the level of existing environmental degradation, the level of socio-economic development and the level of established international co-operation. While for the Great Lakes Basin a detailed determination of limit values for certain substances lead to significant improvement of the Great Lakes Ecosystem,

this goal was reached through adoption of a legally non-binding action programme at the Rhine River. In the case of the Okavango River the protection of its delta's ecosystem was ensured through listing it as a Ramsar site. A common characteristic of the three cases is the existence of a joint riparian institution that offered a forum for negotiation and served as an advisory body for environmental issues, among others. Other features favourable to the successful adoption and implementation of ecosystem-oriented management strategies are the definition of common objectives and their stipulation in a flexible form.

The Maputo River Basin in Southern Africa is shared between South Africa, Swaziland and Mozambique. The downstream part of the Maputo River Basin in Mozambique includes sensitive wetland areas such as floodplains, mangrove forests and tidal lakes. These valuable ecosystems play important roles in flood attenuation, shoreline protection and sediment retention and as habitat for many species; they are an important source for livelihood of the local population, as they provide fertile soils for agriculture, drinking water, raw material and fish. Further, they have great potential for the economic development of the Maputo sub-basin that is situated in an under-developed district of Mozambique. Although the Maputo River's water resources are not yet under high stress, development plans indicate that higher amounts of water are going to be extracted from the basin in the future, and the planned construction of diversions and dams is likely to alter the river's flow pattern. Changes in water quality, quantity and flow regime are likely to have negative effects on freshwater ecosystems downstream resulting in impacts on their performance of functions and services.

In August 2002 representatives of the three riparian countries of the Maputo River signed a Tripartite Interim Agreement for Co-operation on the Protection and Sustainable Utilisation of the Water Resources of the Incomati and Maputo Watercourses (Interim IncoMaputo Agreement). The agreement is the result of a lengthy process of negotiation and builds from a series of bi- and trinational agreements on common waters reached at an earlier time. This agreement in connection with the accompanying resolution of the Tripartite Permanent Technical Committee (TPTC) and the existing institutional framework for management of the Maputo River Basin offer some good preconditions for the adoption of water resources management strategies that integrate the protection of freshwater ecosystems. The legal and institutional arrangements within the basin meet a number of the key demands (such as provision for sustainable development, intergenerational equity, flexibility, and co-operation) placed on an ecosystem-oriented management. The Interim IncoMaputo Agreement further provides for a range of specific regulations and instructions (such as minimum instream flows, limit values for certain substances, establishment of classification systems and monitoring programmes), suitable for the protection of freshwater ecosystems. Yet, their successful implementation remains to be seen and has to overcome some major obstacles existing in the lack of hydrological data and scientific knowledge of freshwater ecosystem as well as in insufficient human and institutional capacity. Crucial steps towards the integration of freshwater ecosystem protection into joint riparian management strategies for the Maputo River Basin therefore consist in human and institutional capacity building programmes, establishment of monitoring programmes for quality and quantity of the water resources, and promotion of research on freshwater ecosystems. Achievement of these goals should be facilitated through promotion of knowledge sharing between the riparian countries, and provision of financing for the necessary work programmes.

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List of Abbreviations

BUREP	Bureau de Estudos de Perspectiva Hidráulica
CMA	Catchment Management Agency
CCDZ	Community Conservation and Development Zone
COP	Conference of the Parties
CBD	Convention on Biological Diversity
DWAF	Department of Water Affairs and Forestry (South Africa)
GEF	Global Environmental Facility
GLWQA	Great Lakes Water Quality Agreement
ICPR	International Commission for the Protection of the Rhine against Pollution
IJC	International Joint Commission (between Canada and the US)
ILC	International Law Commission
IUCN	International Union for the Conservation of Nature
JIBS	Joint Incomati Basin Study
JPWC	Joint Permanent Water Commission between Botswana and Namibia
DNA	National Water Directorate (Mozambique)
NGO	Non-governmental organisation
OKACOM	Okavango River Basin Water Commission
ARA Sul	Regional Water Administration of the South (Mozambique)
RAP	Rhine Action Programme
UGB	River Basin Management Units
SADC-WSCU	SADC Water Sector Coordination Unit
SADC	Southern African Development Community
SDI	Spatial Development Initiative
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice of the CBD
MAR	total net natural mean annual runoff
TFCA	Transfrontier Conservation Area
TPTC	Tripartite Permanent Technical Committee (Mozambique, South Africa, Swaziland)
UNCED	UN Conference on Environment and Development
UN	United Nations
UNEP	United Nations Environment Programme
U.S. EPA	United States Environmental Protection Agency

1 Introduction

Predictions of the United Nations suggest an increase in the world's population by 60 percent, from 5.3 to 8.3 billion people, in the years 1990 to 2025. As a result of this continuous population growth, pressure on the world's water resources will be intensified in the next decades. Developing countries will be especially affected by this trend, as in these countries high rates of population growth come together with rising economic development, both resulting in increasing demands for water. Consequences, particularly in the mostly arid and semi-arid Sub-Saharan Region, could be drinking water shortage, conflicts over water resource use and destruction of freshwater ecosystems.

Freshwater ecosystems form a basis for the natural water circulation; their maintenance is a prerequisite for a sustainable use of the world's water resources. In addition to the supply of water, freshwater ecosystems play an important role in the regulation of river flows and flood control, in the self-purification of water resources and as a source of food and raw material for humankind. Their destruction would, in the long-term, result in increasing shortages of water resources and lead to not only ecological but also economic damages.

The maintenance of function and performance of freshwater ecosystems is threatened by the overuse of renewable water resources, construction of dams and land-use for agriculture as well as by introduction of pollutants, nutrients and alien species. Causes for the degradation of freshwater ecosystems often arise geographically far away from the places where their negative effects occur. A successful protection of freshwater ecosystems therefore requires integrated water management, which takes into account the whole hydrological cycle as well as all the water resource uses in the different regions and sectors. A suitable unit for considering these aspects is the catchment area of rivers. As river catchments often extend over national borders, international co-operation between the riparian countries is necessary to guarantee the maintenance of freshwater ecosystems.

Several international agreements and many bi- and multilateral contracts concerning the joint use of transboundary watercourses exist. Besides regulations on navigational use, these mostly contain arrangements on water quality and quantity to serve the demands of population and industry. However, the allocation of water for the maintenance of ecosystems, a precondition for a long-term and sustainable use of natural water resources, has rarely been codified in such agreements.

In negotiations on international rivers, conflicts of interests mostly appear between up- and downstream riparian countries. This stems from the fact that use of water and construction of flow regulation measures in the upstream part of the river influence the water quantity and quality downstream. This can lead to negative effects on the possibilities for economic use and development as well as on ecosystems and structure of watercourses in the downstream riparian country.

As a downstream riparian of eight international rivers, Mozambique is especially affected by these disadvantages. Due to the civil war, that took place in the country for almost twenty years after its independence from Portugal in 1974, Mozambique has been economically underdeveloped for a long time. As a result there was less demand for water and existing water resources had been little exploited as compared to the more developed neighbouring countries like South Africa. Since the end of the civil war and the first independent elections in 1994, Mozambique's economic growth has exploded. The increasing demand for water connected with this development is reflected by the position the country takes in international

negotiations on transboundary watercourses. In the revision of the "Protocol on Shared Watercourses" of the Southern African Development Community (SADC) for example, Mozambique spoke out particularly for the consideration of environmental aspects, which at the same time means a strengthening of downstream riparian concerns.

The water resources of the Maputo River system are shared among Mozambique, South Africa and Swaziland. Recently, the three riparian countries agreed upon co-operation in the protection and sustainable utilisation of the water resources of the Maputo Watercourse. The objective of this study is to highlight vulnerable freshwater ecosystems in the Mozambican part of the Maputo River Basin, and to point out options to integrate their protection into future joint riparian management strategies.

The following questions were investigated during a research stay in the National Water Directorate in Maputo, Mozambique:

- What kind of sensitive ecosystems exist in the river's catchment and adjacent coastal areas in Mozambique?
- Which functions do these ecosystems perform in the maintenance of sustainable water resources and in the provision of other natural resources?
- What importance do they have for socio-economic development and preservation of biological diversity?
- What is the actual conservation status of these ecosystems?
- Which are the main threats to the integrity of these freshwater ecosystems?
- How can the protection of these freshwater ecosystems be integrated into joint riparian management strategies?
- What legal and institutional bases exist to provide integrated management mechanisms?

These questions were tackled in a desk study of available literature and maps, in qualitative interviews with representatives of different non-governmental organisations (NGOs), research institutions, water management institutions and relevant ministries as well as in informal interviews with local populations during a field visit to the basin area.

In order to assess the case of the Maputo River in an international context, the first part of this study report discusses the legal framework provided by relevant international agreements for integrating ecosystem protection into the management of internationally shared watercourses. Further, it gives an overview of three examples for ecosystem orientation in the management agreements of three specific rivers.

2 Freshwater Ecosystems in International Management of Water Resources

If the great variety of functions performed by freshwater ecosystems is to be maintained, it is necessary to consider their responses to stresses resulting from human activities and to take ecosystem protection into account when managing water resources. This management task is further complicated by the fact that boundaries of freshwater ecosystems often exceed national borders. Management strategies have therefore to be tackled internationally if they are to be effective in conservation of freshwater ecosystems. The following chapter presents the key demands placed on management strategies to provide for the enduring use and conservation of freshwater ecosystems. Subsequently, the most relevant international agreements addressing water resources management are examined for the ecosystem orientation of their provisions, and management agreements on three specific rivers are discussed.

2.1 Principles for an Ecosystem-oriented Management of Water Resources

In order to benefit from freshwater ecosystems' goods and services in the long term, a balanced consideration of the needs of people and the environment is required. Further, the complex interconnectedness between the different components of an ecosystem demands that management strategies are broad-based in spatial as well as in intertemporal dimensions. For the spatial dimension this means that management concepts have to consider the interdependencies between all of the different ecosystem constituents, such as water, soil, air, flora, and fauna. In this sense, an appropriate geographical reference point for an ecosystem-oriented management of transboundary freshwater resources could be the **drainage basin** (Brunnée & Toope 1994), determined by the watershed limits of the watersystem, including surface and ground water, as it has been defined in the *Helsinki Rules* on the Uses of International Rivers by the International Law Association already in 1966. Unfortunately the far-reaching implications of the term led to resistance to it in negotiations on international water policy, because states feared restriction not only on their sovereignty over the water resources at issue, but also over surrounding land areas (Teclaff 1996).

Principles designed to promote an ecosystem orientation in an intertemporal dimension include the concepts of sustainable development, intergenerational equity and precaution (compare Brunnée & Toope 1994). The concept of **sustainable development** acknowledges the right of the present generation to develop and use natural resources on the condition that it takes place in accordance with development needs of future generations. Therefore it requires that development of resources is restricted by the limits of what the environment can sustain in the long term in order to ensure continued availability of the resource base on which continued development depends. The idea of sustainable development is reinforced by the principle of **intergenerational equity** that does not focus on development interests of each generation, but rather on the more general obligation to ensure that natural and cultural resources are passed on to future generations in no worse condition than they were received. The **precautionary principle** mirrors the fact that current scientific knowledge on the complex interactions among different components of ecosystems in general is insufficient to predict the long term effects of human interference. In order to prevent significant harm or

environmental degradation in the future, the precautionary principle consequently requires that measures to avoid potential adverse effects should not be postponed due to scientific uncertainty of causal links between human activity and environmental impact.

The lack of scientific knowledge also implies another, procedural demand on ecosystem-oriented management, namely that strategies and regulations provide sufficient **flexibility** to adapt to new scientific insights in and changes of ecological preconditions as well as to new societal interests and concerns. Other procedural principles of ecosystem management, such as the principles of **participation** and **co-operation,** are based on the assumption that the balancing of management objectives between conservation and sustainable use of ecosystem is a matter of societal choice (compare e.g. Klaphake et al. 2001). In order to identify common concerns and achieve management perspectives supported by all relevant players, participation and co-operation of all stakeholders is necessary.

2.2 Ecosystem Orientation in International Water Law and Policy

The most explicit international laws with regard to the management of international rivers are the UN Convention on the Law of the Non-navigational Uses of International Watercourses (UN Convention) and, for the sub-Sahara region, the Revised Protocol on Shared Watercourses in the Southern African Development Community (SADC Protocol). But there also are several other international conventions, treaties, action programmes and declarations that tackle freshwater ecosystems. The most important ones probably are the water chapter of Agenda 21, the Convention on Biological Diversity and the Ramsar Convention on Wetlands, which in conjunction with the mentioned agreements on watercourses, could set a legal basis for an integrative, ecosystem orientated management of international rivers. This will be examined in detail below.

2.2.1 UN Convention and SADC Protocol

The Convention on the Law of the Non-navigational Uses of International Watercourses (1997) (UN Convention) takes the form of a framework agreement, that formulates legal and structural ground rules for individual agreements between riparian states of international watercourses. It contains 37 articles dealing with the obligations of riparian states to share the common water resources, to consult with each other, to protect the environment and to resolve disputes. To date only 8 states have ratified the convention, but the large number (103) of votes for the adoption of the convention in the United Nations General Assembly indicates general acceptance among the member states (Scheumann & Klaphake 2001), and it has been argued that even if the UN Convention never comes into force, it is likely to be the starting point for future negotiations for agreements on transboundary waters (McCaffrey 2001).

At the core of the UN Convention are two principles considered to be the cornerstones of the law of international watercourses (compare e.g. Brunnée & Toope 1997):

- the principle of equitable and reasonable utilisation and participation in the development of the watercourse by all riparian states (Art. 5)
- the obligation not to cause significant harm to another watercourse state by using the international watercourse (Art. 7)

In regard to environmental protection the UN Convention addresses a variety of transboundary conservation and management problems: protection of ecosystems, water pollution, alien species, living resources, flood control and protection of the marine environment. Nevertheless it has been argued that the convention ultimately has failed to adequately integrate environmental and ecological concerns (Dellapenna 2001). Main points of criticism brought forward by various commentators are that:

- the geographical scope neglects important interdependencies e.g. between water and land,
- the obligation to prevent harm is made subordinate to the rule of equitable utilisation,
- the main goal of the Convention continues to be development of a watercourse, while their protection is considered a duty,
- the general obligation to protect and preserve the ecosystems of international watercourses is formulated without providing corresponding rights for potentially affected states.

More detailed discussion of the UN Convention can be found in e.g. Brunnée & Toope 1997, Dellapenna 2001, Klaphake et al. 2001, McCaffrey 2001.

A legal framework for joint initiatives and co-operation on international rivers in the Sub-Sahara region consists in the "Protocol on Shared Watercourses" (SADC Protocol) that was adopted by the members of the SADC in its revised form in 2000. The first protocol was already signed in 1995 and put into effect in 1998, after the required minimum number of SADC countries had ratified it. But during the process of ratification some of the member countries, especially Mozambique, expressed their reservations to some of the 1995 protocol's provisions. The main areas of dispute were that the Protocol did not provide enough for environmental protection and downstream countries' concerns, and that it was neither integrated with the new developments in international water law nor the new perspectives that emerged from the United Nations Conference on Environment and Development (Rio Conference) in 1992 (Canelas de Castro 2002).

The SADC Protocol, which contains guidelines for the protection and joint utilisation of shared watercourses in Southern Africa, follows the discussion about and content of the UN Convention. Therefore, with respect to its provisions for protection of freshwater ecosystems, the SADC Protocol as well shows some of the same drawbacks as the UN Convention. But, on the other hand, the SADC Protocol has been equipped with some of the modern principles, such as sustainable development and intergenerational equity, appropriate to promote an ecosystem orientation in international law (compare 2.1).

General principles of the SADC Protocol are stated in Article 3, in which "the principle of the unity and coherence of each shared watercourse" is named first (Article 3 No. 1). But it can be criticised that the SADC Protocol's geographical reference area, the "watercourse", is defined as "a system of surface waters and ground waters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus such as the sea, lake or aquifer" (SADC Protocol, Article 1). This definition matches the one used in Article 2 (a) of the UN Convention, which has only been amended with "such as the sea, lake or aquifer". Thus, the criticism of insufficient consideration of the interactions between land and water (compare 2.2.1) also applies to the SADC Protocol on Shared Watercourses, and its geographical reference point is not appropriate to provide for the protection of a freshwater ecosystem as a whole.

The two cornerstones of international water law, namely the principles of equitable utilisation and of no harm, can also be found in Article 3, “General Principles”, of the SADC Protocol (Article 3 No. 7 and 8). The wording of the principles in the SADC Revised Protocol is very similar to the formulation of the UN Convention. But, while in the SADC protocol’s 1995 version the no harm principle was not even present, it could be argued that the revised SADC Protocol of 2000, in contrast to the UN Convention, gives precedence to the no-harm doctrine over the principle of equitable utilisation. On the one hand the existence of paragraph (b) of Article 3 No. 10 of the SADC Revised Protocol that lays down what to do “where significant harm is nevertheless caused” can be interpreted as implicitly acknowledging that harm may be caused for the sake of equitable utilisation without engaging the harming state’s responsibility. But on the other hand the fact that paragraph 2 calls upon the harm causing states to “take all appropriate measures...to eliminate or mitigate such harm” and to “discuss compensation” with “due regard for the provisions of paragraph (a)” –namely the no harm article- indicates that the obligation not to cause significant harm retains validity. The UN Convention, in contrast, at this point demands to have due regard to the principle of equitable utilisation (UN Convention, Article 7 paragraph 2) (compare McCaffrey 2001 and Dellapenna 2001, discussing the equivalent Article 7 of the UN Convention). The precedence of the obligation not to cause significant harm over the right of equitable utilisation also implies that the right of development is subordinated to the duty to avoid environmental damage.

The “classical” principles of international water law have been integrated with more modern principles in the SADC Protocol (Canelas de Castro 2002). For example, the obligation to care for future generations is explicitly expressed in Article 3 No. 7 (a), laying down the principle of equitable utilisation, which stipulates that utilisation of the watercourse has to be “consistent with adequate protection of the watercourse for the benefit of current and future generations”. Further, the principle of sustainable development has explicitly been made into one of the General Principles (Article 3) of the SADC Protocol: In Article 3 No. 4 it requires its parties to “maintain a proper balance between resource development... and conservation and enhancement of the environment to promote sustainable development” and in Article 3 No. 1 it calls upon them to “ensure that all necessary interventions are consistent with the sustainable development of all Watercourse States”. The general principles further appeal to the parties to “exchange available information and data” on the shared watercourse, inter alia on its environmental condition (Article 3 No. 6), and to pursue and establish close co-operation with regard to the study and execution of all projects likely to have an effect on the regime of the shared watercourse” (Article 3 No. 5)

New to the SADC protocol’s 1995 version and also to the ideas expressed in the UN Convention is the consideration of an “environmental use” that has been defined as “the use of water for the preservation and maintenance of ecosystems” (SADC Protocol Article 1 No. 1). The environmental use, besides agricultural, domestic, industrial and navigational uses, as stipulated in Article 3 No. 2, shall be included in the utilisation of the resources of a shared watercourse open to each watercourse state. Accordingly, the “environmental needs of the watercourse states concerned”, in addition to social and economic needs, are part of the factors to be taken into account in determining whether a use is in accordance with the “equitable and reasonable utilisation” of a shared watercourse (Article 3 No. 8 (ii)).

2.2.2 Agenda 21, the Convention on Biological Diversity, and the Ramsar Convention on Wetlands

In **Chapter 18 of Agenda 21**, titled "Protection of the Quality of Freshwater resources: Application of Integrated Approaches to the Development, Management and Use of Water Resources" and often called the water chapter, non-binding principles to guide freshwater management are formulated. Chapter 18 only includes a few paragraphs that explicitly deal with the issue of transboundary water resources (e.g. paragraphs 18.4 and 18.10) and strategies for transboundary water resources' management are recommended only in very general terms (e.g. in paragraphs 18.27(d) and 18.40(h)). Therefore Agenda 21 does not provide a sufficient regulatory framework for the integration of freshwater ecosystem's protection into the management of, especially transboundary, water resources.

However, it gives some directions to include the protection of aquatic ecosystems into freshwater resources management in general, for example it names as one of the objectives of "Integrated water resources development and management" (programme area A) that "In developing and using water resources, priority has to be given to the satisfaction of basic needs and the safeguarding of ecosystems." (paragraph 18.8). Programme area C "protection of water resources, water quality and aquatic ecosystems" gives a list of objectives, targets and activities for protection of freshwater ecosystems. It includes the principles of sustainability and precaution, promotes the drainage basin concept and highlights the need for an ecosystem approach in water management (e.g. paragraphs 18.39, 18.9, 18.40). Discussion and criticism of the scope of the water chapter can be found in e.g. Brunnée & Toope 1994, Scheumann & Klaphake 2001.

The **Convention on Biological Diversity (CBD)** emerged as one of three global environmental conventions (the other ones being the Convention to Combat Desertification and the Framework Convention on Climate Change) from the discussions during the UN Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. The broad objectives of the Convention on Biological Diversity cover the conservation of biological diversity, the sustainable use of its components, as well as the fair and equitable sharing of the benefits arising from the utilisation of genetic resources. In pursuing these goals, "the in-situ conservation of ecosystems and natural habitats" is considered the "fundamental requirement" to achieve the conservation of biological diversity (compare the preamble of the CBD), whereas an ecosystem is defined as "a complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" (CBD, Art. 2). Therefore the CBD assigns its contracting parties broad duties aimed at the protection of the long term productivity and diversity of ecosystems and habitats. Obligations include the identification and monitoring of biological diversity and the selection of protected areas. Further, the CBD promulgates an integrated planning and management framework for land and water ecosystems (Korhonen 1996) that is premised on the notions of sustainability, intergenerational equity and precaution (compare the preamble of the CBD).

While the Convention on Biological Diversity itself does not contain any special provisions for freshwater ecosystems, its fourth Conference of the Parties (COP 4) adopted a work programme on biological diversity of inland water ecosystems (decision IV/4, paragraph 1) addressing inter alia the assessment of the status and trends of the biological diversity of inland water ecosystems and the identification of options for conservation and sustainable use. Decision IV/4 also emphasises the need for an integrated management of watersheds, catchments and river basins based on an ecosystem approach that stresses:

- the interdependencies between different components of aquatic ecosystems (decision IV/4, Annex I, 9. (a)(i)),
- the "transboundary nature of many inland water ecosystems" and the need for joint initiatives of riparian states (decision IV/4, Annex I),
- the necessity to improve knowledge of the status of inland water ecosystems and of the processes that threaten their diversity.

The explicit recognition of the importance of ecosystems for biological diversity as well as the statements of the preamble and objectives of the CBD provided the basis for the elaboration of an ecosystem approach, as a framework for analysis and implementation of the objectives of the CBD, by its Conference of the Parties and Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) (compare UNEP/CBD/COP4 1998). The formulated ecosystem approach provides a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus, although the CBD does not include any explicit obligations relating to freshwater ecosystems, its contribution to the establishment of a more ecosystem-oriented water management is thus diverse (compare Klaphake et al. 2001) and has been considered to provide "the most encompassing approach to riverine biodiversity" (Korhonen 1996).

The **Convention on Wetlands** of International Importance Especially as Waterfowl Habitat, adopted in the Iranian city of Ramsar in 1971 and therefore often called Ramsar Convention, was the first modern global intergovernmental treaty on conservation and wise use of natural resources (Klaphake et al. 2001). With the intention to prevent further loss of wetland areas, the Ramsar Convention established a list of wetland areas of international importance. Designation by a member state of a site in its territory for the Ramsar list awards the wetland site international protection by the contracting parties to the convention (Korhonen1996), as parties are obliged to consider the conservation of listed wetlands in planning of land and water resource use. Further, they are requested to promote the "wise use" of all non-listed wetlands in their territory (Ramsar Convention, Article 3 no 1). Conditions for the inclusion of a site to the Ramsar list are its international ecological, botanical, zoological, limnological or hydrological importance.

While the text of the Ramsar Convention itself does not provide any regulations regarding the integration of water resource management and wetland conservation, Resolution VI.23 on "Ramsar and Water" calls on Contracting Parties to undertake a range of actions including the establishment of hydrological monitoring networks on wetlands, studies of traditional water management systems and economic valuation methods, to involve National Ramsar Committees and local stakeholders in river basin management. In order to assist the contracting parties "Guidelines for integrating wetland conservation and wise use into river basin management" were adopted at the 7th Meeting of the Conference of the Contracting Parties (Resolution VII.18). These guidelines include statements on the appropriate design of institutional, legal and policy frameworks for an integrated river basin management as well as recommendations, e.g. on how to minimise the impacts of land use and water development projects on wetlands and their biodiversity, or relating to the assessment and enhancement of the role of wetlands for water management. Integral elements of the guidelines' approach are:

- a focus at the river basin scale, encompassing the land area between the source and the mouth of a river and including all of the lands that drain into the river

- water resource planning and management as a multidisciplinary process including public participation
- the establishment of River Boards and Commissions, responsible for preparing river basin management plans,
- standards and objectives to be achieved relative to water quality and quantity,
- allocation of water for the maintenance of all ecosystems including marine and coastal ecosystems
- use of the precautionary principle to maintain the natural situation as closely as possible
- strategies for the sustainable use of water resources have to be flexible and adaptable to a range of circumstances

In cases where a river basin is shared between two or more contracting parties, the Ramsar Convention's Article 5 makes clear that these parties are expected to cooperate and to consult each other in the management of such resources. In the above mentioned guidelines for integrating wetland conservation and wise use into river basin management, countries sharing a drainage basin are encouraged to establish frequent contacts in order to exchange information on the water resource and its management, to document the key issues of common concern in the basin and to develop formal joint management arrangements for development and implementation of action plans to deal with such issues. The establishment of international river commissions, created by several riverine countries to facilitate consultation and broad co-ordination is considered one option for achieving such outcomes.

Thus, although the text of the Ramsar Convention itself does not provide for comprehensive regulations in regard to water resources management and the convention's focus at the outset was rather limited, documents and guidelines adopted under the Ramsar Convention in recent years have set out a strategic approach to ensure the proper management of ecosystems within river basins (compare Klaphake et al. 2001) which could guide countries and agencies involved in river basin management. In this context, "The River Basin Initiative on integrating biological diversity, wetland and river basin management" was launched in 2000 in order to provide a mechanism to promote sharing of best practices and issues relating to integrated management of river basins based on an ecosystem approach (River Basin Initiative 2001)

2.2.3 Concluding Remarks on International Water Law and Policy

The research into relevant international agreements, such as the UN Convention, the SADC Protocol, Agenda 21, the Convention of Biological Diversity and the Ramsar Convention, shows that the need for integrated water resource management strategies that ensure protection of ecosystems has gained wide recognition in international Water Law and Policy. The UN Convention and the SADC Protocol codified a number of customary laws and procedures applying to the use of internationally shared water resources. They provide a framework in which competing claims for water use can be reconciled. With the explicit introduction of an environmental use, the SADC Protocol recognises the right to claim water for the protection of ecosystems. Further they offer a legal basis for the establishment of international agreements and institutions. Through stipulating binding norms for international

co-operation in water resources management as well as for exchange of data and information, the two framework agreements make an important contribution to the creation of main preconditions for achieving long-term protection of freshwater ecosystems. Agenda 21, the Convention of Biological Diversity and the Ramsar Convention and their respective programmes, on the other hand, provide instructions and guidelines on how to put the protection of freshwater ecosystems into practice. They call on their contracting parties to adopt ecosystem-oriented strategies for the management of river basins and formulate a range of activities and objectives suitable to achieve this goal. The CBD and the Ramsar Convention further provide for legal frameworks to put freshwater ecosystems under international protection.

2.3 Protection of Freshwater Ecosystems in International River Management – Three Examples

Since many aquatic ecosystems expand over political borders and causes for their degradation often occur geographically far away from the places where resulting negative effects appear, the effective long term protection of freshwater ecosystems can only be achieved through international co-operation in taking an ecosystem approach to river basin management. Water sharing among riparian states is an important political and strategic issue for the states concerned. Diverging riparian interests can constitute obstacles for the integrated management of transboundary water resources and might impede joint action for the protection of freshwater ecosystems (compare Klaphake et al. 2001). However, there also are a number of good examples showing that co-operation in the management of shared water resources is possible and can integrate the common care for freshwater ecosystems integrity. Three promising cases of integrated, ecosystem-oriented management of transboundary water resources will be presented in the following sections.

2.3.1 Great Lakes Basin

The Great Lakes constitute the largest system of fresh surface water on earth, containing about 23,000 km^3 of water, roughly 18 percent of the world supply, and covering a total area of 244,000 km^2, which is shared by the United States of America and Canada. As early as 1909 the two riparian states signed the Boundary Waters Treaty, setting out the principles and procedures under which waters along the border were to be managed. The 1909 Treaty also established the International Joint Commission (IJC), which authorises the uses, diversions or obstruction of boundary waters and transboundary streams, and conducts investigations at the request of the governments. Even though the treaty mainly focussed on water levels, flows and uses, it already recognised the importance of water quality, stating "that the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other." (compare Environment Canada 1999). The treaty therefore followed the “no harm” principle that also guided many other agreements on transboundary resources.

In spite of their large size, the Great Lakes are sensitive to the effects of a wide range of pollutants which have led to several environmental hazards during the 20th century. Sources of pollution include the runoff of soils and farm chemicals from agricultural lands, the waste from cities, discharges from industrial areas and leachate from disposal sites. The large surface area of the lakes also makes them vulnerable to direct atmospheric pollutants that

fall with rain or snow and as dust on the lake surface (U.S. EPA 2002). In the early part of the 20th century, water borne diseases prompted water treatment systems, in the 50's the Great Lakes fisheries were being devastated by sea lamprey, and in the mid 60's Lake Erie was a dying ecosystem suffering from eutrophication due to high phosphorous discharges. In 1969 one of the Great Lakes' tributaries, the Cuyahoga River, burned from excessive oil and debris, while high mercury content in Lakes Erie and St. Clair closed the fisheries industries.

This series of environmental crises as well as growing public concern about the deterioration of water quality in the Great Lakes stimulated new investment in pollution research commissioned by the IJC. This environmental concern was formalised in the first Great Lakes Water Quality Agreement (GLWQA) between Canada and the U.S. in 1972. While at that time, the major issue was phosphorus over-enrichment of the lakes, in 1978, the GLWQA was amended to make explicit a broader purpose: "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." Therefore, in the 1978 GLWQA, the riparian countries specifically committed themselves to rid the Great Lakes of persistent toxic substances. These aims are fleshed out through the basic structure of the 1972 and 1978 GLQWA, which includes the stipulation of "general objectives" (Art. 3), and further provides for the determination of "specific objectives" (Art. 4). "General objectives" of the GLWQA encompass the overall goals to free the Great Lakes System from substances and materials that adversely affect beneficial uses or human, animal or aquatic life. Article 4 laid down that further "specific objectives" are to be implemented through agreed upon water quality standards derived from "programs and other measures" dealing with various pollution sources. Comprehensive annexes develop these elements and include detailed lists of limit values for a range of substances. In 1987, the 1978 GLQWA was amended by a protocol, which emphasised the importance of human and aquatic ecosystem health and now explicitly defines the Great Lakes Basin Ecosystem as “the interacting components of air, land, water and living organisms, including humans, within the drainage basin.” In addition, the 1987 Protocol introduced provisions to develop and implement Remedial Action Plans, focussing on geographic Areas of Concern, and Lakewide Management Plans focussing on Critical Pollutants.

The International Joint Commission (IJC) established by The Boundary Water Treaty of 1909, also became the institutional core of the GLWQA. The IJC is an independent international organisation charged with preventing and resolving disputes over the use of waters shared by the United States and Canada. In addition, when requested by the two federal governments, the Commission provides advice on matters affecting the shared environment and has been charged with reviewing and evaluating programs and progress of the GLWQA. In its tasks the IJC has been assisted by the Great Lakes Water Quality Board and the Great Lakes Science Advisory Board, created under the 1972 and 1978 Agreements respectively. In Canada, Environment Canada leads delivery on the GLWQA, while the U.S. Environmental Protection Agency spearheads the United States efforts. Both work in partnership with provincial, state, and municipal governments.

The successful co-operation between Canada and the U.S. within the Great Lakes Basin is surely connected with the particular political, economic and social context and might not be transferable to other cases of internationally shared water resources. But nevertheless some of the institutional and jurisdictional characteristics of the Great Lakes Basin’s case might also give some relevant clues for other contexts (compare Klaphake et al. 2001). With the IJC and the two advisory boards riparians have created an effective institutional arrangement that provides opportunities for interaction and exchange among scientists,

technical experts and policy makers from the two countries. The design of the Agreement, consisting of a main part including the main objectives and a series of annexes dealing with specific aspects of ecosystem-oriented basin management, provides for necessary detail as well as for flexibility, as annexes can be changed independent of the GLWQA itself (Brunnée & Toope 1997). The formal structure of the GLWQA as well as its flexibility to adapt to changing circumstances has been identified, among others, as key prerequisites for the successful co-operation (Valiante et. al 1997).

Because of the comprehensive definition of its geographical reference point, i.e. the Great Lakes Basin Ecosystem, its future-oriented approach and detailed criteria for ecosystem management, the Great Lakes Water Quality Agreement has been considered the "most elevated manifestation of ecosystem-oriented freshwater management" (Brunnée & Toope 1997). Even though the GLWQA does not make explicit reference to such principles as sustainable development, intergenerational equity or precaution, these principles seem inherent in its far-reaching provisions.

2.3.2 River Rhine

The river Rhine is a large alluvial river system flowing from the Swiss Alps to the North Sea. Its catchment area includes territory of Switzerland, Germany, France, Luxembourg, and the Netherlands. Since the early 19th century, the River Rhine has been rectified to control flooding. For this reason water from the braided alluvial system was concentrated into one channel with levees and dams. This development continued in the 20th century when the river was further regulated in order to harness hydropower and to accommodate shipping. Canalisation and regulation of the Rhine has led to a decline in floodplain areas, uniformity in water flow, river banks reinforced with stone, and a reduction of open connections to the North Sea. Results are, among others, a greater danger of floods and the destruction of valuable habitats for the formerly rich fauna and flora. In addition, water quality has deteriorated since the beginning of the 20th century due to increased population density, industrialisation, and the intensification of agriculture along the river banks. The decrease in water quality of the Rhine culminated in serious problems for drinking water and an overall deterioration of the Rhine ecosystem. Degradation of the River Rhine also led to pollution problems and increased nutrient loading in the North Sea (compare e.g. Schulte-Wülwer-Leidig & Wieriks 1997, ICPR 2002).

Due to an initiative of the downstream country, the Netherlands, the riparian states of the Rhine created a common forum in 1950, where questions relating to the pollution of Rhine water were discussed and solutions were sought. In 1963 a basis on international law was given to this forum by the Convention on the International Commission for the Protection of the Rhine against Pollution (Bern Convention), signed by the Rhine bordering countries, Switzerland, France, Luxembourg, Germany and the Netherlands (ICPR 2002). Tasks of the International Commission for the Protection of the Rhine against Pollution (ICPR), as defined in the Bern Convention, are to conduct inquiries on the extent and sources of pollution of the Rhine, to propose appropriate measures for its protection, and to provide the basis for any agreements between the riparian countries. Environment ministers and officials from each member state gather at ICPR meetings on a regular basis. Decisions are taken jointly and each country, land or regional government adopts the ensuing measures. But neither the ICPR nor its secretariat has any executive or coercive power to speak of. Therefore, the ICPR is not an international administrative institution, but rather an advisory body and

committee of negotiation (compare Durth 1996). Co-operation within the framework of the ICPR led, among other things, to the signature of the Conventions on the Protection of the Rhine against Chemical and Chloride Pollution in 1976. Yet, implementation of these, mostly technical, treaties turned out to be problematic and very slow. As a reaction to increasing environmental problems, and especially the disaster caused by a fire at the chemical manufacturer Sandoz, where tons of highly toxic agro-chemicals where flushed into the Rhine, the implementation of the Rhine Action Programme (RAP) was approved by the conference of the environment ministers of the riparian countries in 1987. Goals of the RAP were: the reestablishment of species that had been extinct from the Rhine, the preservation of the Rhine as a source of drinking water and the reduction of suspended matter loading. Significant improvement in the environmental status of the river could be observed in the years following the implementation of the RAP (ICPR 1998) and the flexible and non legally binding design of the action programme, defining common objectives rather than fixed limit values for chemical substances, proved to be very successful (compare Klaphake et al. 2001).

Efforts to protect the Rhine from pollution and to recover the health of its ecosystem have culminated in the signing of the Convention of the Protection of the Rhine in 1998 by its five riparian countries and the European Union. The main goals of the new Convention reflect some of the objectives already stated in the RAP in 1987 and have been laid down in Article 3 of the Convention as follows:

- sustainable development of the Rhine ecosystem,
- ensuring the use of Rhine water for drinking water purposes
- improving sediment quality in order to enable the use or disposal of dredged material without causing any harm.
- holistic flood prevention and protection, taking into account ecological requirements
- restoration of the North Sea in accordance with other measures aimed at the protection of this marine area

In Article 3 number 1. a) to f), the Convention further specifies, that sustainable development should be achieved by, among other:

- including, maintaining and improving water quality, avoiding, reducing or eliminating pollution as fully as possible,
- protecting the population of organisms and the species diversity,
- preserving, improving and restoring natural function of the stream, taking into account interactions between river, ground water and alluvial area, maintaining, protecting and reactivating alluvial areas as natural floodplains
- maintaining, improving and restoring natural habitats for wild animals and plants in the water, on the river bottom and river banks as well as in adjacent areas

The geographical scope of the Convention comprises the Rhine itself as well as ground water and aquatic and terrestrial ecosystems interacting with the Rhine and the Rhine catchment area as far as it is of importance for issues of flood prevention and defence along the Rhine or its pollution affects the Rhine (Article 2). Thus, the Convention considers the

drainage basin as one unit and takes into account the interconnectedness between different parts of the ecosystem. Article 4 of the Rhine Convention lays down principles by which Contracting Parties should be guided when managing the water resources. These include such principles as prevention, precaution, fighting environmental deterioration at the source, polluter pays and application of Best Available Techniques and Best Environmental Practices.

Encompassing main elements of en ecosystem-oriented approach to freshwater resources management, like the principles of sustainable development and precaution, the drainage basin concept and the promotion of common goals, the ICPR can serve as a good example for viable practices in ecosystem management of international river basins (compare Klaphake et al. 2001). Although workable co-operation practices took a long time to establish within the ICPR, the case shows that the long process from the first version of the ICPR, as a mere forum of discussion to the emergence of legally binding norms in the new Convention was worth the patience and efforts. It also supports the thesis, that untimely generation of binding legal norms, such as the conventions on chemical and chloride pollu0tion agreed upon in 1978, might not be successful and that instead, non-legally binding norms, such as work programmes defining common concerns, are worth considering as an initial step to establish mutual trust and co-operation practices (compare Brunnée & Toope 1997). Nonetheless, it should be kept in mind that much of the ICPR's progress was achieved in the aftermath of the Sandoz disaster which created a lot of public concern. Also, success in protection of the Rhine ecosystems was for a great part due to the firm commitment of private actors with an economic interest in remedy of the Rhine, for instance the Rotterdam harbour operator or the International Working-Group of Waterworks in the Rhine Catchment Area (Durth 1996).

2.3.3 Okavango River

The Okavango River rises in the Angolan highlands and passes briefly through the Caprivi strip in Namibia before it discharges into the sands of the Kalahari desert in Botswana, where it forms a huge delta of interconnected rivers and reed lined channels that cover some 5000 km^2. The total basin area is approximately 120 000 km^2, and mostly lies in Angolan territory. While Angola is a water-abundant country and its part of the catchment area is rather little developed, the downstream countries Namibia and Botswana are water-stressed nations that depend on the Okavango River for their further development (compare Turton 2001). The Okavango Delta is one of the largest remaining inland wetland ecosystems in the world (Monna 1999) and home to innumerable species. The delta's rich diversity of wildlife and largely undisturbed condition form the backbone of the tourism industry that is a major source of foreign revenue for Botswana. Further, most of the people living in the area depend on the Okavango Delta for their livelihood as they collect water, fish, edible or medicinal plants from the delta and conduct farming in the delta floodplains (Rothert 1999). The integrity of the Okavango Delta could be threatened by abstraction of water from the Okavango River, by the construction of dams that alter the natural patterns of flooding or by unsustainable agricultural practices (compare Turton 2001) and generally by the lack of a comprehensive natural resources management plan (Monna 1999).

Co-operation in the Okavango River Basin started with the establishment of the Joint Permanent Water Commission (JPWC) in 1990 by a bilateral agreement between Botswana and Namibia focussing on the bilateral management of the Okavango River and the Kwando-

Chobe-Liyati reach of the Zambezi River (Turton 2001). Two years later, talks were commenced with Angola, and in 1994 an agreement on the establishment of a Permanent Okavango River Basin Water Commission (OKACOM) was signed by representatives of the three riparian countries, Angola, Botswana and Namibia. The main function of the Commission is to advise the riparian countries, for instance on the demand for and availability of water resources in the basin, the criteria to be adopted in the conservation, equitable allocation and sustainable utilisation of water resources or on measures that can be adopted to alleviate difficulties resulting from water shortages (Article 4). The OKACOM agreement only deals with the composition and functioning of the Commission and does not provide any legally binding norms regarding the management of the Okavango River Basin apart from the general obligation of the riparians to give prior notification to the commission of any relevant development. Neither does it define its geographical scope. But in the preamble of the agreement, the Contracting Parties laid down their acceptance of the "concepts of environmentally sound natural resources management, sustainable development and the equitable utilisation of shared watercourse systems as reflected in the relevant provisions of Agenda 21".

As a forum for discussion, the OKACOM provides opportunities for Okavango River Basin states to tackle important questions in regard to ecosystem management, such as instream requirements and environmental water demand (Rothert 1999) and generally the Commission is functioning satisfactorily (Turton 2001). An exception of this was introduced by plans to build a pipeline to transport water from the Okavango River to Central Namibia, brought forward by the Namibian government after extended droughts in 1996, without passing the contractual procedures of OKACOM. The project was hotly contested by Botswana, claiming that environmental impact studies did not include downstream effects in Botswana and questioning whether alternatives had been taken into due consideration (Ramberg 1997). The dispute cooled down by the occurrence of a period of rain shortly after the plan had come up and in general OKACOM parties seem to have realised that negotiated solutions are better than heated conflict (Turton 2001).

In 1997, Botswana ratified the Ramsar Convention on Wetlands and, as a reaction to the Namibian pipeline plans, declared the Okavango Delta a Ramsar site, thereby hoping to increase international pressure on Namibia (Ramberg 1997). Because Namibia is also a signatory to the Ramsar Convention, it is under the same obligations as Botswana to manage the delta wisely. The listing of the Okavango Delta as a Ramsar site offers protection to the delta and support to the riparian countries by the Ramsar Convention Bureau. For instance Botswana has been working out an Integrated Management Plan for the Okavango Delta in co-operation with the Bureau (Monna 1999). But it also makes future development subject to the approval by a number of international role-players what might turn decision finding even more complex (compare Turton 2001).

The case of the Okavango River again shows that even if no legally binding norms for the environmental management of a shared watercourse have been agreed, the mere establishment of a joint riparian commission, such as the OKACOM, serving as an advisory body and discussion forum, as well as the general obligation to give prior notification of water resources development, can create an environment for negotiation which helps to avoid escalation of conflicts. The listing of the Okavango Delta as a Ramsar site gives an example on how international environmental conventions may influence specific conditions for the management of shared watercourses.

2.3.4 Lessons learnt from the three cases

Each of the three cases discussed above shows specific preconditions, which differ considerably in the level of existing environmental degradation, the level of socio-economic development and the level of established international co-operation. Analysis of the adopted management strategies reveals that protection of freshwater ecosystems can be tackled in various ways, with each way having its advantages for the specific case of transboundary water resources management. While in the case of the highly economic developed Great Lakes Basin, where a high level of co-operation already started in 1909 and a very critical environmental situation existed, the formulation of detailed lists of quantitative water quality targets proved to be successful, this strategy failed in the case of the River Rhine. Instead, co-operation in the Rhine river basin first needed to be improved through the formulation of legally non-binding common goals and action programmes. A completely different strategy was adopted in the Okavango Basin. As co-operation between riparian states showed to be insufficient to elaborate common management goals, Botswana decided to declare the freshwater ecosystem at issue a Ramsar site in order to put it under international protection.

Still, there also are common characteristics of the three cases. Above all, in all three cases, a common institution existed that offered a forum for negotiation and served as an advisory body for environmental issues, among others. A similar opportunity for interaction and sharing of knowledge among technical experts and/or policy makers from the different riparian countries seems an appropriate measure to foster co-operation and to identify relevant policy options. Other features that can be identified from the three examples which serve to positively influence the successful adoption and implementation of ecosystem-oriented management strategies are the definition of common objectives and their stipulation in a flexible form. The very broad definition of the geographical reference point in the GLWQA and the Rhine Convention should further serve as a good example for other agreements on transboundary water resources.

3 The Case of the Maputo River

The Maputo drainage basin is located between latitudes 26? 10' S to 27? 40' S and longitudes 30? 00' E to 32? 40' E in East Southern Africa where it is shared among South Africa, Swaziland and Mozambique. Its total area is 29,970 km^2 (Interim IncoMaputo Agreement 2002) and encompasses the Usuthu, Pongola and Maputo sub-basins as well as the Maputo Estuary. While both of the upstream countries, South Africa and Swaziland, can claim for major parts of the basin area falling within their national borders, only about 5 % of the basin area lies in Mozambican territory. Figure 1 shows the Maputo River Basin.

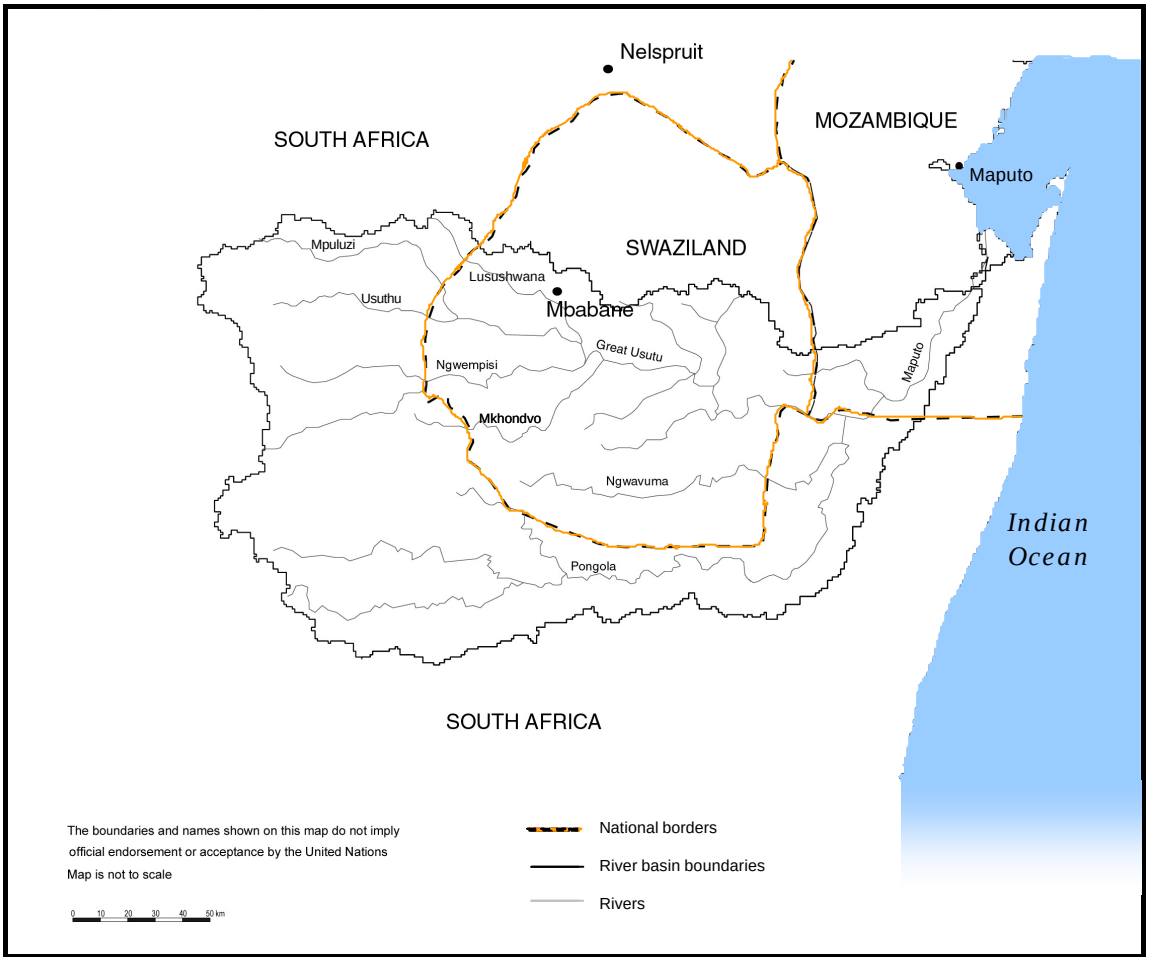

Figure 1: Map of the Maputo River Basin (GEF 2001)

The Usuthu sub-basin with its tributaries Lusushwana, Mpuluzi, Ngwempisi, and Mkhondvo has a total catchment area of 16,690 km^2 (compare Interim IncoMaputo Agreement 2002) and springs from the upper veldt in South Africa. From there the tributaries cascade over the mountainous Highveld region into Swaziland, where they pass Middleveld and Lowveld regions and join into the Great Usuthu River before entering Mozambique through a narrow gorge in the Lebombo mountain range. After having passed the Lebombo mountains, the river forms the border between Mozambique and South Africa for about 15 km until it is joined by the Pongola River to form the main stem of the Maputo River.

The Pongola River with its main tributary Ngwavuma has a total catchment area of 11,710 km^2 (compare Interim IncoMaputo Agreement 2002). It rises in the Drakensberge in South Africa and flows eastwards until it reaches the Lebombo mountain range. After having

crossed these mountains into the coastal plain, the Pongola River turns northwards and forms extensive and very fertile floodplains. Shortly before reaching the Mozambican border, the Pongola River is joined by the Ngwavuma rising in Swaziland and swings to the west. At the border with Mozambique, the Pongola flows into the Usuthu River. After the Junction of the Usuthu and Pongola River, the main stem of the Maputo flows north-eastwards through a plain landscape into the Maputo Bay and the Indian Ocean without being joined by any tributaries.

The Maputo River Basin has a few glacial sources but it is mainly fed by rainfall and land drainage. This implies that the highest discharges arrive in and shortly after the rainy season between January and April (Langedijk 1984). The total net natural mean annual runoff (MAR) (i.e. the mean annual runoff in the natural condition without any land and water use effects and allowing for river channel losses) of the Maputo watercourse at the estuary is estimated at 3,800 million m^3. The contribution of each riparian country and catchment to the MAR is given in Table 1.

Table 1: Area and mean annual runoff of the Maputo River Basin and its sub-catchments (adapted from Interim IncoMaputo Agreement 2002)

Catchment	Area (km^2)	MAR (10^6 m^3)	Contribution to MAR		
			Mozambique	South Africa	Swaziland
Lusushwana	1,390 km^2	420 x 10^6 m^3	--	19 %	81 %
Mpuluzi	1,870 km^2	260 x 10^6 m^3	--	85 %	15 %
Usuthu	5,970 km^2	610 x 10^6 m^3	1 %	16 %	83 %
Ngwempisi	3,570 km^2	500 x 10^6 m^3	--	58 %	42 %
Mkhondvo	3,890 km^2	570 x 10^6 m^3	--	65 %	35 %
Ngwavuma	2,130 km^2	180 x 10^6 m^3	--	11 %	89 %
Pongola	9,580 km^2	1,160 x 10^6 m^3	--	95 %	5 %
Maputo	1,570 km^2	100 x 10^6 m^3	100 %	--	--
Total	29,970 km^2	3,800 x 10^6 m^3	3 %	57 %	40 %

3.1 Current and Future Water Resources Use in the Maputo River Basin

No complete lists of current water resources use and water infrastructure were available for the whole Maputo watercourse. The following paragraphs thus compile data and information that was collected from different literature sources (and might not be complete).

3.1.1 Usuthu Sub-Basin

South Africa

In the Upper Usuthu Basin in South Africa, large quantities of water , i.e. up to 114 million m^3/a, are being transferred to the Upper Vaal and Upper Olifants Basins, mainly for the strategic use of power generation (DWAF 2002). This interbasin transfer is realised through four dams on the Usuthu and its tributaries: the Westoe Dam on the Usuthu River with a maximum capacity of 5 million m^3, the Jericho Dam on the Mpama River with a maximum capacity of 59 million m^3, the Morgenstond Dam on the Ngwmpisi River with a

maximum capacity of 46 million m^3, and the Heyshope Dam on the Assegai River (DWAF 1986). Large forest plantations in the upper catchment area use a further 43 million m^3/a, while irrigation, urban and rural water requirements only account for 13, 8 and 5 million m^3/a respectively. There was no major industrial water usage in the South African part of the Usuthu sub-basin in 2000 (DWAF 2002).

There were no indications of future water use or resources development projects in the South African part of the Usuthu sub-basin. The National Water Resources Strategy of 2002 states that available water resources in the Upper Usuthu Basin are already being well exploited and offer no potential for further development. But also, the strategy does not predict significant increase in water requirements for the sub-basin until 2025 (DWAF 2002).

Swaziland

In Swaziland, the major users of water resources in the Usuthu sub-basin are human settlements and irrigated agriculture of sugar cane and citrus. There are only two cities located in the basin area: Mbabane, the country's capital with 61,000 inhabitants, and Lobamba, a smaller city. Apart from that only small settlements with less than 5,000 inhabitants exist and water abstractions for domestic use are likely to be rather insignificant. Though dry season water allocations for irrigation in the Usuthu basin are excessive, and in some years the Usuthu dries up completely in the section just above Matata. But zero flows more frequently occur in tributary rivers, such as the Mhlatuzane. Current sediment load in the rivers reflects major soil erosion problems in the catchment areas (Environmental Consulting Services 2001).

Several projects for the construction of water infrastructure in the Usuthu sub-basin in Swaziland are planned to commence before the year 2010. The most extensive project is the Lower Usuthu Smallholder Irrigation Project, which is foreseen to finally provide smallholder irrigated cropping on 11,600 ha. The main infrastructure includes a low weir on the Usuthu at Bulungapoort and 23 km of feeder canal leading to Bovane reservoir which will have a storage capacity of 155 million m^3. Crops to be grown would include sugarcane, cotton, vegetables, beans, corn, bananas, and other fruit. Half of the irrigation planned is sprinkler (particularly on the more marginal soils), the other half surface irrigation. Drainage is planned on 10% of the surface-irrigated area (Environmental Consulting Services 2001). Other smaller projects foreseen to be started before 2010 include the construction of further three dams on tributaries of the Usuthu: a dam on the Mhlatuzane River with a storage capacity of 12 million m^3 to develop a smallholder irrigation scheme to irrigate 500 ha of which 175 ha have already been developed, a dam on the Lhusushwana River with a storage capacity of 16 million m^3 to develop a smallholder irrigation scheme to irrigate 800 ha, and the construction of the Mahamba Gorge Dam on the Mkhondvo River to increase irrigation area in the Mkhondvo River catchment (Interim IncoMaputo Agreement 2002).

3.1.2 Pongola Sub-Basin

South Africa

The main requirements of water in the Pongola sub-basin within South Africa are for irrigated agriculture, consuming up to 213 million m^3/a. Other significant uses are made for afforestation projects (34 million m^3/a) and water transfers out of the basin (30 million m^3/a), whereas urban and rural settlements only require 1 and 6 million m^3/a respectively. Water uses for mining and bulk industrial enterprises amount for 1 million m^3/a. Further, to meet the

ecological water requirements of the Pongola sub-basin within South Africa, 200 million m³/a are being reserved in the Proposed First Edition National Water Resource Strategy (DWAF 2002). Part of the freshwater needs in the sub-basin are made available through one of the five largest dams in South Africa, the Pongolapoort dam (situated close to the city of Jozini and therefore formerly known as Jozini Dam) that can store up to 2,445 million m^3 of water and inundated an area of 133 km^2. The consumption requirements of the dam are mainly for irrigation and domestic uses (50 and 16 million m³/a respectively) (Uthungulu District Municipality 2001). A further 250 million m³/a are released for floodplain management of the Pongola River floodplain that extends from a couple of kilometres below the Pongolapoort dam to the confluence of the Pongola and Usuthu rivers on the Mozambique border. Part of this floodplain lies within the Ndumo Game Reserve bordering on the frontier to Mozambique, which has been listed as a Ramsar site in 1996.

For the South African part of the Pongola sub-basin no explicit information was available on future water resource development projects. However, the Proposed First Edition National Water Resource Strategy of 2002 identified possibilities for further water resource development in the upper reaches of the Pongola River, which may serve to augment shortfalls in the Vaal River System. Additionally, it states that potential for irrigation development, something that could make a substantial contribution to rural development and poverty relief, exists in the area downstream of Pongolapoort Dam where good soils are available. Therefore, "national control will be exercised over construction of new dams in the Pongola River catchment" (DWAF 2002). Other sources indicate that an application is under consideration for water transfer of about 50 million m³ from the Pongolapoort Dam to the Mkuze catchment (Uthungulu District Municipality 2001).

Swaziland

A small part of the Pongola sub-basin (i.e. mainly the basin of its tributary Ngwavuma) that contributes approximately 15 % to the total Mean Annual Runoff of the Pongola sub-basin, lies within Swaziland. From the information available, it can be concluded that main water uses in this portion of the sub-basin are made for irrigated agriculture. The irrigation area developed by 1995 accounted for about 5,400 ha (Interim IncoMaputo Agreement 2002). There were no indications for any plans of water resources development projects within the Pongola sub-basin in Swaziland in the next 10 years.

3.1.3 Maputo Sub-Basin

As far as information could be gathered, no major amounts of water are currently extracted in the Maputo River Basin in Mozambique. Present water use for irrigated agriculture is minimal, because instability factors, such as the struggle for independence and the following civil war, have resulted in the abandonment of large portions of previously existing cultivated land. Existing farming activities are carried out with limited intensity in the form of subsistence agriculture (see also Chapter 3.2.1). Water extraction for domestic use is also of insignificant amount. Only the two largest villages within the sub-basin, Bela Vista and Salamanga, have piped water supply systems. In Bela Vista about 6,000 inhabitants are served through a supply system using water from a borehole, whereas Salamanga's water supply system uses treated water of the Maputo River. No actual list of water infrastructure was available for the Maputo River in Mozambique. While no dams have ever been built in the Maputo sub-basin, old lists available in the Regional Water Administration of the South (ARA Sul) document that several small dykes existed for irrigation uses. However, it is most

likely that all were destroyed by the big floods in 1984 and 2000 (personal communication with Mr. Paulinho, technical department ARA Sul). The eastern bank of the Maputo River estuary falls within the Maputo Special Reserve, a conservation area especially aimed for the protection of elephants with high potential for the development of eco-tourism facilities.

In the draft Land Use Plan for the Matutuíne District tourism and irrigated agriculture in the Maputo river valley have been considered the main potential for development in the district (Governo da Província de Maputo 1996). The latest plans existing for water resources development in the Maputo River Basin in Mozambique are based on studies conducted in 1981 by the Bureau de Estudos de Perspectiva Hidráulica (BUREP). It estimated a total area of 61,000 ha, that could be used for irrigated agriculture along the river valley and in the area of the Lake Pandjene and Catuane, north of the river (BUREP 1981). Nowadays explicit plans are reduced to recover irrigation areas of about 8,000 ha in the vicinity of Catuane and 8,000 ha in the vicinity of Salamanga through the construction of two off-river channels in the respective locations (Interim IncoMaputo Agreement 2002). Further, it is envisaged to possibly use water resources of the Maputo River to supply the growing cities of Maputo and Catembe and also the planned port at Ponta Dobela on the southern coastline of Mozambique (Interim IncoMaputo Agreement 2002).

Other resource-use projects in the Maputo Basin in Mozambique are connected with the creation of conservation areas. The General Trans-Frontier Conservation and Resource Area Protocol, signed by Mozambique, South Africa and Swaziland in 2000, the creation of the Lebombo Ndumu-Tembe-Futi Trans-Frontier Conservation and Resource Area was agreed among Mozambique and South Africa. This project intends to link the Tembe Elephant Reserve in South Africa with the Maputo Special Reserve, through the so-called Futi Corridor, the limits of which have yet to be determined. Part of this corridor will most probably fall into the Maputo Basin area. Connected with this project is the proposal to create a Community Conservation and Development Zone (CCDZ) along the eastern bank of the Maputo River, from approximately the junction of the Pongola and Maputo River in the south, and up to Bela Vista in the north. The CCDZ is projected to be an area, where local communities are going to be encouraged to form partnerships for ecotourism and sustainable use of natural resources (Direcção Nacional das Áreas de Conservação 2001).

3.1.4 Overview of Water Uses in the Maputo River Basin

Even though the data and information available on current water uses and future resource use development projects was incomplete, it is clear that abstractions of water from the Maputo River Basin will increase within the next 10 years. Table 2 summarises current water uses and planned developments as well as their likely effects on river flow and water quality.

Table 2: Current and future water resources use in the Maputo River Basin (own compilation)

	Current water uses	**Planned developments[1]**	**Effects**
Usuthu sub-basin	South Africa: interbasin transfers out (114x10^{6}m^3/a) forest plantations (43x10^{6}m^3/a) irrigation area 2,600 ha (13x10^{6}m^3/a) Swaziland: irrigation area 24,800 ha	no indication of development plans extension of irrigation area: LUSIP[2]: 11,600 ha (153x10^{6}m^3/a); other smallholder schemes: 1,300 ha, increased development in Mkhondvo River catchment construction of infrastructure: Bulungapoort Diversion Usuthu River and off-channel reservoir (155x10^{6}m^3) Dam Mhlatuzane River (12x10^{6}m^3) Dam Lusushwana River (16x10^{6}m^3) Mahamba Gorge Dam Mkhondvo River	decrease of river flow change in flow regime higher risk of soil erosion
Pongola sub-basin	South Africa: irrigation area 22,800 ha (213x10^{6}m^3/a) forest plantations (34x10^{6}m^3/a) interbasin transfers out (30x10^{6}m^3/a) Swaziland: irrigation area 5,400 ha	no explicit project plans indication[3] of plans to increase interbasin transfers out by 50x10^{6}m^3/a no indication of development plans	
Maputo sub-basin	Mozambique: no major abstractions of water	development of irrigation area: Catuane: 8,000 ha, Salamanga: 8,000 ha, development of water supply for: City of Maputo (up to 87x10^{6}m^3/a), Port at Ponta Dobela construction of 2 off-channel reservoirs	decrease of river flow increase of water demands

(1) Projects contemplated to commence before 2010 (Interim IncoMaputo Agreement 2002)
(2) Lower Usuthu Smallholder Irrigation Project
(3) Uthungulu District Municipality (2001)

3.2 The Maputo River Basin in Mozambique

3.2.1 Natural and Socio-Economic Characteristics of the Maputo River Basin in Mozambique

The Maputo River enters Mozambican territory at the very south of Mozambique, at the point where its three riparian countries meet. The total section length of the Maputo River within Mozambique is approximately 150 km (Langedijk 1984). For the first approximately 15 km the river flows in west-easterly direction and forms the frontier between South Africa and Mozambique, until it is met by the Pongola River and turns to the Northwest to eventually flow into the Indian Ocean at the Maputo Bay. In the Mozambican part of its basin the Maputo River has no main tributaries. However, about 10 km downstream of the junction with the Pongola River there is a big lake (Lake Pandjene) situated very close to the rivers northern bank. Although there is no definite channel between these two water bodies, they are connected through swampy areas.

Downstream of the Lake Pandjene the river flows into a valley that is about 2 to 5 km wide and has hills on both sides. The river channel meanders, with many bends and steep banks at a width of 50 to 100 m. Close to Salamanga, about 40 km from the river's mouth, the river widens and curves only mildly. Approximately 12 km before the river enters the Maputo Bay, the basin's landscape flattens out, the river straightens and is about 500 to 1,200 m wide, now flowing from south to north. Finally, close to the bay the river broadens considerably, its width increasing from 2 up to 8 km at the mouth.

Climate

The whole Maputo River Basin is characterised by a clearly distinguishable rainy (from October to March) and dry season. The mean annual rainfall in the Mozambican part of the basin ranges from 1,054 mm near the coast to 388 mm in the inland. The mean annual temperature varies from 22.1 ?C to 23.0 ?C, the mean maximum ranging from 25.5 ?C to 26.7 ?C and the mean minimum from 17.8 ?C to 20.0 ?C. The relative air humidity reaches from 67.3 % to 80.5 %. It decreases from the coast to the interior and with increasing altitude.

Hydrology

In general terms, the natural flow of the Maputo River is characterised by high runoff during the wet season (October-March), accounting for more than 70 % of the total, and very low flow during the dry season. Highest discharges do usually occur in February. As the region is vulnerable to floods and droughts, the variation between individual years is significant. Freshwater discharges of the Maputo River are usually ranging from 10 to approx. 300 m^3/s. But for instance, between 1982 and 1983 the discharge came down to almost zero after a period of severe drought. Great floods occurred in 1983/84 after the cyclone Desdemoina and subsequent water releases from Pongolapoort Dam and again in 2000. Average discharges lowered considerably between 1975 and 1984 due to water abstractions in Swaziland and South Africa (Langedijk 1984). In the hydrogeological map of Mozambique the figure given for the average annual runoff of the Maputo River at the border with Swaziland is 89 m^3/s and 92 m^3/s for the average annual discharge to the sea at Maputo Bay (Carta Hidrogeológica de Moçambique 1987)

The depth of the river ranges from zero up to 11 m. Cross sectional average values range from approx. 2 m in the upstream part up to 4.5 m at mid-tide near Maputo Bay. The

tidal water level amplitude in the Bay of Maputo varies between almost zero (neap tide) and 1.5 m (spring tide) (Langedijk 1984). Up to Salamanga (km 41) the periodic water level amplitude is still in the same order of magnitude as in the Bay of Maputo. Between Salamanga and Santaca the amplitude is usually damped very quickly due to the steep bottom slope and the quite narrow and constant cross-sectional river profile. In minimum discharge periods the tidal movement causes varying water levels even 65-70 km upstream (near Santaca) of the river's mouth (Langedijk 1984).

Geology

The river basin in Mozambique can roughly be divided into two parts: the Lebombo mountain range in the western strip, close to the border with Swaziland, and the extensive coastal plain, that covers the rest of the basin. The Lebombo range, which has a north-south orientation, is comprised of volcanic rocks, rhyolites and basalts. The coastal plain is built up on sedimentary deposits (marine and continental) of the cretaceous and early tertiary age, which are generally composed of calcareous sandstone with different levels of clay content. These sedimentary deposits outcrop in the east of the Lebombo mountains, in the region of Catuane and Lake Pandjene. In the rest of the basin these sediments are covered by a quaternary sand sheet formation of marine and alluvial origin, characterised by inland dunes. Tertiary calcareous sediments only outcrop in narrow strips along the Maputo River valley, especially between Salamanga and Bela Vista. The river valley itself is filled up with recent alluvial sediments that are composed of fine sands and clays (BUREP 1981, Carta Hidrogeológica de Moçambique 1987).

Soils

The most common groups of soil in the Maputo River Basin are alluvial and different psamitic soils. Fertile alluvial soils consisting of sand and clay, with a high water retention potential, are found in the river valley. Downstream of Salamanga these soils are moderately salty with the salt content increasing significantly towards the estuary. Outside the valley, the river basin is mostly covered with sandy and psamitic soils with significant calcareous layers. These soils are characterised by little potential for retention of water and restricted suitability for agriculture. In the stripe west of Lake Pandjene, argilic soils predominate. Their composition is specified by the basaltic and rhyolitic sediments they are built on. These soils are usually very fertile and of significant water retention capacity (BUREP 1981).

Groundwater occurrence, composition and availability

Correlated with geology and soils of the Maputo River Basin is the occurrence, availability and composition of groundwater in the area. The river basin in Mozambique generally lies within an area with brackish or saline groundwater and is therefore of limited suitability for boreholes. Exceptions can be found in recharge areas like those covered with sandy soils or depressions along the valley. In the estuary the upper aquifer also contains saline water due to infiltration of sea water, making the area unsuitable for the use of shallow dug wells. Aquifers in the estuary, that are unconsolidated towards the surface generally offer yield prospects below 5 m^3/hour and therefore do not present good possibilities for the use of boreholes (Carta Hidrogeológica de Moçambique 1987).

Socio-economic characteristics

All of the Mozambican area of the Maputo River Basin is located in the Matutuíne District, Maputo Province, in the most southern part of Mozambique. The district has a total surface area of 5,403 km^2 and borders on South Africa to the south, Swaziland to the west

and the Indian Ocean to the east. In the north the district is limited by the City and Bay of Maputo. The census of population in 1997 accounted for a total of 35,161 habitants in the district, the average population density, 6.5 habitants/km^2, is thus very low. The major part of the population is concentrated along the fertile Maputo valley and in the area of Zitundo and Ponta Douro at the coast. There are only three bigger settlements in the Maputo River Basin in Mozambique: Bela Vista, the district's capital, with approximately 2,300 habitants, Salamanga (1,800 habitants) and Catuane, a smaller village in the western part of the basin, close to the South African border. These settlements include a few shops and little markets.

Matutuíne is one of the poorest districts in Mozambique. Due to the lack of job opportunities, communities in the district are very dependent on natural resources for their livelihood. Their economic base consists primarily of subsistence dry land farming, charcoal production, small scale livestock production, fishing, hunting and gathering of local natural resources for some trade in these products. By far the larger part of the local population living in the basin relies completely on family scale subsistence agriculture. No industry is established in the district apart from a limestone quarry, situated close to Salamanga. Further, a cement factory and a rice peeling factory exist, but have been out of operation since war times. During colonial times most of the river valley had been used for irrigated agriculture, mostly of rice. Today, no major water abstractions from the Maputo River are done in Mozambique: Salamanga has a water supply system using water of the river, apart from that, only small amounts of water are directly taken from the river for consumption or watering of family scale farms. The supply of clean drinking water to many communities in the basin is unsatisfactory.

3.2.2 Sensitive Aquatic Ecosystems in the Maputo River Basin in Mozambique

No comprehensive studies on the ecosystems of the Maputo River Basin have yet been undertaken. The following paragraphs will describe sensitive aquatic ecosystems of the basin which might be vulnerable to changes in river flows and water quality, and should therefore be considered when developing and managing the Maputo River's water resources.

3.2.2.1 Maputo Estuary

Before entering the Maputo Bay approximately 20 km south of the City of Maputo, the Maputo River forms an extensive estuary with a width of about 8 km close to the river mouth. As can be seen from Photo 1, the estuary is funnel shaped, straightening up significantly in the inland where it is only about 1 km wide.

The Maputo Estuary is comprised of extensive mangrove forests, tidal wetlands, and saline lakes. The estuary's ecosystems are very much affected by the tides and therefore by the entering of salt water into upstream parts of the river with the high tide, a phenomenon called salt intrusion. The dimension of salt intrusion is determined by the geometry of the estuary, the characteristics of the tides and the river flow. With little inflows from the river, the flow of the entering tide can reach further upstream and the salt water mixes less with freshwater. In the Maputo River salt intrusion usually occurs up to Bela Vista, but in dry years saline water reaches Salamanga bridge 40 km up the river with the high tide (DNA 1982).

Photo 1: The Maputo Estuary. Photograph by James Culverwell.

Mangroves

The mangrove forests of the Maputo Estuary principally consist of the species *Rhizophora mucronata, Avicennia marina, Ceriops tagal* and *Bruguiera gymnorhiza* (Robelus 1984) with comparatively little heights of 2,2 m in average (de Boer 2000). The herbaceous layer is mainly composed of *Paspalum spp., Juncus spp.* and *Chenolea diffusa* (Vegetation Map of the Maputo Special Reserve 2000).

Mangroves play a very important role in flood control and in protection of the coast from erosion as they retard the water flow and their roots stabilise the shoreline. Sediments originating from the sea or derived from land are trapped within the mangroves, where they build up soils as well as breeding ground for microflora and a large number of animal species, which represent a primary link in the food chain. On the other hand, the retention of sediments also enhances the protection of coral reefs in the Maputo Bay (Kalk 1995). Sea grasses and seaweeds that enter the mangroves with the high tides, and dead parts originating from the mangroves themselves, such as leaves, fruits, and dead wood, are also trapped. The biological degradation of this organic matter by bacteria, fungi and larger detrivores results in detrital complexes representing a very important source of nutrients. Further, the roots of the mangroves provide shelter from water currents and predators. Thus, mangroves act as a habitat, nursery and source of food for many fish, crustacea and mollusc species. While some of the produced detritus stays within the mangroves, the rest is transported into other parts of the estuary and plays an important role in maintaining estuarine fishery and in supporting tropical marine coastal ecosystems. Over 60% of commercially important marine species are known to either live in mangroves or depend on mangrove food webs at some stage in their life cycle (Shumway 1999).

Apart from the value associated with the ecological function of mangroves, they also directly serve as resource for many different needs of the human population in the area. In the Maputo Estuary their wood is used inter alia for the construction of houses, little boats and furniture, poles are utilised for fixing fishing nets in the water and for drying fish on the

land. Mangrove forests are also exploited for firewood and for the production of charcoal. The selling of construction wood or charcoal is one of the very few possibilities for the local population to earn a monetary income. Photo 2 shows mangrove forests in the Maputo Estuary.

There was no information available on the current conservation status of the mangrove forests in the Maputo Estuary. But it has been reported that the extraction of wood from the mangrove forests of the Maputo Estuary has often happened in an unsustainable manner, especially on the western bank, leading to deforestation in some parts of the area. Mangrove forests have also been opened for saltpans and agriculture land during the last decades. In his study, De Boer (2000) identified a loss of 8 % of mangrove area between 1958 and 1991 through the analysis of aerial photographs. However, as the population in this area has grown significantly since the end of the civil war in 1992, this rate is likely to have grown during the last ten years. On the eastern bank the mangroves fall within the territory of the Maputo Special Reserve and are therefore protected from heavy exploitation. But signs of old clear felling along the east bank of the river and the loss of mangrove areas in the north of the Reserve, probably due to lowering of the groundwater table, has been reported by Ministério de Agricultura e Pescas (1996) in its Management Plan for the Maputo Special Reserve.

Photo 2: Mangrove forests in the Maputo Estuary. Photograph by James Culverwell.

Tidal wetlands and lakes

Further inland, the estuary of the Maputo River consists of tidal wetlands and saline lakes. Vegetation of the tidal wetlands in the Maputo Estuary is typically composed of *Avicennia marina* trees and reeds of *Phragmitis sp.* (Vegetation Map of the Maputo Special Reserve 2000). Two major tidal saline lakes which receive water from the Maputo River as well as salt water from the Maputo Bay exist in the estuary: Lake Tzembezanhe in the west of the river, just north of Bela Vista and Lake Mahanse close to the river's mouth on the east. The latter hosts various islands with mangrove vegetation and is included in the protected

area of the Maputo Special Reserve. Photo 3 shows an aerial photograph of tidal lakes on the eastern bank of the Maputo Estuary.

Lake Tzembezanhe is comprised of a valuable swamp area that is frequented by pelicans and flamingos (Direcção Nacional das Áreas de Conservação 2001). Among these the Lesser Flamingo appears (Carlos Bento, Chairman of the Mozambican Ornithological Club, personal communication), which is considered a globally threatened specie (Parker 1999) During the African Waterfowl Census 1997, 793 water birds of 27 species were counted in Lake Tzembezanhe. Most numerous were Little Egret *Egretta garzetta* and Sacred Ibis *Threskiornis aethiopicus.* The lake and the adjacent swamps were therefore considered as a wetland of potential international importance (Dodman et al. 1997) and plans existed to propose the establishment of a Lake Tzembezanhe and Mangrove Forest Reserve on the western bank of the Maputo River (Direcção Nacional das Áreas de Conservação 2001). In addition to the high ecological value, the lake is also important for local fishery that supplies Bela Vista mainly with shrimps from Lake Tzembezanhe. Shrimp aquaculture has also been practised in the lake, but installations were destroyed during the big floods in 2000 and have not yet been re-established.

Photo 3: Tidal lakes on the eastern bank of the Maputo Estuary. Photograph by James Culverwell.

3.2.2.2 Maputo Floodplain

Downstream of Lake Pandjene, the Maputo River flows in a broad floodplain incorporating various small lakes and pans along both sides of the river, as can be seen from Photo 4 showing a detail of the Maputo Floodplain.

Floodplains form where a river regularly breaks the confines of its normal channel and floods a substantial area which includes a number of suitable depressions to retain water over the dry season. These requirements are usually only met where a river carrying significant runoff attains grade on a flat plain (Heeg et al. 1980), as is the case in the Maputo River valley. The regular inundation leads to seasonal deposition of suspended silt on the

floodplain. This material is rich in nutrients and makes the soils fertile for natural floodplain vegetation and also for planting crops. Apart from fertile soils, floodplains provide a variety of other natural resources and perform many ecological functions like groundwater recharge, water storage, flood control, water purification and as habitats for a variety of species.

Like a sponge, floodplains fill up with water during the rainy season and release it slowly during the year, thus representing water depots that provide a constant downstream water supply for long periods. Part of the water retained by the floodplain percolates through the subsoil and fills up subterranean water reservoirs. The depth of the groundwater table (which does not equal the depth of the aquifer) is therefore usually not very deep. Infiltration of water from the floodplain into more profound layers has also been assumed to contribute to the recharge of deeper laying aquifers, but more research is needed to prove this hypothesis (Chenje 2000).

Photo 4: Detail of the Maputo Floodplain. Photograph by James Culverwell.

While percolating through the floodplains soils, the water is purified from sediments and other compounds due to a number of physical, chemical and biological processes. Although these are not yet completely understood, some factors are thought to be important: The velocity of water flowing into the floodplain is being reduced, because the flow is dissipated over a wider area and also impeded by vegetation. Sedimentation occurs, as the velocity is insufficient to retain particles in suspension. Some pollutants are readily adsorbed by mineral and organic sediments, which then become buried in the soil substratum. Anaerobic conditions within the bottom sediments permit the conversion of soluble forms of, for instance heavy metals, to insoluble oxides, hydroxides, carbonates, phosphates and sulphides. Uptake, especially of nutrients, by the floodplain vegetation, may as well take part in the water purification (Breen et al. 1997).

Floodplain vegetation also plays a major role in flood damage mitigation. Apart from the fact that it reduces the flood flow's velocity, its roots protect the soils from erosion.

Riverbanks with abundant vegetation usually recover easily from flood damages, while areas that have been cleared suffer severely from erosion and often never recover (Chenje 2000). Further, floodplains represent a very suitable habitat for the juveniles of various fish species. The flooded margins that are rich in organic matter and support a diverse invertebrate fauna, promote rapid growth of the young fish. In addition, this feeding ground is shallow and thus protects the juveniles from aquatic predators

Most of the Maputo River floodplain has been used extensively for irrigated agriculture, mainly of rice, sugar cane and maize, during colonial times. Therefore the floodplain has been drained, and irrigation channels have been cut into the plain as can be seen from Photo 5. This, of course, has led to significant changes in the floodplain's ecosystems. After Mozambique's independence, and during the following years of war, the irrigation farms were abandoned and most of the irrigation schemes destroyed. Therefore, drainage and irrigation channels are nowadays mostly blocked through siltation and vegetation growth. Today, this wetland area is mostly covered by a herbaceous layer consisting of grassland and reed beds typically composed of *Themeda spp., Chloris spp., Eragrostis spp.,* and *Phragmitis spp.*. The woody layer, covering only 2% of the grassland area, is mainly comprised of *Acacia xanthophloea* and *Acacia nilotica* (Vegetation Map of the Maputo Special Reserve 2000). The original riverine forests have been cleared for agricultural purposes, so that nowadays only a few spots of this vegetation exist. These have a mean height of 35 m and are dominated by species of *Ficus sycromorus, Fleidherbia albida, Rauvolfia caffra, Trichilia emetica,* and *Syzygium cordatum* (Governo da Província de Maputo 1996) The remaining relicts rate top priority for conservation (Hatton & Munguambe1998)

Photo 5: Old drainage channel in the Maputo Floodplain. Photograph by James Culverwell.

The local population living in the Maputo sub-basin is very much dependent on the ecological functions performed by the floodplain and relies on the natural resources provided by the ecosystems of the floodplain for their livelihood. All of the 25 interviewed people living

in the Maputo River's vicinity stated that they had small fields (so called "machambas") in the fertile river valley. According to the season and the water needs of the crop, they plant maize, beans, sweet potato, sugar cane, cabbage, onion, tomato, salads and sometimes fruit trees like banana and papaya in different parts of the valley. Most of the population is entirely dependent on this kind of agriculture for self-sufficient livelihood, as there is very little opportunity to generate monetary income in the district. Because other water sources are often absent or very distant, in many places people depend on the Maputo River water for drinking and domestic use as well as for watering their "machambas". For these uses they either take water directly from the river or sometimes dig little holes further away from the riverbank, but inside the valley, where the groundwater table is not very deep. As people usually have to carry all the water they need, they try to plant their "machambas" as close to the river as possible, where they are very vulnerable to floods. In the river floodplain the local population also finds the construction material for their houses, which are mainly built out of reed. Rushes, also found in the floodplain, are used to make mats and baskets. The selling of construction material or mats gives some of the people a possibility of a monetary income.

No data on fishing activity within the Maputo sub-basin could be made available. From the information gathered through interviews with the local population, only a few people practice fishing and most of the fishing activity in the Maputo Floodplain is done by boat. Nevertheless, it seems that some of the fisherman can earn their living from what they catch, and one of them is told to have earned a fortune (i.e. he could even by a car and sell his fish at markets further away) after the occurrence of greater numbers of fish subsequent to the great flood in 2000.

No information on the abiotic and biotic characteristics of the different pans in the Maputo River floodplain was available. Floodplain pans in general represent a very important spawning area for various fish species and in Maputaland host the greatest number of fish species compared to other freshwater bodies (Bruton & Kok 1980). For the Pongola Floodplain, the ecosystems of which are comparable to the Maputo River floodplain, it is reported that at least 25 of the 35 fish species accounted for in the Pongola River enter the floodplain pans after floods to spawn. According to the interviews held, a major part of the fishing activities in the floodplain takes place in the pans.

3.2.2.3 Lake Pandejane and adjacent swamp areas

Very little information exists on the ecosystems of the area of Lake Pandejane and the adjacent swamps. According to personal communication with Carlos Bento (Chairman of the Mozambican Ornithological Club) the swampy areas between the Lake Pandejane and the Maputo River are mostly comprised of reeds and rushes. The lake itself is very rich in fish and hosts big colonies of waterfowl, in particular Whitefaced Duck and Fulvous Duck. Interviews with people from Catuane revealed that the lake Pandejane is used extensively for fishing, while the adjacent swamps are used for family scale agriculture. The area is presumably of high tourism value and land concessions for tourism of almost 10,000 ha have already been requested in the Catuane vicinity (Governo da Província de Maputo 1996).

3.2.2.4 Overview of Sensitive Freshwater Ecosystems

The Maputo River Basin hosts a number of wetland areas, such as floodplains, mangrove forests and tidal lakes. These sensitive ecosystems perform important ecological functions and play a crucial role as source for livelihood of the local population. Table 3

summarises the main sensitive freshwater ecosystems within the Maputo River Basin in Mozambique as well as their key ecological functions and direct economic uses. Even though very little information was available on the basin's biodiversity and the occurrence of threatened species, it should be taken into account that the basin area lies within the Maputaland Centre of Endemism, which is reckoned to be one of four Centres of Plant Diversity in Africa (Van Wyk 1994) and also hosts numerous endemic animal species (Ministry for the Co-ordination of Environmental Affairs 1997).

Table 3: Main ecological functions and direct uses of sensitive freshwater ecosystems of the Maputo River Basin in Mozambique (own compilation)

Sensitive ecosystems	Ecological functions	Direct uses
Maputo Estuary		
mangrove forests	- flood attenuation - sediment retention - shoreline protection - habitat for fish and crustaceans - breeding and nursery functions	- construction wood - firewood - charcoal production - fishing ground - tourism
tidal wetlands and lakes	- waterfowl habitat - fish habitat	- shrimp aquaculture - fishing ground - tourism
Maputo Floodplain	- flood attenuation - water storage and flow control - groundwater recharge - water purification - sediment retention	- farming ground - drinking water supply - construction material for: houses (reeds), mats/ baskets (rushes) - fishing ground

3.3 Estimated Effects of Land and Water Use Development in the Maputo River Basin on Aquatic Ecosystems in Mozambique

From the information on water resources development compiled in chapter 3.1, it is clear that use of water resources in the Maputo River Basin will be expanded in the near future. As no baseline data on the Maputo River ecosystems in Mozambique exists, it is difficult to assess the effects that water uses produced on them in the past, and thus to predict how different ecosystems will react to increasing water uses in the future. However, experiences from comparable cases of other rivers in the region and general knowledge of the functioning of estuarine and floodplain ecosystems can help to give indications on potential threats and consequences. In the Maputo River Basin, various projects of irrigated agriculture development are planned in the upstream countries as well as in Mozambique. The construction of further dams and abstractions of water will lead to reduced inflows and a changed flow regime in the Mozambican part of the Maputo River Basin. Reduced inflows do not only result in less water but also in smaller introduction of nutrients and fertile silts into the ecosystems. Alteration of the flow regime and attenuation of river flow will change the extent of regularly flooded areas along the Maputo River and its estuary. On the other hand, the use of land for agriculture might provoke increased erosion and subsequently higher

loads of suspended solids, while leakage of fertilisers from irrigated areas into the river's water can cause increased nutrient concentrations and consequently eutrophication of aquatic ecosystems. Changes in the ecosystems' composition and functioning are likely to have negative impacts on their use values. Direct use values of ecosystems exist in the consumptive (e.g. construction material) and non-consumptive (e.g. tourism) use of their resources. Indirect use values derive from their regulatory ecological functions, such as flow regulation, shoreline protection, and food web support, which have an indirect economic value because they support or protect economic activities (compare Turpie et al. 1999). The following evaluates effects of extended water resource development on vulnerable ecosystems of the Maputo sub-basin and points out possible implications for their use value in order to highlight ecological aspects that should be considered in future resource use planning.

3.3.1 Possible Effects on the Maputo Estuary

The reduction of freshwater inflow is considered to be one of the biggest threats to estuarine ecosystems (Boyd et al. 2000), as it can lead to increased salinity of water and soils, siltation of the estuary, reduced availability of nutrients and decrease in regularly inundated areas. Increased salinity of water and soil in the estuary can occur as a consequence of extended salt intrusion due to lower freshwater inflows (see chapter 3.2.2.1). As a result, species with limited salt tolerances might disappear from the Maputo River estuary and would probably be replaced by other, more tolerant species. This will primarily affect the distribution of freshwater fish, shrimps and estuarine vegetation. Increased salinity of water can further lead to diminishing its suitability for its various uses. As given in a report dating from 1982, salt intrusion in Maputo River usually occurs up to Bela Vista, but in dry years saline water might reach Salamanga bridge, 40 km up the river, with the high tide (DNA 1982). Further reduction of freshwater inflows might therefore possibly impose a restriction to the suitability of the river water for Salamanga's water supply system or even for its use for irrigation in the planned agriculture projects close to Salamanga. Inflows of water from the river also play an important role in flushing sediments out of the estuary. Reduced discharges of the Maputo River could hence lead to increased siltation of the estuary and Maputo Bay. As a further consequence, this might possibly induce raising costs for dredging of the Maputo Port, an important infrastructure for Mozambique's in- and export industry. This effect could possibly be intensified by increased loads of suspended solids in the river water, a likely result of unsustainable agriculture on the riverbanks. The following will discuss the consequences increased salinity and siltation as well as other effects of reduced riverine inflow might have for vulnerable ecosystems and resources use in the Maputo Estuary.

Possible effects on mangroves and tidal lakes

In addition to their excessive exploitation in the Maputo Estuary, mangrove forests can be further stressed by a decrease in freshwater inputs for various reasons (compare Shumway 1999). First, mangrove vegetation is very much dependent on regular inundation, thus a decrease of frequently inundated areas leads to a decrease of mangrove habitats. Secondly, although salt is important for growth and survival of mangroves, different mangrove species have different levels of tolerance and very high salinity will retard even the most resistant species (Hoguane et al. 1999). A similar effect has already been observed in the estuary of the river Incomati, which flows into the Maputo Bay about 40 km north of the Maputo River's mouth, where mangrove vegetation has been replaced by saline grasslands

(Dr. Tauacale, Shared River Initiative, personal communication). Third, viable nutrients and fluvial clayey sediments brought in by riverine inflows are crucial for the maintenance of mangrove ecosystems. In contrast, too heavy sediment loads may have negative effects if they lead to silting up of mangrove areas. The direct use value of mangroves consists in its use as timber resources. The dying of mangroves would therefore make an important resource of construction material less available for the local population and reduce the already few possibilities of cash income generation in the area. Another economically important value of the mangrove forests in the Maputo Estuary is their high attraction for tourism (see below). More far-reaching might still be some of their indirect use values: for instance their crucial role in protecting the coastline from erosion and as habitat for various fish and shrimp species, the latter being discussed in the following paragraph. The two major saline lakes in the Maputo Estuary host ecosystems of high conservation value (compare 3.2.2.1) which are adapted to and dependent on regular flooding and the well balanced inflows of fresh and saltwater. Any change in river flow regimes will shift this balance and thus influence composition and levels of water in the tidal lakes, probably making living conditions inappropriate for some of its flora and fauna. Consequences could be the loss of a valuable wetland area and habitat for waterfowl of significant conservation value.

Possible effects on fishery, especially shrimp

Areas associated with the Maputo River estuary represent main fishing grounds in the Maputo Bay (Tomás 2001). Reduced stream, changes of salinity and reduction of mangrove areas in the estuary are therefore likely to have effects on the fisheries in Maputo Bay. At least 5 shrimp species of commercial importance (*Peneus indicus, Peneus semisulcatus, Peneus monodon, Peneus japonicus, Metapeneus monoceros*) depend on mangroves in their juvenile stadium (Robelus 1984). While the larvae hatch out in the sea, the juveniles migrate into the mangroves for feeding, growth and shelter, before they return back to the sea as adults. This juvenile and sub-adult migration is triggered by a change in environmental conditions, namely salinity. Changes in salinity in the Maputo Estuary will possibly reduce the availability of shrimp for fishery in the Maputo Bay. In a study of the influence of Zambezi River inflow on shrimp availability in the Sofala Bank in central Mozambique, a linear relation between the catch rate and the total annual river discharge has been observed. For the Sofala Bank it was calculated, that a reduction by 1 m^3 of the total annual discharge of the Zambezi River would result in a decrease of the shrimp catch rate per hour by 156 kg (GTA/IUCN/USAID 2000). Similar studies are currently undertaken on influences of the discharge of the river Incomati (António Mubango Hoguane, Grupo de Trabalho Ambiental, personal communication) that enters Maputo Bay in the north. The shrimp industry in Mozambique dominates the country's exports; it accounts for 38 % of FOB (free on board) (GTA/IUCN/USAID 2000). In 1999, captures of shrimp in Maputo Bay numbered at about 500 tons by semi-industrial and 200 tons by small-scale fishery (Tomás 2001). But shrimps also play a very important role as a source of protein in the alimentation of the local population, who catch shrimp in the bay at low tide. Freshwater inflows from the Maputo River are likely to have significant effects on other fisheries in the Maputo Bay as well. More studies on the influences of nutrients brought in from upstream, salinity and fish habitats associated with the estuary are required to predict possible impacts of reduced inflows. Currently a study on the distribution of nutrients in the Maputo Bay is being undertaken in the National Fisheries Research Institute (Instituto Nacional de Investigação Pesqueira, IIP), Maputo.

Impact on tourism value

The ecosystems of mangrove forests and tidal lakes as well as the linked avifauna represent high potential for tourist attraction in conservation areas. Tourism is one of the most profitable and prospective industries in the Matutuíne District and has been growing considerably during the last five years, especially in the Maputo Special Reserve and along the coast line. Big parts of the mangrove forests of the Maputo Estuary as well as one of the major tidal lakes, Lake Mahanse, fall within the limits of the Maputo Special Reserve and plans exist, for the construction of high level tourism facilities in the mangrove forests close to the river mouth (personal communication James Culverwell, Technical Advisor to the National Directorate for Conservation Areas (Direcção Nacional das Áreas de Conservação)). Changes in water flow regime of the Maputo River might therefore also have negative impacts on the tourism value of the estuary if they result in major changes of the estuary's ecosystems and in loss of their biodiversity.

3.3.2 Possible Effects on the Maputo Floodplain

To maintain the functions of the Maputo River's floodplain seasonal and occasional inundation is essential in which the time and duration of the flooding are as important as the water quantity. Reduced water inflows and alterations in the flow regime can result in a decline of regularly inundated areas in the floodplain and in the decrease of viable input of sediments and nutrients. Changes in its vegetation cover, loss of soil fertility and lowering of the water table could be the consequences. Another threat to the floodplain ecosystems could emerge from poor agricultural practices and deforestation of catchment areas causing erosion and hence increased sediments loads in the river. Although siltation is the primary means by which the fertile alluvial floodplains are formed, excessive siltation can create several problems. For example, high sediment loads create turbidity, which in turn reduces primary production and the suitability of the water for consumption. Excessive siltation can also significantly reduce the capacity of lakes and pans, and may even bury them.

Loss of subsistence farming ground

The ecosystem of the Maputo River's floodplain plays a significant role in raising the standard of living for communities in this area, as the fertility and the residual moisture of the floodplain soils provide good agriculture conditions. The subsistence farmers depend on the fertile alluvial deposits and seasonal replenishment of nutrients brought from upstream parts of the river, as they do not have possibilities to buy fertilisers. Because of lacking water infrastructures, they also depend on the availability of water from the river or shallow-dug wells for bucket watering of their fields, if the soil itself does not provide enough moisture. Reduce of freshwater inflow might therefore in its worst case result in the rising of absolute poverty in an area that is already considered one of the poorest in the country and where other possibilities to gain monetary income are very rare.

Loss of potable water sources

Water spreading out into the Maputo River valley during floods is retained in its floodplain and pans from where it infiltrates into subterranean water reservoirs. Reduced inflows and decrease of flood peaks might consequently lead to the lowering of the water table and diminish possibilities for shallow wells to be dug. As groundwater in many parts of the river valley is saline (compare 3.2.1) and only insufficient boreholes exist to supply the local population, dug wells in the floodplain and water withdrawn directly from the river are

main sources of drinking water for communities living close to the floodplain. Lowering of the water table could thus make drinking water resources less available. This effect might be exacerbated if alterations in floodplain vegetation and soils weaken its performance of water purification (compare 3.2.2.2) or if changes in water tables bring saline and alkaline groundwater, which occurs in the Maputo Floodplain (compare 3.2.1), to the surface.

3.3.3 Summary of Possible Effects on Freshwater Ecosystems and their Direct and Indirect Uses

The information available on current and future water uses within the Maputo River basin is insufficient to estimate how land and water resources development projects will influence water quantity and quality as well as the flow pattern of the Maputo watercourse. However, likely consequences are a decrease in river flow and changes in its flow regime. Further, extension of irrigation agriculture increases the risk of soil erosion and high sediment loads, if agriculture is practiced in an unsustainable manner. The establishment of hydrological measurement stations and water quality control programmes in the basin is indispensable in order to monitor the consequences downstream. More scientific knowledge of the freshwater ecosystems in the Maputo River Basin in Mozambique is needed to precisely predict the effects that land and water use developments will produce on them. Therefore, Table 4 can only provide a very general indication of some possible effects on the ecological functioning of sensitive ecosystems as well as of possible impacts on their direct and indirect uses.

Table 4: Possible effects of land and water use development on sensitive freshwater ecosystems and their uses (own compilation)

Consequences of land and water use developments	Possible effects on sensitive ecosystems	Possible impacts on direct and indirect uses
• reduced freshwater inflows • changes in flow regime • risk of increased silt loads	**Maputo Estuary**: - increased salinity of water and soils - changes in distribution of shrimp, freshwater fish and estuarine vegetation - siltation of the estuary - loss of mangrove habitat - loss of waterfowl habitat **Maputo Floodplain**: - reduced input of nutrients - decline in regularly inundated areas - changes in floodplain vegetation	**Maputo Estuary**: - impacts on shrimp and other fishery - diminishing of water suitability for drinking and irrigation - loss of timber resources - impact on tourism value - siltation of port **Maputo Floodplain**: - loss of fertile farming ground - loss of drinking water sources - reduced potential for flood attenuation

3.4 Legal and Institutional Framework for Co-operation in the Maputo River Basin

On August the 29th 2002, at the World Summit on Sustainable Development in Johannesburg, authorised representatives of the three riparian countries of the Maputo River, i.e. the Republic of Mozambique, the Kingdom of Swaziland and the Republic of South Africa, signed a Tripartite Interim Agreement for Co-operation on the Protection and Sustainable Utilisation of the Water Resources of the Incomati and Maputo Watercourses (Interim IncoMaputo Agreement). The agreement is the result of a lengthy process of negotiation that was initiated by the parties in 2000 and builds from a series of bi- and trinational agreements on common waters reached at an earlier time by the riparian countries. This chapter deals with the Interim IncoMaputo Agreement and the history of its origins as well as the main international and national institutions involved in development and management of the Maputo River Basin's water resources.

3.4.1 Institutions Involved in Water Resources Management

Water institutions in Mozambique

In Mozambique the *Ministry of Public Works and Housing* (Ministério de Obras Públicas e Habitação), which for some years was named Ministry of Construction and Water, is responsible for all water issues. Its duty is to promote the best use of the national water resources by proposing and implementing policies for the development of water resources. The *Ministry of Public Works and Housing* is structured in various National Directorates, the *National Water Directorate* (Direcção Nacional de Águas (DNA)) being the one responsible for the management of the water sector in Mozambique. Main functions of the DNA include policy making and planning for water resources management, provision of water supply and sanitation services, maintenance of an inventory and of the balance of water resources and needs at national, regional and river basin level, as well as the execution of investments for studies, development projects and major water infrastructure works.

In the National Directorate of Water, the *International Rivers Office* (Gabinete dos Rios Internacionais) is the department responsible for the definition of general guidelines for the management of shared river basins and for the establishment of agreements on international rivers. Therefore it is the communication partner for corresponding water institutions in other riparian countries and for the SADC Water Sector Coordination Unit (SADC-WSCU).

The National Directorate of Water has recently attempted to decentralize its decision making in water resource management, especially at the operational level, by establishing *Regional Water Administrations* (Administração Regional de Águas, ARA), organised on the basis of one or more adjacent river basins. The ARA responsible for the Maputo River Basin is the *ARA South* (ARA Sul) that covers all the territory from the southern border of Mozambique up to the Save River Basin, thus including the main basins of the Maputo, Umbeluzi, Incomati and Limpopo rivers. The ARA Sul was the first Regional Water Administration to be created in 1993. Its responsibilities are the implementation and monitoring of a hydrometeorological network, establishing of an inventory of waters of common use, the issuing of licences and concessions for private water uses, and the management of conflicts resulting from different water uses. The management functions of the ARA Sul are to be carried out by various *River Basin Management Units* (Unidade de Gestão de Bacia, UGB). The Maputo Basin is included in the Umbeluzi UGB. In each UGB a

Basin Committee, including representatives of various groups of water users, municipalities and experts, is to be formed to promote coordination between different water users and the UBG. The Committee shall be consulted on issues like the annual water allocation plan, water resource development projects, flood mitigation, and measures to improve the efficiency of water use.

Water institutions in South Africa

In South Africa, the *Minister of Water Affairs and Forestry* is responsible for the preparation of any regulations regarding the management of water resources and other water related issues. He also has the power to establish and operate government waterworks like storage dams, water transfer schemes and flood attenuation works. These powers and duties are often delegated to the Director-General of the *Department of Water Affairs and Forestry* (DWAF).

The Minister of Water Affairs and Forestry also has the responsibility to manage and authorise the use of the nation's water resources. This may be done by delegation to a *Catchment Management Agency* (CMA). CMAs are to be established for specific water management areas, which are determined under consideration of watercourse catchment boundaries (compare Water Act 1998). The functions of the CMA are, to develop a catchment management strategy, to co-ordinate the related activities of water users and of the water management institutions and to promote community participation. The board of a CMA are supposed to be constituted in such a way that interests of the various stakeholders are represented or reflected in a balanced manner and the necessary expertise to operate effectively is provided. The respective agency responsible for the Maputo watercourse is the Usutu to Mhlatuze CMA.

Water institutions in Swaziland

In Swaziland all natural resources, including water, are owned by the King. This presents a different legal and institutional set up, in which traditional chiefs have an important say in the allocation of water resources (Leestemaker 2000). Although a new water law has been discussed for some years in Swaziland, the New Water Bill proposed in 2002 has not yet been approved. According to the 1967 Water Act, up till now, basically a system of riparian water use right exists except for areas designated as Government Water Control Areas or Catchment Control Areas. The *Water Resources Branch* of the *Ministry of Natural Resources and Energy,* in addition to recording and registering riparian water use rights, monitors the surface water resources and issues water abstraction rights for public waters. To fulfil these tasks the Minister of Natural Resources and Energy may establish a *Water Court* to settle disputes regarding the use, diversion or appropriation of public waters. Further, an advisory *Water Apportionment Board* is appointed by the Minister to foster, plan and promote the better and more effective co-ordinated exploitation of the water resources.

The objectives of this proposed new Water Bill are, to: (a) declare water in Swaziland to be a national resource to facilitate fair distribution of water; (b) provide for the establishment of a National Water Authority which shall ensure co-ordination and policy development relating to water; (c) provide for the establishment of the Department of Water Affairs so as to eliminate duplication of water sector activities and will assist in enhancing the capability of professionals in the sector; (d) facilitate the establishment of River Basin Authorities who shall effectively take over the functions of the Water Apportionment Board (e) provide for the development of a National Water Master Plan which will provide a framework for water resources development;

Bi- and Trilateral Institutions

A guiding institution for co-operation of the three riparian countries was founded in 1983 with the Agreement between the Governments of the Republic of South Africa, the Kingdom of Swaziland and the People's Republic of Mozambique relative to the Establishment of a **Tripartite Permanent Technical Committee (TPTC)**. The TPTC consists of three representatives from each of the three governments, which meet on an ad hoc basis, as and when circumstances require. Each government has the right to include in its delegation any number of suitable persons to take part in the discussions as additional advisors.

The functions and duties of the TPTC are mainly to advise the three Governments in the development and management of waters of common interest, including recommendations on:

- Measures to alleviate short term problems regarding water shortages on rivers of common interest during drought periods,
- The division of flows in rivers of common interest,
- The implementation of any agreements that are entered into between the three Governments,
- Arrangements for the investigation of, and access to, common watersheds and joint water schemes on rivers of common interest,
- Mechanism to co-ordinate and integrate the findings and plans of each country,
- The optimum joint scheme or schemes that cater for the needs of the three countries.

The respective leaders of the national delegations to the TPTC currently are: the National Water Director (the Director-General of the National Water Directorate) for the Republic of Mozambique, the Principal Secretary in the Ministry of Natural Resources and Energy for the Kingdom of Swaziland and the Director-General of the Department of Water Affairs and Forestry for the Republic of South Africa. Figure 2 gives an overview of the national water institutions involved in management and development of the Maputo River Basin and their representation in the TPTC.

In addition to the TPTC, the riparian countries of the Maputo Basin created bilateral Joint Water Commissions by agreements between the respective two countries:

- Treaty on the Establishment and Functioning of the Joint Water Commission between the Government of the Kingdom of Swaziland and the Government of South Africa (1992),
- Agreement between the Government of the Republic of South Africa and the Government of the Republic of Mozambique on the Establishment and Functioning of the Joint Water Commission (1996),
- Agreement on the Establishment and Functioning of the Joint Water Commission Concerning Water Resources of Common Interest between the Government of the Republic of Mozambique and the Government of the Kingdom of Swaziland (1999).

The main functions and powers of the Joint Water Commissions are to advise the contracting parties on technical matters relating to the joint management of water resources of common interest, including the exchange of information, the monitoring of water quality and the prevention of pollution.

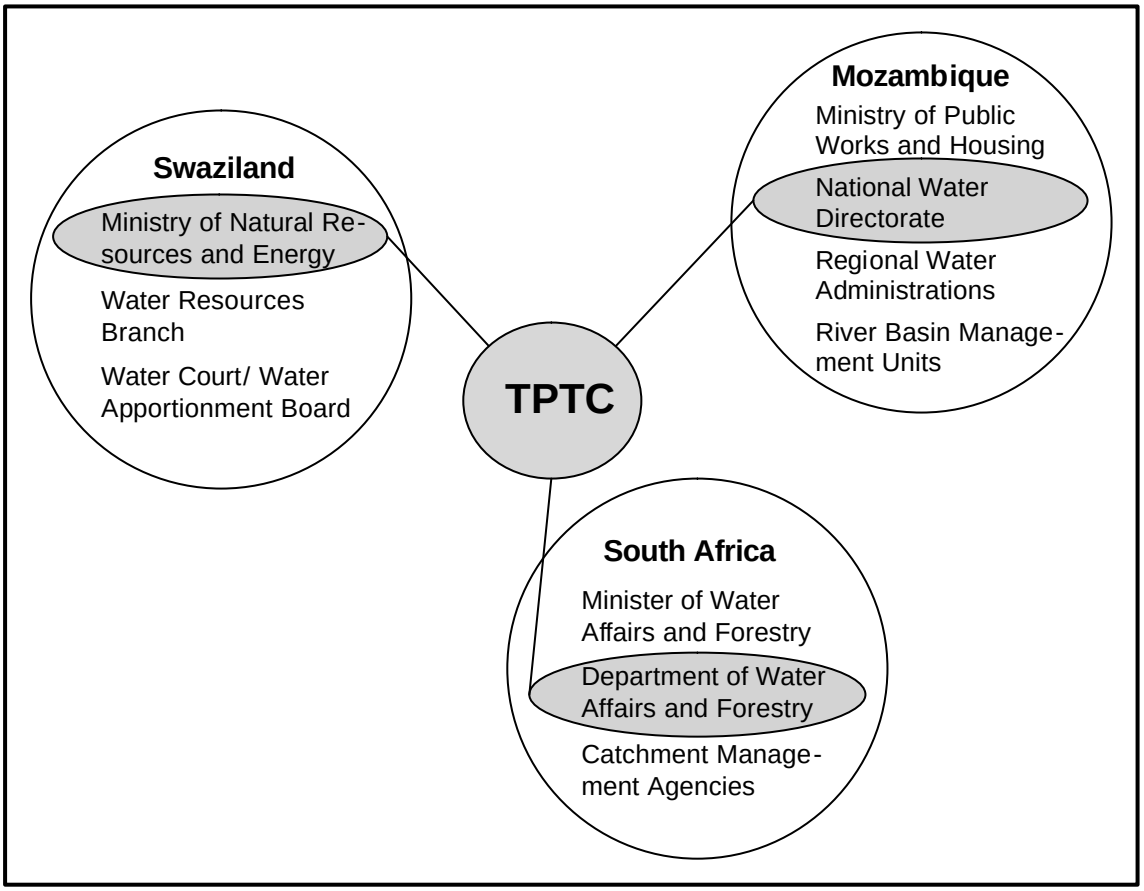

Figure 2: National and trinational water institutions in the Maputo Basin (own graphic).

3.4.2 History of Co-operation in the Maputo River Basin

The first basis for co-operation between the riparian countries of the Maputo River Basin was set in 1964, when the "Agreement between the Government of South Africa and Portugal in regard to Rivers of Mutual Interest and the Cunene River Scheme" was signed in Lisbon. Swaziland acceded to the first part, Rivers of Mutual Interest, in 1967 and Mozambique succeeded to the Agreement in 1975 after it had achieved independence. In the Agreement the contracting parties acknowledged shared watercourses as one of the main factors for development. They recognised the mutual advantages of technical and economical collaboration for deriving benefit from the resources of rivers of mutual interest and stated that such collaboration should follow the principle of good neighbourliness and take the form of specific agreements based on joint studies for each basin. Further, the principle of optimal joint utilisation, i.e. utilisation on an equitable basis and with the aim to achieve maximum advantages, of water resources of rivers of mutual interest was stipulated. Collaboration was concluded to take place on a technical level first, including exchange of information, mutual consultation in regard to main water infrastructure projects affecting other parties' interests and elaboration of joint studies, before negotiations on agreements on the diplomatic level should begin.

Another antecedent of the Interim IncoMaputo Agreement, which covers the Incomati as well as the Maputo watercourse, consists in the Agreement on the Utilisation of the Water Resources of the Incomati River Basin (1991). This agreement stipulated: first, that a joint study on the whole Incomati River Basin would be undertaken, second, that the construction of two major dams would proceed, and third that, pending the results of the joint study, a determined minimum cross-border water release from South Africa to Mozambique has to be maintained and South Africa has to refrain from construction of major water works in one of the sub-catchments without prior consultation at TPTC level. The interim measures agreed upon in this accord can nowadays be considered to be insufficiently comprehensive and have not even always been obeyed. However, the Joint Incomati Basin Study (JIBS), which was launched in consequence of the agreement, has led to the joint involvement of the riparian countries in the characterisation of the water resources situation in the basin. Even if this happened on the level of private consultancy companies, it promoted the sense of common effort and helped to reduce mistrust and thus might have been a supporting factor for good collaboration in the following negotiations on an interim agreement on the Incomati and Maputo River Basins (Canelas de Castro 2002).

In addition to the above mentioned agreements on management of shared water courses other initiatives regarding transboundary natural resources management have been launched by the riparian countries of the Maputo watercourse. These transnational activities contribute to fostering political, economic and cultural co-operation among their parties and provide mechanisms to promote the protection of the Maputo sub-basins freshwater ecosystems (compare Klaphake et al. 2001). The most important of such arrangements for the Maputo basin area are the agreements on the establishment of a Lubombo Transfrontier Conservation Area and the Lubombo Spatial Development Initiative.

The Transfrontier Conservation Area (TFCA) concept focuses mainly on expanding protected areas by linking national conservation areas situated in two or more neighbouring countries. Broad objectives of the TFCA concept are to foster transnational collaboration in implementing ecosystem management, to encourage partnerships in the management of biological natural resources among government, private sector, local communities and NGOs, to promote trans-border ecotourism and to develop strategies for local community participation. The Lubombo Transfrontier Conservation Area, including territory in Mozambique and South Africa is one of three pilot TFCAs that have been established between those two countries, Swaziland and Zimbabwe. The Lubombo TFCA will link the Ndumo Game Reserve and the Tembe Elephant Park in Kwazulu Natal in South Africa with the Maputo Special Reserve (formerly known as the Maputo Elephant Reserve) in Mozambique. Parts of the proposed protection area fall within the Maputo River Basin and establishment of the Lubombo TFCA could therefore not only strengthen the common concern of the riparian countries about freshwater ecosystem protection but also directly affect natural resources development and management decisions in the basin area.

With launching so called Spatial Development Initiatives (SDIs), national and local governments in collaboration with development banks and the private sector aim at increasing economic development across large areas and sometimes across national boundaries. The Lubombo SDI covers part of South Africa, Swaziland and Mozambique and encompasses the proposed Lubombo TFCA and parts of the Maputo River Basin. Planned activities in the Lubombo SDI include projects in the field of tourism industry intermixed with agricultural development.

3.4.3 New Agreements on the Maputo Watercourse

Interim IncoMaputo Agreement

The process of co-operation between the riparian countries of the Maputo River Basin, including the above mentioned institutions and agreements, at last led to the signing of the "Tripartite Interim Agreement between the Republic of Mozambique and the Republic of South Africa and the Kingdom of Swaziland for Co-operation on the Protection and Sustainable Utilisation of the Water Resources of the Incomati and Maputo Watercourses" (2002) (Interim IncoMaputo Agreement). International developments as well have influenced the process: the agreement is based on the framework provided by the Revised SADC Protocol on Shared Watercourses (TPTC 2002) and in the preamble its contracting parties state their acknowledgement of the modern principles and norms of International Law as reflected in the UN Convention on the Law of the Non-Navigational Uses of International Watercourses (1997) and their "common desire to proceed with sustainable development on the basis of Chapter 18 of Agenda 21". The contracting parties recognise that agreements and co-operation on shared watercourses are necessary to enable sustainable development and will bring mutual advantages. Therefore, they express their determination to co-operate and seek mutually satisfactory solutions with a view to improving the standard of living of their populations (Preamble) and to set the general objective "to promote co-operation among the Parties to ensure protection and sustainable utilisation of the water resources of the Incomati and Maputo watercourses" (Article 2).

The Interim IncoMaputo Agreement comprises of 19 Articles and 5 Annexes and is supposed to "remain in force until 2010 or until superseded for the relevant watercourse by comprehensive water agreements" (Article 18). Its interim character mirrors the recognition of the Parties that comprehensive agreements will have to "be based on water use and water resource development and conservation studies "(Annex V n ° 1 which were not available at the time of signature. While the main part of the Interim IncoMaputo Agreement includes more general provisions applied in the same way for the two watercourses situated next to each other, different flow regimes as well as different time frames and programmes for the establishment of comprehensive agreements are stipulated for the Incomati and the Maputo watercourse respectively in the Annexes. The combination of the two watercourses into one agreement allowed for some "trade off" in the negotiations on the individual regulations (personal communication with Rui Gonzales, member of the Mozambican delegation to the negotiations), because the Maputo watercourse still offers some development opportunity, whereas the water resources of the Incomati River are already exploited.

The general principles laid down in the Revised SADC Protocol on Shared Watercourses, especially the principles of sustainable utilisation, equitable and reasonable utilisation, participation, prevention and co-operation also apply for the Interim IncoMaputo Agreement (Article 3). Responsibilities of the parties are stated in Article 4 and include the obligation to:

- prevent, reduce and control pollution of surface and ground waters;
- protect and enhance the quality status of the waters and associated ecosystems for the benefit of present and future generations;
- prevent, eliminate, mitigate and control transboundary impacts;
- co-ordinate management plans;
- promote partnership in effective and efficient water use;

- monitor and mitigate the effects of floods and droughts;
- establish comparable monitoring systems;
- exchange information on the water resources quality and quantity, and the uses of water;
- implement capacity building programmes;

This is done through the development and adoption of technical, legal, administrative and other reasonable measures. These responsibilities are translated into more detailed duties in the following articles of the agreement.

The joint body for co-operation between the Parties is the Tripartite Permanent Technical Committee (TPTC) that is supposed to meet at least twice a year for the purpose of implementation of the Interim IncoMaputo Agreement (Article 5). Task of the TPTC is, inter alia, the adoption of resolutions in order to support the riparian countries in proceeding to (Article 8):

- an endeavour to develop a classification system for the water resources;
- state objectives and criteria in respect of water quality variables to be achieved through the classification system;
- adopt a list of substances the introduction of which is to be prohibited or limited;
- prevent, reduce and control pollution and environmental degradation that may cause significant harm to other parties or to the living resources of the watercourse;
- implement a regular monitoring programme and report on the status and trends of the associated aquatic, marine and riparian ecosystems;

Until specific water quality objectives and criteria are determined, the contracting parties have to fulfil the provisions of the Resolution of the TPTC on Exchange of Information and Water Quality (see below).

The Interim IncoMaputo Agreement further includes special provisions for flow regimes which riparian countries are required to comply with. Criteria applying to the establishment of the flow regimes are the natural characteristics of the watercourse, the water quantity required to sustain the watercourse and its associated ecosystems as well as water requirements for existing infrastructure (Article 9). In Annex I to the agreement, maximum water uses are determined for each riparian country and the respective sub-catchment of the Maputo watercourse. The determination is based on past water uses and estimates of present availability and grants first priority to supply water for domestic, livestock and industrial use, as well as ecological water requirements (Annex I, Article 1). The latter is reflected in the definition of Interim Target Instream Flows to be maintained in key points of the watercourse in order "to sustain its ecology including the estuary" (Annex I, Article 7). Also, operating rules for existing dams, which are to be reviewed regularly by the TPTC, should take account of the tolerance of the riverine and estuarine ecosystems (Annex I, Article 6 n°6). The flow regimes, determined in Annex I are to be assessed by the TPTC, which may establish temporary or revised interim flows if necessary (Annex I, Article 10).

Special obligations for incidents of droughts and floods, accidental pollution and other emergency situations are laid down in Articles 10 and 11 of the Interim IncoMaputo Agreement. It also provides for detailed procedures for the exchange of and access to

information (Article 12), planned measures likely to cause significant harm (Article 13) and the settlement of disputes (Article 15). Recognition is given to the special situation of developing countries with Article 14 requiring the TPTC to "identify capacity building programmes necessary for the implementation and monitoring of the Agreement".

Resolution of the Tripartite Permanent Technical Committee

The Interim IncoMaputo Agreement is completed by the "Resolution of the TPTC on Exchange of Information and Water Quality", signed on 13 August, 2002, by the leaders of the delegations of the riparian countries. Taking into account the "limitations imposed on the Parties by the availability of human, infrastructural and financial resources" the resolution aims "to contribute towards the dynamic implementation of the Interim Agreement" (Preamble of the resolution). The resolution provides a detailed list of actions and objectives to be pursued by the parties in order to promote water quality management, information exchange and capacity building processes.

In regard to water quality management the resolution states that parameters should generally include: water level, quantity and pattern of flow, water quality, "character and condition of the in-stream and riparian habitat", and "characteristics, condition and distribution of the aquatic biota". Short term water quality management goals should, inter alia, ensure the protection of existing aquatic ecosystems and the possibility to use surface water in the production of drinking water after appropriate treatment. Provisional minimum water quality management goals are given in Appendix A to D of the resolution, which encompass a list of short term water quality guidelines including microbiological and chemical parameters, sampling methods and analysis as well as the location of stations for qualitative and quantitative monitoring of the watercourse. Appendix F provides a list of actions to identify, design, establish and re-enforce monitoring systems.

The resolution includes detailed obligations stipulating how and when water quality, hydro-meteorological and other relevant information shall be exchanged, and gives a detailed list of aspects on which data will be required (Appendix G). Capacity building programmes shall be carried out with respect to hydrometric stations and associated information systems, human resources, identifying and strengthening laboratories and institutions, a detailed list of required actions is provided in Appendix F of the resolution.

3.4.4 Comments on the Institutional and Legal Framework

The most explicit legal framework in regard to joint riparian management of the Maputo River water resources is given by the **Interim IncoMaputo Agreement** (compare 3.4.3). Protection of the water resources is stipulated as one of the main objectives of the agreement and same importance is attached to it as to their sustainable development, as can be read from the formulation of the aim of the agreement "to promote co-operation among the Parties to ensure the protection and sustainable utilisation of the water resources of the ... Maputo watercourse" (Article 2 "General Objective"). The definition of the geographical reference point, i.e. the Maputo watercourse, corresponds to the 'watercourse' definitions in the UN Convention and the SADC Protocol. Likewise it does not encompass other components of freshwater ecosystems than water itself, neglecting thus the interconnected-ness of, for instance, land and water that is vital for an ecosystem-oriented approach to water resources development (compare 2.1). However, some of the agreement's provisions indicate that the importance of riparian ecosystems for water quality in the river system is

being recognised. For example, one of the responsibilities of the contracting parties, laid down in Article 4 of the Interim IncoMaputo Agreement, is to "protect and enhance the quality status of the waters and associated ecosystems for the benefit of present and future generations;" and in Article 8 the riparian states are requested to report "on the status and trends of the associated aquatic, marine and riparian ecosystems in relation to the water quality of the said watercourses."

Just as the UN Convention and the SADC Protocol (compare 2.2.1), the Interim IncoMaputo Agreement includes an overall obligation to "take all measures to protect and preserve the ecosystems of the ... Maputo watercourses" (Article 6). But different to the two other (more general) agreements, the Interim IncoMaputo Agreement translates this overall duty into specific instructions, including the demand on the parties to establish a classification system for the water resources, to adopt a list of critical substances and to implement a monitoring programme as well as the already above mentioned mandatory reporting on "associated aquatic, marine and riparian ecosystems" (compare Article 8). Further, water requirements of the ecosystems of the Maputo watercourse are turned into enforceable rights of the riparian country by the formulation of instream flows to be maintained to sustain the ecology of the watercourse (Annex I, Article 7). High priority is given to environmental instream flows, as reductions in water supply for the riverine and estuarine ecosystems are to be allowed only under conditions of extreme drought (Annex I, Article 6(5))

The design of the **joint body for co-operation** between the riparian countries, the Tripartite Permanent Technical Committee (TPTC), offers the possibility to provide a forum for discussion among experts from the three basin states, as government representatives to the TPTC have the right to include in their delegation any number of suitable persons to take part in the discussions as additional advisors (compare chapter 3.4.1). Thus it provides the opportunity to assemble specialists, who could be scientists, lawyers etc., according to the issue area under question, and the possibility to discuss how to best address a given problem more independently of state policy concerns. Yet, the TPTC remains an advisory committee without executive powers. The fact that **executing water management institutions** in Mozambique and South Africa, as well as the new institutions envisaged in the proposed Water Bill for Swaziland, are organised on the basis of hydrological boundaries, i.e. river basins or catchment areas (compare chapter 3.4.1), is likely to facilitate basin wide co-ordination in the future (compare Klaphake et al. 2001). But some of these institutions are not yet fully established and capacity building is definitely needed.

From a procedural point of view, **flexibility** to adapt regulations to changing circumstances is very important in providing an ecosystem-oriented approach to water resources management in the long term (compare Brunnée & Toope 1997). Today's knowledge on ecosystems and their diverse interdependencies is generally not sufficient to predict with certainty what effects human action will produce on them. This becomes even more obvious for the case of the Maputo sub-basin, where currently almost no baseline data on its freshwater ecosystems exists. The structure of the Interim IncoMaputo Agreement allows for adaptation of its regulations in various ways. First of all, the interim character, with prospect of reaching more comprehensive agreements in the future, most explicitly recognises the fact that actual knowledge of the water resources is insufficient. Secondly, specific regulations, like the determination of minimum flows and reference projects on water resources development, have been laid down in Annexes to the agreement that can be modified by a decision of the responsible ministers upon recommendation of the technical

committee (TPTC) (Article 16 Interim IncoMaputo Agreement) independently of the agreement itself. In addition, Annex I, defining flow regimes, for example, already provides for regular review of the agreed regimes by the TPTC. Third, provisions of the agreement that require more detail for implementation, are fleshed out through a resolution of the TPTC (compare 3.4.3) which may be amended at any time and includes, for instance, short term water quality standards and lists of polluting substances subject to special attention.

The legal and institutional framework for management of the Maputo River Basin meets a number of the key demands, such as provision for sustainable development, intergenerational equity, flexibility and co-operation, placed on an ecosystem-oriented management. Therefore it offers good preconditions for the adoption of water resources management strategies that integrate the protection of freshwater ecosystems. Yet, the successful implementation of the new agreements remains to be seen.

4 Options and Obstacles for the Protection of Freshwater Ecosystems in the Maputo Basin

The existing legal and institutional arrangements within the riparian countries as well as on regional and international level offer different frameworks for the implementation of water resources management. The following paragraphs will discuss some of the options this provides and obstacles that still have to be overcome for achieving an ecosystem-oriented management of the Maputo River Basin.

The set of goals of the Interim IncoMaputo Agreement represents an ambitious step towards substantively integrating the protection of water resources and associated ecosystems into joint riparian management strategies for the Maputo watercourse and it clearly demonstrates the recognition of environmental water needs in principle through the contracting parties. Yet, implementation of the detailed regulations as well as monitoring compliance might prove to be difficult, considering the fact that today even data on water flow in the Maputo sub-basin in Mozambique is very incomplete and hardly any information exists on its ecosystems. Conscious of these constraints, the contracting parties highlight the **need for capacity building and exchange of data and information** on hydrology, water quality, and environmental conditions of the watercourse in the Interim IncoMaputo Agreement (compare Article 12 and 14). Co-operation in these fields could offer opportunities to share knowledge between the three riparian countries which are at very different stages of development, and thus to improve basin-wide understanding of the ecosystems affected. Additionally, exchange of information and collaboration in capacity building could help to generally reduce mistrust resulting from, among other things, the different levels of development: The upstream country, South Africa, is reaching first-class status on the world stage in some fields and has water resources development plans ready to present. Mozambique, the downstream riparian, on the other hand, lags behind with the elaboration of new plans due to the long period of instability during civil war and thus fears to lose possibilities for own water resources development in the future (Canelas de Castro 2002). In this context of unequal potential, the absence of shared technical data and impartial analysis can breed a lack of confidence, as it has already been observed in general in debates concerning freshwater resources (compare Brunnée & Toope 1994).

The TPTC Resolution further stipulates a set of general goals for water quality management as well as work programs for capacity building and implementation of the agreement's provisions. This way of defining **common objectives** and action programmes has been proven very successful with the Rhine Action Programme (compare chapter 2.3.2). Whether the work programmes envisaged will take effect and implementation processes are going to be successful in the specific context of the Maputo watercourse remains to be seen. Nevertheless, the definition of capacity building programmes and shared perspectives offers a good starting point. Because, even if scientific **knowledge on the ecosystems is still limited** and does not allow to predict consequences of human actions, lack of stuff, training and awareness as well as insufficient financial provisions often represent more fundamental problems to put ecosystem protection into practice (Klaphake et al. 2001). However, ecosystem protection needs a scientific basis and in the end, once fundamental administrative problems are overcome, it is not a legal, but a scientific task (compare Brunnée & Toope 1994). For instance, the determination of environmental flows is a very difficult question and lacking the necessary knowledge, instream flows to sustain the ecology

of the watercourse as stipulated in the Interim IncoMaputo Agreement, might not actually be appropriate. In calculating environmental instream flows for the Maputo sub-basin, the water needed to maintain a healthy floodplain, with fertile soils and reed beds as well as estuarine freshwater requirements, including consideration of the effect of salt intrusion, should be taken into account. In order to define water flow and quality parameters for the envisaged comprehensive agreement **co-operation with research institutions** could be helpful. For example, extensive studies have been undertaken on the Pongola Floodplain in South Africa, which has similar characteristics as the Maputo Floodplain. Today the Pongola Floodplain is partly included in the Ndumo Game Reserve and co-operation with its administration, the Kwazulu-Natal Department of Nature Conservation, could help to foster understanding of the Maputo Floodplain ecosystem's functioning. In respect to the calculation of environmental instream flow requirements, studies have been undertaken by the Incomati Shared River Initiative and benefit could be derived from their experiences. Another co-operation partner could be the International Union for the Conservation of Nature (IUCN), a nongovernmental organisation with broad experiences in environmental aspects of international rivers' management that already supported programmes in the Zambezi and Incomati River basins.

Another source of expertise on ecosystem functioning is the local population, who is directly affected by the degradation of freshwater ecosystems. Mobilising their knowledge contributes to broadening the water management perspective and helps to take potential economic losses of ecosystem degradation into account (Klaphake et al. 2001). Actually, the **participation** principle, an integral feature of an ecosystem-oriented approach (compare 2.1), is named as one of the main principles of the Interim IncoMaputo Agreement (Article 3). Yet, no provisions are made in the agreement for the implementation of this principle. On the other hand, the local communities living in the basin area are directly dealing with the basin's resources in their everyday life. Thus, they also play an important role when it comes to conservation and protection of the freshwater ecosystems. **Training and awareness raising** could therefore be important steps in maintaining the functions of the basin's ecosystems. In the Maputo sub-basin, especially Helvetas (Swiss Association for International Cooperation) and IUCN have worked with local communities on issues of natural resources management. Their experiences and networks could therefore be helpful, if local knowledge is to be consulted and communities are to be involved in the management and protection of the freshwater ecosystems.

In addition to the Interim IncoMaputo Agreement, co-operation in ecosystem management among the three riparian countries could be enforced through the collaboration in other trilateral agreements, such as the Lubombo Transfrontier Conservation Area and Lubombo Spatial Development Initiative agreements (see chapter 3.4.2). Other frameworks for co-operation in the protection of freshwater ecosystems are given by international environmental conventions like the Ramsar Convention and the Convention on Biological Diversity (compare 2.2.2), as the Maputo sub-basin encompasses wetland areas of potential international importance (see chapter 3.2.2.1) and lies within the Maputaland Centre of Plant Diversity (see chapter 3.2.2).

Last but not least, in order to benefit from the legal frameworks provided by the IncoMaputo Agreement, by international conventions and other multinational agreements, their implementation has to be made sure. Therefore, it is indispensable that national water laws and policies as well as all other related laws and policies take into account any international conventions or agreements accepted by the riparian country. Further, it might be necessary to develop and establish appropriate regulations and procedures to ensure

effective implementation of the agreements. Creation and promotion of public awareness on existing international agreements and joint riparian programmes could also foster their implementation. In order to avoid negative impacts of non-water policies on the freshwater ecosystems of the Maputo Basin it is important to harmonise policies of other related sectors and to co-ordinate programmes and activities of respective ministries and institutions. In Mozambique e.g. better co-operation and co-ordination between the National Water Directorate (Direcção Nacional de Águas (DNA)), the Ministry for the Environment (Ministério para a Coordenação da Acção Ambiental (MICOA)), the Ministry for Agriculture and Rural Development (Ministério da Agricultura e Desenvolvimento Rural (MADER)), the National Directorate for Forests and Wildlife (Direcção Nacional de Florestas e Fauna Bravia (DNFFB)), and the National Directorate for Conservation Areas (Direcção Nacional das Áreas de Conservação). Intersectoral co-ordination in, and achievement of an integrated management of freshwater ecosystems could be facilitated by integrating the goal of protecting freshwater ecosystems into general programmes of activities and strategies of the riparian countries' governments.

5 Conclusion

The Maputo River supports a number of valuable ecosystems, like fertile floodplains and mangrove forests, performing various ecological functions, delivering resources for the livelihood of the local population and of high importance for biodiversity. In addition, these ecosystems have great potential for the economic development of the Maputo sub-basin that is situated in an under-developed district of Mozambique. Although the sub-basin is not yet under high water stress, existing development plans for the Maputo catchment area are expected to result in higher abstractions of water in the future and will most probably produce negative effects on freshwater ecosystems downstream.

The legal and institutional framework existing within the Maputo River Basin offers good opportunities for riparian co-operation in an ecosystem-oriented management of the Maputo River. The Interim IncoMaputo Agreement, based on the provisions of the SADC Protocol, includes the main principles of ecosystem orientation (sustainable development, intergenerational equity, precaution) and recognises the need for ecosystem protection in turning water requirements of aquatic ecosystems into enforceable rights. Further, the interim agreement and the accompanying resolution of the TPTC include a range of specific regulations and instructions (such as limit values for certain substances, establishment of classification systems and monitoring programmes), suitable for the protection of freshwater ecosystems. With the TPTC, a suitable international institution exists for the implementation of the agreement, which offers possibilities for exchange and negotiation among technical experts and policy makers. The precise description of procedures for the exchange of data and information as well as the definition of common goals in the resolution is likely to foster co-operation and reduce mistrust between the riparian countries. On national levels, the establishment of basin management institutions is envisaged for all of the three riparians and is likely to facilitate basin-wide co-operation in water resources management in the future.

Yet, this advanced legal and institutional framework as well as the ambitious set of goals formulated by the riparian countries still need to be implemented, and major constraints have to be overcome before ecosystem-oriented management strategies for the Maputo River can be put into practice. Main obstacles for their adoption and implementation (which have also been recognised by the riparian countries in the Interim IncoMaputo Agreement and the accompanying resolution of the TPTC) are the lack of hydrological data and insufficient knowledge of freshwater ecosystems within the basin, on the one hand, and lack of trained staff and implementation of national water management institutions on the other.

Crucial steps towards the integration of freshwater ecosystem protection into joint riparian management strategies consist therefore in:

- human and institutional capacity building programmes,
- establishment of monitoring programmes for quality and quantity of the water resources,
- promotion of research on freshwater ecosystems.

Achievement of these goals should be facilitated through:

- effective implementation of international agreements through appropriate national policies
- promotion of knowledge sharing between the riparian countries,
- provision of financing for the necessary work programmes,
- promotion of intersectoral co-ordination,
- information and involvement of the public.

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