

5. CASE STUDIES

5.1 The National Water Act of South Africa: implications for estuaries and the coastal zone

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From resource development to resource management

The principal objective of South Africa's National Water Act (Act 36 of 1998) is to balance long-term protection of water resources with short- and medium-term use. The Act recognizes that water is part of a larger ecosystem that provides us with services and benefits such as drinking water, water for economic development, transportation and recreation opportunities. The Act has signaled a shift from resource development to resource management and the environment. The environment is no longer seen as a competitive use of water, but rather the base from which the resource is obtained, and must therefore be protected.

Progress and development with regard to Resource Directed Measures for estuaries, the implementation process and links with other water resources, comprise a collaborative effort involving a number of estuarine scientists and managers.

The Reserve

The National Water Act (Act 36 of 1998) makes provision for a Reserve to be determined prior to authorization of water use (examples of the 11 water uses include agriculture, industrial uses, waste discharges). The Reserve is the *quantity and quality* of water required to satisfy basic human needs, considering both present and future needs and to protect aquatic ecosystems in order to secure biological sustainable development and use of the resource.

The importance of freshwater to estuaries – case studies

Over the last eight years a number of studies funded by the Department of Water Affairs and Forestry have determined the freshwater requirements of estuaries:

- ◆ The **Olifants** is a permanently open estuary on the dry west coast. It has the largest supratidal saltmarsh area in the country and is dependent on floods to keep the habitat moist and flush out accumulated salts. Further freshwater abstraction from this estuary will result in saline intrusion in summer and agricultural return flow stimulates algal blooms and reed growth.
- ◆ The **Great Brak** is a temporarily closed estuary on the southern Cape coast. Releases of water are made from the Wolwedans dam to keep the mouth of this estuary open, particularly at those times of the year when fish and invertebrate recruitment takes place from the sea into the estuary. If the mouth remains closed and water levels increase then the intertidal saltmarsh plants and animals will die.
- ◆ The **Tugela (Thukela)** on the east coast functions as a river mouth, as the brackish, mixing zone occurs out at sea. This system provides sediment and nutrient rich water to the marine environment. This is important as it results in beach nourishment and maintains the productive prawn industry on the Tugela banks.

From these and other case studies we have a generic understanding of the freshwater requirements of estuaries. **Baseflow** is important as it keeps the mouth of an estuary open. The flow required to do this varies due to local coastal conditions e.g., beach slope, wave action, availability of sediments. Baseflow is also important as it maintains a longitudinal salinity gradient required for biotic diversity.

Freshwater pulses (freshettes) introduce nutrients into an estuary and stimulate water column productivity. **Floods** flush out accumulated sediment and thus affect the long term sediment erosion / deposition processes.

Development of methods for determining the reserve

To facilitate the determination of the ecological reserve for aquatic ecosystems, water resources have been sub-divided into groundwater, rivers, wetlands and estuaries. Methodologies to determine the ecological reserve are still being developed and tested for each of these resources. There are currently three levels of Resource Directed Measure determination (RDM) for estuaries:

1. Rapid determination of RDM which is a desktop assessment.
2. Intermediate determination (which takes approximately two months to complete)
3. Comprehensive determination (which takes approximately 12 months to complete).

The level of RDM determination required depends on the sensitivity of the water resource, the scale and degree of the impact of proposed water uses, and the urgency for a reserve determination. All three levels include six basic steps that are used to determine the reserve for estuaries:

- Step 1. Delineate the geographical boundaries of the estuary.
- Step 2. Determine the eco-regional type.
- Step 3: Assess present state and determine reference condition.
- Step 4: Determine present ecological status and ecological importance.
- Step 5. Determine and set the Ecological Management Class (EMC)
- Step 6. Quantify the reserve and set the Resource Quality Objectives (RQO)
- Step 7. Design appropriate resource monitoring programme.

The intermediate reserve process can be demonstrated using the Palmiet and Nahoon estuaries.

State of the Environment indicators

Components of the Reserve project such as the assessment of **present ecological status** and **monitoring requirements** links up well with another project on the development of State of the Environment indicators for estuaries. This project falls under the umbrella of the **SA-ISIS** project (South African Integrated Spatial Information Systems). SA-ISIS is essentially a ‘switchbox’ to access remotely located information and databases. One would be able to log onto a website and reach a comprehensive estuary database containing information on ecological health, conservation importance and sensitivity to development. The web-site will also house a set of fourteen generic “State of the Environment” indicators to enable managers to select those important for tracking the health of their particular estuary. Management information will focus on what equipment is needed for monitoring, how, where and when to sample, and how to analyse, interpret and present the outcome of the monitoring. Ecological implications of indicator trends will be highlighted and there will be direct lines of access to specialist advice.

5.2 The dynamic interaction of Maputo Bay and its river catchments: a proposed model catchment-to-coast integrative project for the AfriBasins initiative

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This project is aligned with southern African initiatives to increase collaboration and co-operation in decision-making on shared river basins of SADC. This collaborative project seeks to maximize opportunities for integration between different disciplines and regional aquatic resource management institutions, and increase internal and external capacity to address and resolve resource management problems between shared river basins and the coastal systems that depend on them.

This project is primarily developing the skills and the tools, which can be used to support present and future needs of sustainable management of Maputo Bay and its key catchments. The objective is not to formulate the management strategies *per se* as that is the responsibility of the actual resource managers but to provide the basis (understanding and tools) on which quality decisions can be made. This approach can then be extended and applied in other systems where the management of the coastal zone requires an explicit understanding of land forcing through the dynamics of river catchments.

Background

After more than two decades of near paralysis, the economic development of Mozambique is now underway with an intensity which could lead to unexpected social and environmental impacts. This applies particularly to the metropolitan area of the capital city of Maputo and its surrounding environment, which includes the Maputo Bay and its associated rivers and estuaries, which together comprise the Maputo Bay System. Maputo has historically been the seaport for the Witwatersrand (Gauteng) and Highveld industrial and mining heartland of South Africa as well as an important tourism destination. Following a period of political change (1975-1995) the country in general but Maputo specifically is undergoing rapid re-development through both industrialization and tourism development. One of the main consequences of such rapid development is that in many instances there is no holistic way of assessing the impacts of investment decisions and in the main EIA are carried out on case-by-case basis. This mostly excludes an overall assessment of the ecological or health implications of cumulative or interactive perturbations.

The environmental and economic management of the impacts of human activities in the Maputo Bay system has two important scales:

- **Local Scale:** this comprises activities, uses and needs in the immediate vicinity of the system.
- **Regional Scale:** this comprises the activities, uses and needs in the catchment areas of the 5 rivers that flow into the Maputo Bay system.

The socio-economic importance of the Maputo Bay system as a nucleus of growth both in Mozambique and for the Maputo Corridor IDZ makes it imperative that future beneficial uses are not foreclosed and that the environmental and human health impact risks of growth are constrained.

This study aims to provide both the understanding and the tools to allow these impacts and their costs to be explicitly determined in order that investments take a more regional and strategic perspective.

The system and its main characteristics

The Maputo Bay system comprises a complex system of linked water bodies, which include five rivers (Incomati, Maputo, Tembe, Umbeluzi and Matola) discharging into three estuarine systems (Espírito Santo, Maputo and Incomati) which open into Maputo Bay. The bay system, in turn, is linked to the southern end of the Mozambique current through the gyral feature of the Maputo Bight. The main concerns and likely

forcing factors are summarized in Table 1. Important natural and anthropogenic features, which could have an economic bearing on the sustainable growth of the system are:

- **Rivers from South Africa:** the five rivers discharging into Maputo Bay all originate from the South African or Swaziland catchment areas and act as vectors to transfer catchment management problems in water quality to the bay itself. Recent studies of sediment biogeochemistry in the Maputo Bay system have shown that the natural erosion of mineral rich rocks and mining waste discharges from the catchment areas dominate its characteristics. While this is a recognized trans-boundary problem there has been little quantitative assessment of the impact of such forcing. There is an independent study of some aspects of the Incomati River catchment part of the system and a key part of the proposal development will be to link up and coordinate the two efforts.
- **Sediments dynamics:** Maputo Bay is a soft edge system – it has sandy beaches, silt-rich mangroves and substantial sediment loads from the river inputs. These have major implications: costly maintenance dredging of a shipping channel, coastal erosion and stability of sensitive ecosystems such as coral reefs and mangroves. The impacts of river catchment management are felt within the bay itself. The extent to which catchment erosion linked to rural development strategies contribute to the costs of annual dredging in the Maputo Bay system is not understood.
- **Ecology:** The Maputo Bay system not only includes an important coral reef system (Inhaca Island reef) but also extensive mangroves (~10,000ha.) which are a key habitat for the local prawn and clam industry as well as both pelagic and reef fisheries. These vulnerable systems are not only under threat from population pressures but also from water quality and sediment (turbidity) forcing. While their key role in the long-term stability of the local economy is not clearly understood or quantified it is likely that ecological and resources exploitation will continue.
- **Effluent discharges:** the Maputo area contains both old and new industrial facilities and a large and dense urban area whose sewage is only partly treated. These have had a significant impact on the local economy through the banning of filter-feeder collection, eutrophication and sediment contamination. While these impacts are at the moment limited to the waters around the urban - industrial zone further environmental deterioration can be envisaged if the hydrodynamic/water quality and ecological interactions are not correctly understood.
- **Islands:** the islands in the vicinity of Maputo Bay are both centres of bio-diversity and popular tourism destinations. These sensitive sub-tropical systems are vulnerable to environmental change driven by remote decisions such as river catchment management and local water quality through the discharge of domestic and industrial effluents.

These factors make this an ideal system where predictive modelling and DSS expertise and IT based technology can serve to strengthen regional aquatic management institutions, improve communication, improve the quality of information for investment risk management and for sustainable growth of the local and regional economies. Such an approach will empower local and regional system managers with tools and understanding, which will allow them to weigh up the consequences of certain decisions and interact with investment bodies constructively and proactively.

Goal:

To design, develop and validate a generic catchment-to-coast planning and management support system for the southern African region, which can also be implemented beyond the region. This will enable water resource managers to incorporate trans-boundary water resource issues and strategies in their medium- and long-term development plans. Recent advances and developments in water resource management policies are based on a new set of philosophies; this has opened the way for the development and implementation of new technologies and new operational procedures that are designed to support and promote sustainable water resource management on a whole catchment basis, including the coastal zone.

Objectives:

To achieve this goal, the following objectives can be set for this project:

1. Technical

- To develop a sound scientific understanding of the dynamic linkages between catchments and coastal processes, and the ways in which these linkages are influenced by activities within a catchment; and
- To develop appropriate tools and the predictive capability to quantify and internalize the linkages between these processes and the implications of catchment management decisions and actions on water quantity and quality. In this process, it is important to be able to distinguish between, and make provision for, the influences of natural and anthropogenic activities.

2. Institutional

- To develop a clearer understanding of the social, ecological and economic factors which contribute to, or control, the sustainability of water resources;
- To develop and expand effective institutional and organizational links that will enable efficient sharing of knowledge, tools, insights, experience and responsibilities for water resources and catchment management;
- To promote and develop effective capacity creation (including scientific and management skills) amongst potential participants and beneficiaries;
- To effectively and efficiently co-ordinate and integrate inputs from different disciplines (social, economic, political, ecological) into a truly trans-disciplinary programme; and
- To re-position the southern African expertise base for provision of technical and management advice to support regional water management policies, including impacts on coastal systems.

3. Resource management

- To promote and ensure the development of a sound scientific and socially acceptable basis for decision-making by resource managers, that will enable a regional perspective to be taken;
- To ensure that the potential benefits of successful catchment management are also extended to those whose socio-economic well-being is governed by the sustainability of coastal systems dependent on upstream catchments; and
- To provide local solutions in the context of regional-scale impacts.

Rationale

- Lack of information leads to the inability to make proper decisions that, in turn, leads to poor policy implementation and failure to deliver benefits to stakeholders on the ground;
- This is a trans-disciplinary study which seeks to bridge the gaps between scientific (especially ecological) understanding, and the social and economic interests of stakeholders;
- The need to shift the focus of water resource management from a predominantly “reactive” mode, to a more “proactive” mode, with a regional (whole catchment) focus; and
- There is a growing need to develop regional-scale solutions that seek to resolve resource management issues, and also seek to establish “local” problem-solving capacity and appropriate institutional and organizational structures to facilitate stakeholder participation and involvement.

Table 1. Matrix reflecting the relationship between issues and impacts for Maputo Bay.

Environmental Issue	Impacted systems	Impacted beneficial uses	Driving process	Forcing scale	Management responsibility
Coastal Erosion	Beaches Islands Coral reefs	Urban infrastructure Tourism	Catchment flow and sediment transport dynamics Wave (wind and ocean) energy Sand transport within the bay Dredging of shipping channel Sea level Land use	Local Regional (river catchments)	Maputo and Matola councils CFM Emodraga
Disposal of dredged material	Shipping channel Beaches Islands Estuaries Mangroves Coral reefs Sediment biota Water column biota	Fishing Mariculture Harbour and shipping Saltworks Industrial activity	Circulation Flocculation Catchment processes Contamination Dredging Flooding Land use	Local Regional (river catchments)	CFM Emodraga Fisheries Institute (IIP) Environment Affairs
Water and sediment quality	Estuaries Mangroves Coral reefs Sediment biota Water column biota	Fishing Mariculture Harbour and shipping Saltworks Industrial activity	Local effluents Catchment effluents Flocculation Catchment erosion Dredging Flooding Land use	Local Regional (river catchments)	Water Affairs City councils Environment Affairs
Biodiversity	Estuaries Mangroves Coral Reefs Sediment Biota Water Column Biota	Fishing Mariculture Tourism Recreation	Water quality Sediment quality Sediment (mud and sand) dynamics	Local Regional (river catchments)	

5.3 Development of ecological indicators for the North Sea

Saa H. Kabuta

This paper describes the development of ecological indicators as management tools, and the steps taken in the Netherlands for the proper management of the Dutch section of the North Sea (NCP).

Background information

Because of the increase in intensity of human activities and the increased attention for the conservation of species and habitats in the North Sea, discussions over the health of the North Sea ecosystem started at the third North Sea Ministers Conference in 1990. This was followed by a number of workshops under the auspices of the North Sea Task Force and the Oslo and Paris Conventions (OSPAR). Regulations of the European Union, treaties for the conservation of the Rhine, Meuse and Scheldt and the International Maritime Organisation (IMO) were further factors that influenced management procedures for the ecological quality of the North Sea.

In the Netherlands, the Ministry of Transport, Public works and Water Management (V&W) and the Ministry of Agriculture, Nature and Fisheries Management (LNV) set up and are implementing various projects that will create better understanding of the ecosystem of the Netherlands section of the North Sea (NCP). The results from these projects should enable the formulation of policies that could lead to the creation of a balance between the effects of human activities and the preservation of the natural qualities of the North Sea ecosystem. This balance is expected to lead into an effective management of both the ecosystem and the various uses of the North Sea.

One of the projects undertaken in the Netherlands is the GONZ project (GONZ is Dutch acronym for indicator development for the North Sea), designed to develop ecological indicators for the NCP. These indicators are based on various monitoring data which when properly used could evaluate the effects of human impacts on the ecosystem, thereby making it possible for the policy makers and the managers of the NCP to evaluate the effects of their policy and management recommendations on the quality of the ecosystem (Kabuta and Duijts 1999).

This paper presents the steps taken towards the development of ecological indicators for the NCP and the role they could play in describing the level of human impacts on the various attributes of the ecosystem. The relationships between the changes in the ecosystem and the policy recommendations for the North Sea are considered by using examples of the ecological indicators developed in the GONZ project.

The study area

The North Sea is part of the North Atlantic Ocean. It is surrounded by the coasts of Great Britain, Norway, Denmark, West Germany, the Netherlands, Belgium and France (Figure 1) and has a total area of 575000 km² which is 14 times the size of the Netherlands. The North Sea is a relatively shallow part of the Atlantic Ocean, only 40 m deep in the southern part, but from averaging 100-200 m in the north and, especially off southern Norway, down to 700 m.

The North Sea is one of the most productive seas in the world. The rivers deposit enormous amounts of nutrients (nitrate and phosphate) into the sea while the water flow from the south of the North Sea thoroughly mixes these nutrients.

In addition to the nutrient deposits from the rivers, solar radiation in the North Sea supports high primary production levels (<50 - >1000 gC m⁻² yr⁻¹). The cumulative effect of these factors has resulted in a high level of production which has led to numerous commercial activities in the North Sea, including fisheries.

The North Sea is one of the busiest seas in the world, with huge numbers of ships including freighters, trawlers, tankers, gravel and sand excavation ships (Kabuta and Duijts 1999). There are also a large number of platforms for oil and gas mining industries from the surrounding countries.

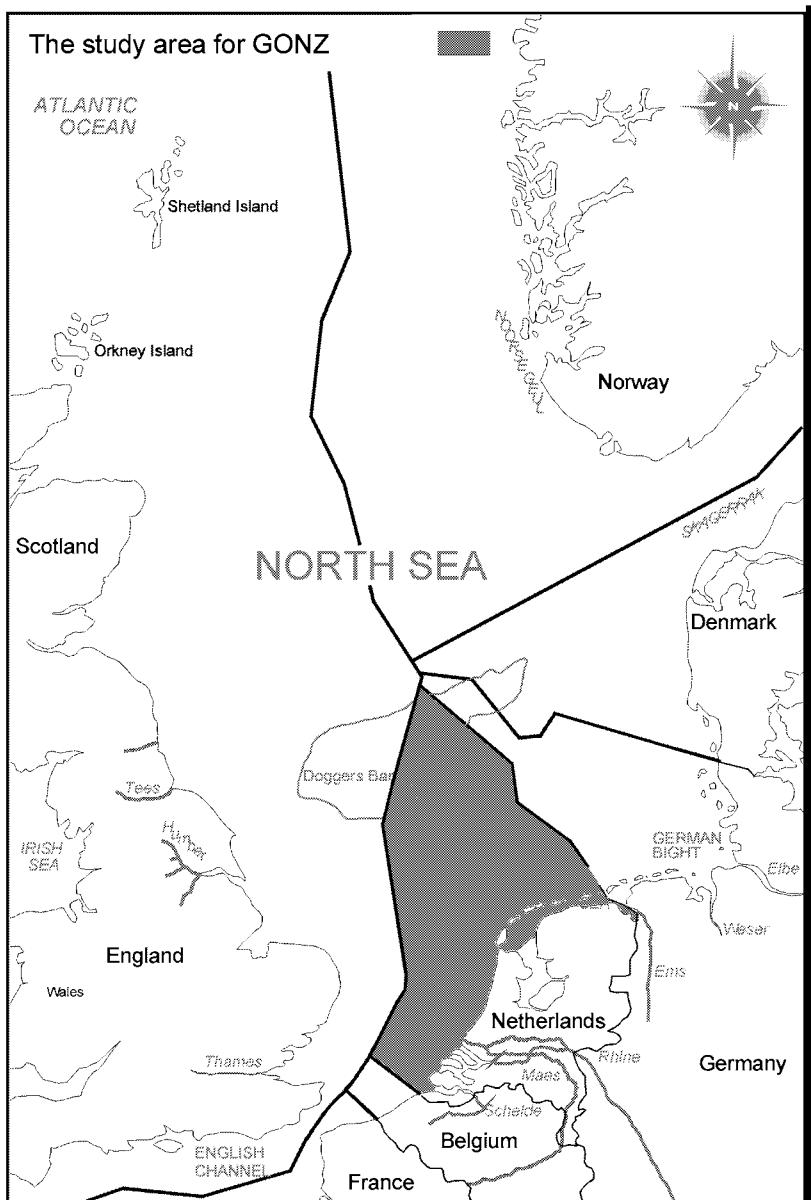


Figure 1. The North Sea and the Netherlands Continental Plate (NCP).

Why Ecological Indicators for the Netherlands?

The increase in commercial activities in the North Sea and increased awareness of the degradation of the marine ecosystem led to the need for a reliable, effective, reproducible and multifunctional management tool for the North Sea ecosystem. The construction of such an integral management tool in the Netherlands was initiated by the North Sea Directorate of the Ministry of V&W, with support from the Ministry of LNV.

The Ministry (LNV) makes policies for the conservation of nature in the North Sea whilst the Ministry (V&W) has the task of making policies that will result in sustainable use of the North Sea. These two ministries have a common view of the development of ecological indicators for the North Sea (Duel *et al.* 1997). The new tool will be based on the principles underlying the existing tools but will replace those tools, which were designed for similar purposes by the two ministries. These tools include the 'general methods for describing and evaluating ecosystems (AMOEBE)' and the 'use nature conservation parameters (NDT)'. The AMOEBE was developed for the Ministry V&W whilst the NDT was developed for the Ministry LNV.

Various tools for the evaluation and assessment of the water and nature policies were in use. For the water policy the ecological evaluation system AMOEBE (Ten Brink and Hosper 1989; Ministry of Transport, Public Works and Water Management 1989) was used. As the interest in maintaining a high quality of ecosystems in the Netherlands increased, the quest for developing and using a more integrated instrument for the monitoring and evaluation of the related policy recommendations increased. The two main operational instruments (AMOEBE and NDT) were considered outdated and could not be used to answer the numerous policy-related questions over the quality and management of the ecosystem. To address all the policy issues, a new set of tools was therefore needed. These tools must be relevant not only to the ecology of the water system and the related policy recommendations for water and nature conservation but also to the policy recommendations for the environment (Latour *et al.* 1993).

The GONZ project

The GONZ project was started in 1996 and has been implemented by the National Institute for Coastal and Marine Management in the Netherlands (RIKZ) under contract from the North Sea Directorate (DNZ) of the Ministry of V&W. Both organisations (RIKZ and DNZ) are departments under the ministry of V&W and are involved in the management, monitoring and evaluation of the Netherlands section of the North Sea. The RIKZ takes part in the preparation of new policies for the North Sea and shares the responsibility of analysing the effects and the viability of existing policy measures for the North Sea ecosystem. The DNZ is responsible for the management of the North Sea and issues licenses for commercial activities in the North Sea.

The GONZ project is designed to develop ecological indicators for an integral evaluation of the policy recommendations for the North Sea and should functions as an eye opener for the development of robust policy evaluation instruments for the description of the ecological qualities of both marine and fresh waters in the Netherlands.

Participating Institutions

The development of ecological indicators (GONZ) is a multidisciplinary research project being carried out by several research institutions in the Netherlands which study the North Sea to increase knowledge about the ecosystem and to provide advice for policy- and decision-makers in the various sectors. Among these institutions are the National Institute of Coastal and Marine Management (RIKZ), the Royal Netherlands Institute for Fisheries Research (RIVO), the Netherlands Institute for Sea Research (NIOZ), The Green World Research Institute (ALTERRA), the National University of Groningen (RUG), the Institute of Environmental Sciences, Energy Research and Process Innovation (TNO) and the Institute for Inland Water Management and Wastewater treatment (RIZA).

The expected qualities of the GONZ indicators

The indicators developed from the GONZ project must be able to assess the water management (V&W) and nature conservation (LNV) policies for the North Sea. At the same time the use of a common set of indicators must provide solutions to the various (scientific) criticisms against the existing evaluation systems (AMOEBE and NDT). To enhance the development of the indicator systematic it is accepted that these existing evaluation tools must form the basis. The indicators must include both biotic and abiotic parameters, to measure biodiversity, ecological functioning and sustainability of the North Sea. The indicators could be process variables, species, species groups or indices expressed in ecological terms. Variables related to the ecosystem could also be used as indicators.

Steps taken towards the development of the Indicators

Based on the terms of reference above, development of the indicators involve a number of specific targets. Essential requirements were:-

1. the design must comply with the project objectives for GONZ;
2. the design must have an obvious relationship to the (mutual) water and nature policy objectives;
3. the design must provide solutions to criticism of the existing tools (AMOEBE and NDT) as well as integrating them as much as possible.

1. The design must comply with the GONZ project objectives

The main objectives for the development of the indicators are as follows:

- to develop an evaluation system for the ecological quality of all water systems in the Netherlands.
- to be able to assess and evaluate both the water policy and nature policy for the North Sea.
- to provide a solution to the various (scientific) criticisms of the existing evaluation systems (AMOEBE and NDT).
- the evaluation system is also required to integrate the existing evaluation systems.

Even though the GONZ project is focused on the development of indicators for water and nature policies for the North Sea, some of the indicators are linked to specific environmental policy themes. The ecological quality of the North Sea is influenced by activities along the rivers, especially those that result in higher concentrations of nutrients and micro-contamination in the North Sea. Therefore indicators which are related to the productivity of the North Sea ecosystem contain information regarding the issue of eutrophication (caused by excess nutrient input). Indicators which are developed to describe the effects of various human activities in the North Sea do also contain information regarding environmental policy themes, e.g., TBT distribution by the shipping industry.

2. The design must have an obvious relationship with the water and nature policy objectives.

The development of the indicators was preceded by a condensed analysis of the related national policies (Water and Nature) and the existing evaluation tools (AMOEBE and NDT). The most important elements from the existing tools were the parameters which could be used for the quantification of the indicators. The advantage of using these parameters is that they are already known to both the policy makers and the managers of the ecosystems and could be recognisable by them when presented as key parameters for the indicators.

2a. The Water policy for the North Sea

The Ministry of Transport, Public Works and Water Management (V&W) bears the responsibility for the development and implementation of the water policy for the national waters in the Netherlands. In order to carry out the GONZ project, an analysis of the national water policy objectives was carried out. This was done by studying the third and fourth policy documents for water.

In the Third Memorandum on Water Management policy - NW3 (Ministry of Transport, Public Works and Water Management 1989) - recommendations were made for the sustainable management and utilisation of the water systems. These policy recommendations are the result of a strategy which is based on the concept of integral water management. The basic principle behind this strategy is that the objective of the water policy could be achieved through an integrated approach to the problems of the water systems. These policy recommendations were further specified in the Fourth Memorandum on Water Management (Ministry of Transport, Public Works and Water Management 1997). The Fourth Memorandum also recommended the integration of policies (also from other departments) for water, town and country planning, environment and nature. This policy recommendation created the opportunity for a more area-orientated approach: a combination of an integrated generic approach for the national collective objectives and a more specific regional approach, taking into account the local conditions and opportunities.

The objective of the Fourth Memorandum on Water Management policy is as follows:

“Having and maintaining a safe country and the development and conservation of healthy and resilient water systems which guarantee sustainable utilisation.”

Thus, the water policy for the North Sea is geared towards sustainable development and use of the water system. Fishery and ecological objectives are brought into balance using an integrated approach in relation to the ecosystem qualities. The precautionary and ecosystem approaches are used for this purpose. Coastal expansion plans go hand in hand with investments in the coastal environment. These views were used as targets for realisation in the subsequent years (Ministry of Transport, Public Works and Water Management 1997).

2b. The nature policy

The Ministry of Agriculture, Nature Management and Fisheries (LNV) is responsible for developing policies that will improve the quality of nature in the Netherlands (including the related water systems). This ministry is also responsible for making policy recommendations regarding fisheries in the North Sea. Recommendations for the nature policy in the Netherlands are laid down in the Nature Policy Plan (Ministry of Agriculture, Nature Management and Fisheries 1990). The main objective of the nature conservation policy is defined as:

“sustainable maintenance, recovery and development of natural and landscape values.”

This objectives could be expressed in two words: biodiversity and naturalness.

The most important means for the fulfilment of these objectives is the realisation of the National Ecological Network (Ecologisch Hoofd Structuur - EHS). Species protection-related measures are also taken, such as the shelter of grassland birds and geese outside the EHS. Key points are:

- the EHS is a connected network of ecosystems which are nationally and internationally considered important and are to be durably maintained.
- the EHS must be realised in 2018 and comprise 700,000 ha land and 7,000,000 ha of water (Ministry of Agriculture, Nature Management and Fisheries 1995).
- all large marine and fresh waters, including the total NCP, are key areas within the EHS.

3. The design must provide solutions to the criticism of the existing tools (AMOEBE and NDT).

Problematic issues around the use of the existing evaluation tools

The AMOEBE and NDT approaches use limited numbers of species for evaluation of the water systems. The problem with this is the uncertainty over the drawing up of a one-to-one relationship with regards to making trend analyses of the said species. In the Water policy the biodiversity objectives are evaluated based on a set of species which describe a cross-section of the ecosystem. The occurrence of the species in this set can be controlled to a significant level by managers. This set comprises both common and rare species. The first group can be used to follow the process of change in the ecosystem as a consequence of the policy recommendation, while the second group (rare species) can be used to assess the deviation from the desired situation. The so-called ITZ species (I=species to be conserved from international point of view, T=species that are declining in number, Z=species that are uncommon in the Netherlands) are used for the evaluation of the biodiversity objectives for the nature policy for terrestrial ecosystems. This approach was only effective to a limited extent for the aquatic ecosystems including the North Sea.

The extent of controllability of the ITZ species through policy measures is ambiguous. In practice evaluating biodiversity objectives using the ITZ species are restricted. The observation of changes in the biodiversity can be based upon ITZ species through monitoring. However, rare species can hardly be observed in monitoring programmes. This results in a significant interference, which in turn masks the signal.

Apart from these criticisms, the AMOEBE and the NDT concepts provide opportunities for an integrated evaluation system. The underlying similarities between the two concepts are seen from their attempts to define the ecosystem. The aspects to be defined in the two systems differ but these can be integrated. Integration opportunities lie mainly in enhancing and broadening the scopes of the two evaluation systems. Enhancement can be achieved through the inclusion of natural processes and structural characteristics of the ecosystem other than just species. Broadening can be achieved using another choice and definition of the ecosystem and the related species. The indicators and indicator parameters should then give a general picture of the ecosystems. To develop such a robust indicator systematic, a conceptual framework preceded by a set of criteria is necessary.

Perception of the design

The state of and the changes in the ecological quality of the North Sea can only be understood properly with the use of indicators which are related to the relevant and characteristic processes and patterns (structural characteristics) of the North Sea ecosystem. Therefore the characteristics of the North Sea

ecosystem are pivotal to the development of the evaluation system. The indicators must be linked to one of the various ecosystem characteristics. The relationship between indicators and the mutual water and nature policy themes is specified in the evaluation system using the ecosystem characteristics. The quality of the indicator is determined using one or more parameters. Two groups of indicators can be identified:-

- **system indicators:** these indicators enable observation and quantification of developments in the ecological qualities of the water systems ;
- **utilisation indicators:** these indicators enable analysis and quantification of impacts of use on the ecological quality of the water systems.

By definition the indicators for human activities should be controllable by the use of policy recommendations. The system indicators cannot be controlled by the management forces. The steps taken towards identification of the indicators are shown in the schema below (Figure 2).

1. Water and Nature Policy objectives

2. Biodiversity

Ecological functioning of the North Sea with (sustainable) use

3. Characteristics of the ecosystem

Species (groups)

Productivity

Ecotypes

Feeding structure (types)

Populations

Hydro-, morpho-dynamics

4. Indicators

13 variables

10 variables

Indicator species (monitoring data)	Indicator species (monitoring data)
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Figure 2. The relationship between the policy objectives and the indicators for the North Sea ecosystem.

Identification of the ecological indicators

The process of identifying the ecological indicators for the North Sea started with the analysis of the existing Water and Nature Conservation policies made by the ministries of V&W and LNV respectively (see Figure 2). The Water policy recommendation focuses on the maintenance of a sustainable ecosystem in the North Sea, tolerating human activities that would not hinder the normal ecological functioning of the ecosystem. The Nature policy recommendation focuses on maintaining the wildlife and biodiversity in the ecosystem.

The existing tools (AMOEDE and NDT) were analysed and integrated to cover the main issues of the policy statements. These issues include optimum biodiversity and sound ecological functioning of the ecosystem. Because the existing tools (AMOEDE and NDT) have a common quality of describing the ecosystem, they were analysed and integrated for the purpose of identifying the ecological indicators.

During the integration of the Water and Nature policies, the concept of biodiversity (a central theme for the Nature policy) was extended to include not only species diversity but also community diversities and functional diversities (habitat, ecotypes) in the North Sea. As well as the natural processes of hydro- and structural dynamics, energy transport patterns were used as elements for identification and selection of ecological indicators. For the analysis and description of the functional aspects of the ecosystem a new set of indicators was chosen.

Quality controls in the designing of the indicator system

Every stage in the process of identifying the indicators was analysed for the purpose of maintaining high quality and reproducible products. The relevance of the selected indicators to the policy recommendations and the ecosystem were thoroughly debated before acceptance. Workshops were held between the potential users of the indicators (policy-makers, managers, stakeholders) and researchers whereby general consensus on the methodology and the use of the indicators was reached (Duel *et al.* 1997).

The Nature and Water policies form the basis for the indicator systematic. The policy objectives were then interpreted into more concrete ecological concepts (biodiversity and ecological functioning). These ecological concepts were further described on the basis of the characteristics of the North Sea ecosystem. The relationships between the ecosystem characteristics were used to identify appropriate indicators and the subsequent indicator species for the ecosystem. It was realised during the design that changes in the ecosystem can only be brought into focus when indicators are developed which define the relevant and characteristic processes and structural characteristics of the ecosystem concerned. The following general characteristics of an ecosystem are based on the various organisational levels within the ecosystem and the associated functional aspects which define organisational levels:

- species**, both at individual level (number of species) and populations level (numbers of single species);
- species groups and ecological communities**: composition, structure and succession;
- productivity** of the various trophic levels;
- structure of the food network**: the food chains within an ecosystem and the inter-relationships, transverse connections and contacts;
- hydro-morphodynamics**: processes which cohere with water movements and sediment management that are also controlling elements for the creation of environmental conditions in which species and ecological communities can develop;
- ecotopes**: parts of an ecosystem which can be distinguished on the basis of hydromorphological factors which influence the occurrence of certain species or ecological communities.

Integration of the policy themes

In the integral evaluation system, the policy theme of conservation of biodiversity is coupled with the ecosystem characteristics, ecological community and ecotopes. The outcome is the following types of diversity which were used as bases for the development of biodiversity indicators:

- species diversity (inclusive genetic variation);
- diversity in species groups and ecological communities;
- diversity of habitat and ecotopes.

Although ecological processes are undoubtedly influential to the biodiversity of the ecosystem, indicators dealing with these processes are not included in the interpretation of biodiversity. The influence of ecological processes on biodiversity is based on the development of habitats, species, species groups and ecological communities. The inclusion of ecological processes when defining biodiversity will result in all ecological components being incorporated in diversity, which will result in a significant overlap with ecological functioning, which in turn results in the ecosystem acquiring a non-transparent structure.

The policy theme of **healthy ecological functioning** is evaluated using indicators which are linked to the following ecosystem characteristics:

- productivity;
- structure of the food network;
- hydro and morphodynamics.

There are distinct links between biodiversity and ecological functioning. In the evaluation system, ecological functioning and biodiversity are specified from various standpoints. In the integral evaluation system the interfaces of both themes are expressed using a common set of system indicators.

The policy theme of **ecologically responsible use** is principally under discussion in the Water policy via the route of integral water management in which the ecological values for the North Sea and the economical values of the utilisation are weighed up against each other. The following utilisation functions are dealt with for the North Sea: fishery, shipping industry, recreation, military activities, mining industry, sand excavation and supplementation, land reclamation and infrastructure. This policy theme deals with keeping the balance between the impact of human activities on the ecological quality of the ecosystem and on biodiversity and the ecological functioning of the system. With regard to the indicators for ecologically responsible usage an overlap exists between biodiversity and ecological functioning. The indicators for describing the ecology-conscious usage are placed in a different category of indicators related to usage.

Basic selection criteria for the indicators

The final selection of the indicators and indicator parameters is based on a set of criteria which include:-

a. Criteria for the selection of indicators

- the indicators must be relevant to both the Water and Nature policies;
- the relationship between indicators and ecosystem characteristics must be unambiguously expressed;
- the indicators are quantified by one or more indicator parameters;
- in the indicator systematic, a distinction must be made between system and utilisation indicators;
- the total set of indicators provides the most comprehensive image of the North Sea's ecosystem;
- only indicators and indicator parameters which comply with the selection criteria will be included in the indicator system.

b. Criteria for the selection of indicator parameters

- the indicator parameter must have a significant relevance with the Water and Nature policies.
- the indicator parameters must have a distinct relationship with the process and/or structural characteristics of the North Sea ecosystem;
- one or more indicator parameters must be capable of making the indicator operational;
- the set of indicator parameters must be capable of providing a total picture of the quality of the North Sea ecosystem.

The following technical requirements are very relevant for the selection of the indicator parameters:

1. Measurability: the quality of the indicator parameter must be able to be determined based upon field data and/or model data. Information about the indicator parameters in the form of historic data and time-series is also an advantage.

2. Unambiguity: the direction in which an indicator changes must be unambiguous for the direction in which the ecosystem changes.

- 3. Sensitivity:** the indicators must be able to perceive gradual changes in the ecosystem; a distinction must be made between natural fluctuations and changes due to human activities. The trends and indicator parameters must not have a broad tolerance for changes in environmental factors or ecological processes.
- 4. Broad relationships** with existing evaluation systems is also an advantage.

The selected indicators for the North Sea

Indicators are developed based upon the various characteristics of the ecosystem (see Table 1).

The indicators are made operational by using one or more indicator parameters. The indicator parameters are ecological quantities or units (indices) derived from data on the parameters. The quality of the indicator parameter is determined using field and model data. By using these data, it is therefore possible to carry out policy evaluations both in advance (policy analysis) and in retrospect (monitoring). It is essential that reference points or a time-frame be defined for evaluation of the quality of the indicators. Reference points can be classified into:

- more or less natural reference, based on system definitions of more or less undisturbed situations in the past or comparable systems elsewhere;
- target value, based on a situation which is derived from the natural reference, taking specific social prerequisite constraints into consideration (such as safety, maintaining existing infrastructure and such like);
- standards, values established by the policy and which must be complied with;
- “base-line”, a situation from the past which concerns impact caused by human actions and which serves as a reference point for the evaluation of the current situation and future planned developments; if data is only available for the current situation this can function as a baseline for the evaluation of future planned developments.

Using these reference points, a background can be created which can be used to describe the current quality of the ecosystem as well as recent developments and future developments in the ecosystem.

The integration of policy recommendations and characteristics of the ecosystem resulted in the identification of 23 indicators for the NCP ecosystem (see Table 1). Further development of the individual indicators was strongly based on the available knowledge of the indicator parameter.

As the first step in the development of a workable set of ecological indicators, 13 indicators were selected based on a pragmatic set of criteria. These criteria involved both administrative and technical qualities of the indicators. The administrative criteria were based on the qualities necessary for the use of the indicators for management purposes. The technical criteria is based on the technical requirements necessary for the development of the indicators. The evaluation system has a hierachic structure, in which the following levels are distinguished in descending order: policy themes; ecosystem characteristics; indicators; indicator parameters; and basic data.

Table 1. GONZ Evaluation System Diagram

Policy themes	Ecosystem-characteristic	Indicator	System indicator parameters	Utilisation indicator parameters
biodiversity	species	plankton species diversity	<ul style="list-style-type: none"> •phytoplankton: average number of species •mesozooplankton: Simpson's index 	<ul style="list-style-type: none"> •phytoplankton: average number of species (e) •mesozooplankton: Simpson's index (e)
		macrobenthos species diversity	<ul style="list-style-type: none"> •diversity macrofauna: •number of species •Shannon-Wiener index •Simpson's index •relative abundance of most dominant species 	
		macrobenthos population	<ul style="list-style-type: none"> •Quahog/Icelandic cyprine density •Masked Crab/Helmet Crab density •starfish density 	<ul style="list-style-type: none"> •Quahog/Icelandic cyprine density (v) •Whelk density (s,x) •starfish density (v)
		fishes species diversity	<ul style="list-style-type: none"> •Simpson's fish fauna index •Simpson's fish fauna per length classification index 	<ul style="list-style-type: none"> •Simpson's fish fauna index (v) •Simpson's fish fauna per length classification index (v)
		salt water fishes population	<ul style="list-style-type: none"> •Stingray:fishery mortality and spawning biomass •Fint: spawning biomass 	<ul style="list-style-type: none"> •Herring: fishery mortality and spawning biomass (v) •Cod: fishery mortality and spawning biomass (v) •Plaice: fishery mortality and spawning biomass (v) •Stingray: fishery mortality and spawning biomass (v) •Fint: spawning biomass (i)
		coastal and sea birds species diversity	<ul style="list-style-type: none"> •Simpson's gulls and sterns index (breeding birds) •Herring gull: number of breeding pairs •Mediterranean gull: number of breeding pairs 	
		coastal and sea bird population	<ul style="list-style-type: none"> •Sandwich tern: number of breeding pairs and number of fully-fledged young birds per breeding pair •Kentish plover: breeding pairs •Common scoter: number of mating days in winter 	<ul style="list-style-type: none"> •Sandwich tern :number of breeding pairs and number of fully-fledged young birds per breeding pair (v,x) •Kentish plover: breeding pairs (r) •Lesser black-backed gull: number of breeding pairs (v) •Common scoter: number of mating days in winter (v)
		marine mammals population	<ul style="list-style-type: none"> •Porpoise: number of animals •Common seal: number of animals 	<ul style="list-style-type: none"> •Porpoise: number animals (v,x) •Common seal: number of animals (x)

		distribution area of marine mammals	<ul style="list-style-type: none"> •Porpoise: distribution area •Common seal: resting area 	<ul style="list-style-type: none"> •Porpoise: distribution area (s,v,m) •Common seal: resting area (r,m)
	species groups and ecological communities	plankton community structure	<ul style="list-style-type: none"> •phytoplankton: •length-distribution •ratio of densities between flagellates and diatoms •total duration of flowering of <i>Phaeocystis</i>, <i>Noctiluca</i> and <i>Dinophysis</i> •zooplankton: not yet specified 	<ul style="list-style-type: none"> •phytoplankton: •distribution of length (e) •density ratios between flagellates and diatoms (e) •total duration of <i>Phaeocystis</i>, <i>Noctiluca</i> and <i>Dinophysis</i> flowering (e) •zooplankton: not yet specified
		macro-benthos community structure	<ul style="list-style-type: none"> •ratio density r-and K-strategists 	
		fish community structure	<ul style="list-style-type: none"> •average weight of fishes •biomass percentage fishes >25cm in total fish biomass 	<ul style="list-style-type: none"> •average weight of fishes (v) •biomass percentage fishes >25cm in total fish biomass (v)
	ecotopes	surface of ecotopes	<ul style="list-style-type: none"> •<i>Spisula</i> banks area in ecotope shallow coastal zone •undisrupted gravel banks area •area of undisrupted stone ecotopes in the area of Texelse Stenen 	<ul style="list-style-type: none"> •<i>Spisula</i> –banks area in ecotope shallow coastal zone (v) •undisrupted gravel banks area (v,z) •area of undisrupted stone ecotopes in the area of Texelse Stenen (v)
Ecologically functioning	productivity	primary production	<ul style="list-style-type: none"> •primary production by phytoplankton 	<ul style="list-style-type: none"> •primary production by phytoplankton (e)
		secondary production	<ul style="list-style-type: none"> •secondary production by copepods •secondary production by benthos 	
		tertiary production	<ul style="list-style-type: none"> •somatic fish production 	<ul style="list-style-type: none"> •somatic fish production (v)
		decomposition	<ul style="list-style-type: none"> •starfish density •Masked Crab/Helmet Crab density 	<ul style="list-style-type: none"> •starfish density (v)
	food network-structure	staple food	<ul style="list-style-type: none"> •copepods density: <i>Calanus finmarchicus</i> <i>Temora longicornis</i> •<i>Spisula subtruncata</i> density •Small sand eel: fishery mortality and spawning biomass •Herring: fishery mortality and spawning biomass 	<ul style="list-style-type: none"> •<i>Spisula subtruncata</i> density (v) •Small sand eel: fishery mortality and spawning biomass (v) •Herring: fishery mortality and spawning biomass (v)
		top predators	<ul style="list-style-type: none"> •Cod: fishery mortality and spawning biomass 	<ul style="list-style-type: none"> •Cod: fishery mortality and spawning biomass (v)

			<ul style="list-style-type: none"> •Sandwich Tern: number of breeding pairs and number of fully-fledged young birds per breeding pair •Porpoise: number of animals •Common seal: number of animals 	<ul style="list-style-type: none"> •Sandwich Tern: number of breeding pairs and number of fully-fledged young birds per breeding pair (v,x) •Porpoise: number animals (v,x) •Common seal: number of animals (x)
		complexity of food network	as yet no indicators proposed	
		trophic structure of macrobenthos-community	<ul style="list-style-type: none"> •macrobenthos food groups index (ITI) 	
		trophic structure of fish population	as yet no indicators proposed	as yet no indicators proposed
	hydro and morpho-dynamic	dynamic ecotopes area	<ul style="list-style-type: none"> •sand bar area 	<ul style="list-style-type: none"> •sand bar area (z,i)

Examples to explain the use of the indicators

Example 1: Marine fish population

Relevance and sensitivity of the indicator

Fisheries strongly influence the fish populations in the North Sea, not only the commercially attractive species such as cod, herring, plaice and sole, but also the commercially less important sharks and rays. Ecological sustainability means that the viable fish populations must remain in existence and conservation of biodiversity and ecotopes must advance. The commercial species are the most significant for the fisheries, of which the viable species must also remain in existence. Ecological sustainability and fishery concerns are equally significant for the commercial species. This does not apply for commercially uninteresting species, for which only ecological sustainability is important.

For policy-making purposes the fish population is an obvious group. The situation in which fish stock find themselves makes a statement about both the quality of the North Sea ecosystem and about the utilisation of the ecosystem by the fishery. The population development of the various fish species can be seen as an indicator for the ecological quality of the North Sea. The Water policy is geared towards sustainable development of the water system and a durable utilisation. Sustainability is pivotal for ecological quality and combines both the Nature concerns and the fishery concerns.

Indicator species

The following species have been chosen as indicator species: cod, herring, sand eel and plaice as commercial species; stingray for the non-commercial species. Herring is a pelagic species; of the demersal species cod live and plaice live on the seabed. The different feeding habits are also represented: herring eat zooplankton, plaice eat benthos, cod eat fish and benthos, sand eel eat copepods and worms, and the stingrays eat sand eel and crustaceans.

For the indicator ‘population marine fishes,’ the population parameters of spawning biomass and fishery mortality are used as indicator parameters. Fish species which are characteristic elements of the fish fauna and at the same time reflect the clearly distinguishable form of fishery make up the indicator species (herring, cod, plaice, sand eel and stingray (susceptible to fishery pressure)).

Data compilation and processing methodology

Mortality and spawning biomass of the four species are measured. The monitoring frequency is once per year. There are very few measurements for the stingray.

Developments and trends in previous years

In previous decades, the fish populations in the North Sea have been intensively fished, possibly with the exception of the sand eel. The situation appears to have stabilised somewhat in the last few years and in a few cases a slight recovery appears to have taken place.

The indicator and the current quality of the North Sea

Table 2 presents an image of the current spawning biomass and fish mortality for the four commercial species, with regards to the concern levels proposed by the ICES in 1998. In previous decades the fish mortality of herring, cod and plaice exceeded the concern levels. The sand eel displays a healthy population; herring, cod and plaice are on and around the safe biological minimum (MBAL). The stingray is suspected to be outside the biologically safe limits.

The ICES proposed levels of minimum spawning existence from 1998 (Bpa in tons) and maximum fisheries mortality representation (Fpa) as well as the decline in percentage per year which complies with the proposed fisheries mortality.

Table 2. Indicator parameters for marine fish populations in the North Sea.

Fish type	Bpa	Fpa	%
Herring	800.000	0.30	26
Cod	150.000	0.65	48
Plaice	300.000	0.30	26
Sand eel	600.000	-	-
Stingray	-	-	-

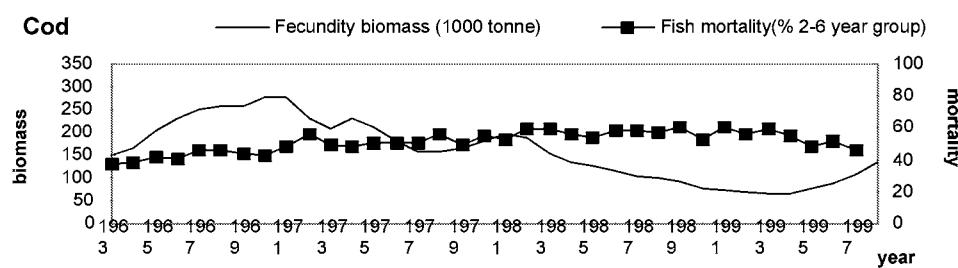


Figure 3. Fecundity biomass and fish mortality for cod.

Example 2 : Sandwich tern (*Sterna sandvicensis*)

Relevance

The Sandwich tern at sea is an indicator of the availability and quality of food. Sandwich terns forage in the Dutch coastal area (to a depth of 20 m) and secure their food by diving from low heights to depths of more than 1 metre. Their food comprises mainly small fish species; along the Dutch coast this is primarily sprat, young herring and sand eel. Further research into the ecology of foraging Sandwich terns is needed, in particular into the impact of water quality on the presence and their ability to catch the food.

As a breeding bird, the species can be used as an indicator for the availability of food in combination with the quality of the foraging areas in the North Sea. The breeding habitat required by this species, slightly

overgrown sandy plains, is constantly under pressure from changes and disturbances. The Sandwich tern broods in colonies in the Scheldt estuary and the Wadden Sea.

The number of Sandwich terns in the Netherlands is largely determined by the availability of breeding areas in combination with the quality of the foraging areas in the coastal area of the North Sea, including the amount of fish, the size of these fish and the quality (accumulation of toxic substances). The numbers of breeding pairs are principally influenced by the availability of suitable breeding biotope. In the Netherlands, in particular the Friesian Islands, a limited amount of breeding biotope is still present, but this is unsuitable due to excessive recreational pressure. An insufficient availability of food in the coastal area can also lead to a reduction in the number of terns that can breed. If this is incidental then it has no impact on the total population range, as Sandwich terns have a long life span.

This bird migrates to Africa in the winter period and the numbers in the Netherlands can be influenced by the situation there. This is why further research into structural changes must always be carried out in order to discover the true cause of population variations.

Trend and current situation

Sandwich terns are virtually only seen along the coast (Stone *et al.* 1995). The distribution is associated with the availability of nesting grounds. Outside the breeding seasons terns normally live in large groups at sea. Figure 4 shows the trend in numbers of Sandwich tern breeding pairs in the Scheldt estuary sector. The trend displays an obvious dip in 1991. This dip was primarily due to the fact that a large section of the "Scheldt population", in Zeebrugge in particular, bred in Belgium. After 1994 the numbers in Zeebrugge declined once more. A section of the breeding birds relocated once more to the Scheldt, but it also became apparent that the total Scheldt population began to grow again (Meininger *et al.* 1999). At the end of the nineties the Scheldt breeding population comprised around 4,500 birds. This is more than the RAMSAR-1%-standard (Rose and Scott 1994).

The number of Sandwich tern breeding pairs in the Wadden Sea follows a slightly rising trend with a dip in 1996. This dip can possibly be explained by a sparse fish availability (herring types), probably as a result of a natural fluctuation. The majority of adult birds then skip a year of breeding, although young Sandwich terns try anyway. (Stienen and Brenninkmeijer 1997).

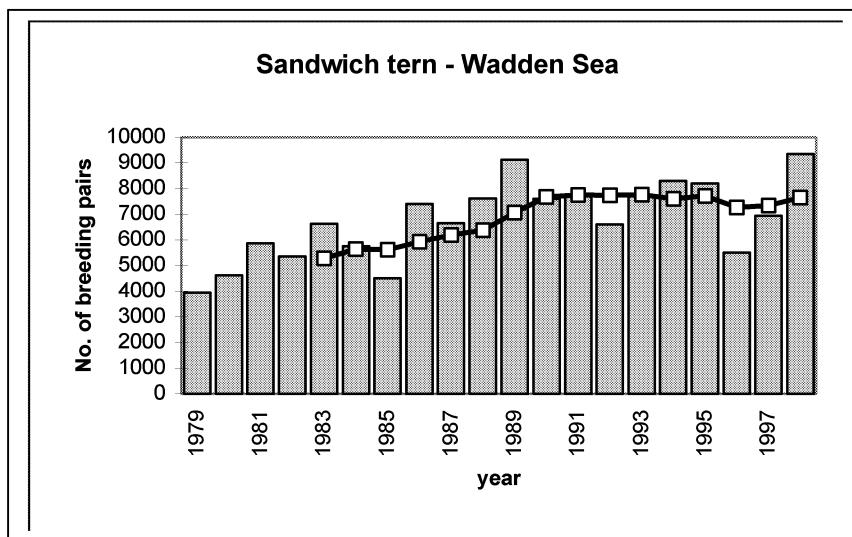


Figure 4. Trend in numbers of breeding pairs of Sandwich terns in the Wadden Sea area, 1979-1998. The black line represents a calculated trend.

Example 3: Trophic structure macrozoobenthos

Relevance and sensitivity

For seabed animals, four different forms of food absorption are recognised. These forms are considered typical to specific forms of food availability, whereby human actions can influence this availability. An index can be calculated using the grouping of species into these four types of food absorption, the Infaunal Trophic Index (ITI). Compared with other indicators such as diversity, biomass, density and level of sedimentation of organic matter, the IT Index is the most sensitive to changes in the structure of the macrozoobenthos community.

Indicator species

A selection is made from all microzoobenthos species which with their specific manner of feeding belong to one of the groups:

1. Suspension feeders: animals which feed on suspended matter, thus floating in the water. This takes place with filter systems or tentacles, fans, arms or a mucous net.
2. Interface feeders: these animals can extract food both from the water and the seabed.
3. Surface deposit feeders: species which are specialised in the detritus (dead organic matter) which lies on the seabed.
4. Subsurface deposit feeders: these animals live off the detritus that is buried in the seabed. Normally a large amount of sediment passes through the intestines of these animals.

Therefore these are not omnivores, predators or herbivores. Subsequently all scarce species are dropped. Ultimately only a small percentage of the animals is left, which is included in the ITI calculations. The IT Index is based upon the total number of species found which belong to one of the stated feeding methods in the selection..

Compilation and processing of the data

When it is determined which animals are to be included in the calculation, from every location or sample, the index can be calculated, using a formula. The multiplication factors 0, 1, 2 and 3 are input in order to obtain a scale distribution. If the result is around 100, then the suspension feeders are dominant for the selected species and the environment is considered stable and barely disrupted. If the result is around 0 then the subsurface deposit feeders are dominant and a large disturbance is probably taking place, almost certainly as a result of human actions.

The ITI can be calculated annually using the microzoobenthos monitoring programme (MWTL). To this end the index is calculated for each sample, after which the median value is presented per sub-sector.

Developments in previous years and current situation

The development of the trophic structure macrozoobenthos indicator in the period (1991-1998).

Oyster grounds (north):

In general relatively high IT indices have been measured in the most northerly sub-sector of the NCS, in particular from 1991-1993, and to a lesser extent in the final years of research, where a drop in the index was perceived. The lowest values of the IT Index in this sub-sector were measured in 1997.

Oyster grounds (south):

In the southern sector of the oyster grounds relatively high figures for the IT Index have been registered, however on average these are slightly lower than in the North. Furthermore, a decline can be seen for the years 1992-1994, although the IT index remained reasonably stable (65-74) between 1995 and 1998 in this sub sector.

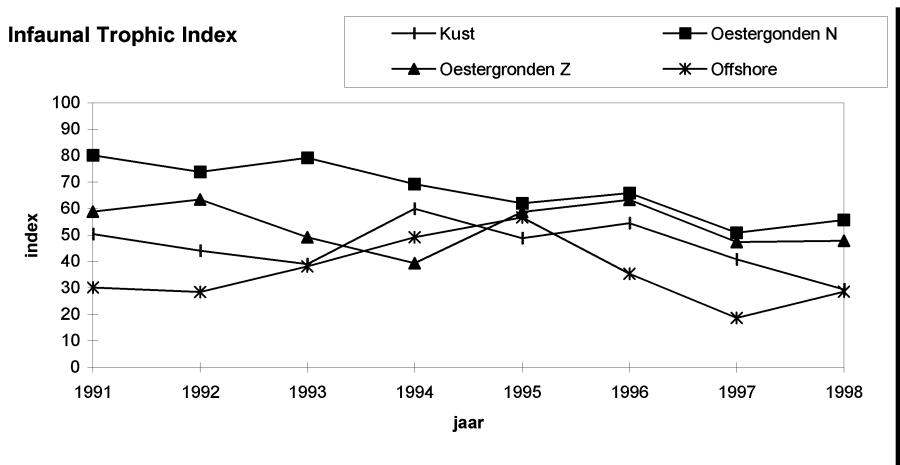


Figure 5. The development of the average ITI in different parts of the North Sea.

Offshore area:

On average a low ITI was found in the offshore area in the years 1991/1992; after an increase up to 1995 a decline was observed during the last three years (1995-1998).

Coastal area:

The widest distribution of the ITI of all four sub-sectors has been observed in the Dutch coastal area. The drop in the index along the coast between 1995 and 1998 is in line with the trend for the offshore area.

The ITI in all four areas shows a drop in the last years. It is striking that the development in the oyster grounds (north and south) shows a conflicting trend. The average spatial distribution of this indicator in the period 1991-1998 shows a high mean ITI in the oyster grounds and at two stations along the coast. The offshore sector shows significantly lower ITI's between 1991 and 1998. It must be kept in mind that the calculation of the index between 1991 and 1994 was carried out using five sub-samples per location, whereas since 1995 only one sample per location is used.

Conclusions

Having based the development of the indicator systematic on the relevant processes and structural characteristics of the North Sea ecosystem, the foundations were laid for the development of indicators for the integral evaluation of the water and nature policy objectives which include:-

- biodiversity
- ecological functioning
- sustainable use of the North Sea ecosystem.

The significant additional benefit of the integral indicator system is that in contrast to the existing evaluation systems (AMOEDE and NDT), the indicator system is based on species, ecological communities, ecotopes, productivity, food network structure, hydro- and morpho-dynamics. This links the assessment and evaluation of the ecological qualities of all sorts of water systems. It creates a better picture of the possible changes in the quality of the ecosystem. In the previous evaluation systems (AMOEDE and NDT), no obvious link was found between the parts of the ecosystem (the species) and the various human activities on the North Sea. The opportunity exists within the indicator evaluation system to evaluate or assess the ecological impacts of human activities in relation to biodiversity and ecological functioning. The impacts of specific human activities such as fisheries could be directly described by using the related (fish and macrozoobenthos) indicators.

The existing monitoring programmes in the Netherlands can supply sufficient information in order to quantify a large number of indicator parameters. In a few cases alteration of the existing monitoring programmes or establishment of an additional monitoring programme is desired.

The development process of the indicators has initiated a communication network between researchers, managers and policy-makers. This communication channel has never been as gainfully used as in the GONZ project. The people involved understand each other and the possibility exist of a collective decision on single sectoral problems as fisheries, sand extraction and eutrophication.

The difficulties with the North Sea in using the indicator systematic is the size of the water mass. The North Sea is big and natural processes play a leading role in the day-to-day changes in the ecosystem. Changes due to humans are mostly local and could be in some way carried over broader areas but with minimum impacts, because the sea has a replenishing component which ensures the cleaning up of the ecosystem to a more balanced and organised state as dictated by the prevailing conditions. Further work in the GONZ project is now being carried out to quantitatively differentiate the changes caused by natural forces from those caused by human activities. The products of this work could be used to reduce some of the uncertainties around the North Sea ecosystem and its behaviour.

References

- Bal, D., Beije, H.M., Hoogeveen, Y.R., Jansen, S.R.J. and Van der Reest, P.J. 1995 *Handboek natuurdoeltypen in Nederland*. (Manual of parameters for nature conservation in the Netherlands). Report. IKC-Nature Management, Wageningen, 278 pages.
- Ten Brink, B.J.E. and Hosper, S.H. 1989 *Naar toetsbare ecologische objectieve voor het waterbeheer: de AMOEDE methode*. (Towards assessable ecological objectives for the water management: the AMOEDE approach). *H2O* 22 (20):612-617.
- Duel, H., Heessen, H., Robbert, J., Lantres, R., Leopold, M. and Marchand, M. (eds.) 1997 *GONZ Indicator development for the North Sea, assessment system for the water and nature policy for the North Sea*. WL, Delft, The Netherlands, 11 pages.
- Kabuta, S.H. and Duijts, H. 1999 Indicators for the North Sea, final report of the project Indicator development for the North Sea (GONZ). *RIKZ Report 20000.022*: 22-26.
- Latour, J.L., Bal, D., Reiling, R., Lammers, G.W. and Bink, R.J. 1993 *Naar een nationale graadmeter voor het natuurlijk milieu*. (Towards a national indicator for the natural environment). RIVM and IKC-NBLF, Bilthoven/Wageningen, 48 pages.
- Meininger, P.L. and Bekhuis, J.F. 1999 De Zwartkopmeeuw *Larus melanocephalus* als broedvogel in Nederland en Europa. (The Mediterranean gull, *Larus melanocephalus* as breeding bird in the Netherlands and Europe). *Limosa* 63: 121-134.
- Ministry of Agriculture, Nature Management and Fisheries 1990 *Nature policy plan. Governmental decision*. SDU, The Hague, 22 pages.
- Ministry of Agriculture, Nature Management and Fisheries 1995 *Ecosystems in the Netherlands*. SDU, The Hague, 28 pages.
- Ministry of Transport, Public Works and Water Management 1989 *Third Policy Memorandum on Water Management*. SDU, The Hague, 17 pages.
- Ministry of Transport, Public Works and Water Management 1997 *Fourth Memorandum on Water Management. Governmental Intention*, The Hague, 6 pages.
- Project Group NW4 1995 *Ruimte voor Water. Visienotitie als aanzet voor discussie*. (Space for Water Vision Memorandum as initiative for debate). The Hague, 10 pages.
- De Vries, I., Laane, R., Jager, Z., Wulffraat, K., Asjes, J. and De Vries, M.B. 1996 *Report from the BEON workshop in the framework of the preparation of the Fourth Memorandum on Water Management (NW4)*. BEON-report, PB BEON and Direct Dutch, The Hague, 39 pages.

6. Catchment to Sub-Regional Assessment Tables

Regional Assessment Tables 1. North West Africa (Morocco) by Maria Snoussi

Table RA 1.1. North West Africa (Morocco): major coastal impacts/issues and critical thresholds

*Overview and qualitative ranking, 1 = minimum, 10 = maximum

Coastal Impact/ Issue	Local site/Region (contributing river basins)	Critical Threshold (for system functioning)	Distance to Critical Threshold (qualitative or quantitative)	Impact category*	References/ Data sources
Erosion	a. Atlantic coast	No specific threshold are available	a. Exceeded. Estimated erosion between 0.05 and 0.4 x10 ⁶ ton/year . The construction of dams has reduced the Sebou sediment flux of nearly 95%. b. Exceeded. Observed coastal erosion of 0.06 x10 ⁶ ton/year 2.5m at Tangiers bay due to the port extension. 94% of the Moulouya sediment flux are trapped behind dams.	a. 7	Snoussi <i>et al.</i> (1990) Charrouf (1991) Probst & Amiotte- Suchet (1992) Zourarab (1994) Haida (2000)
	b. Mediterranean coast			b. 9	
Sedimentation (marine sedimentation due to reduced freshwater inflow or from land -use changes)	Atlantic coast and Mediterranean coast	Not known	Marine sedimentation exceeds fluvial sedimentation in many sites of both the Atlantic and Med. coasts, due to the impoundment of water flows and the reinforcement of the marine influence. The littoral drift is estimated between 0.25 and 8 x10 ⁶ ton/year. All ports and estuaries are silted. 0.7x10 ⁶ m ³ of sediments are deposited annually in the Sebou estuary. This affects navigation channels causing dredging. The inlets of lagoons are periodically closed.	9	Charrouf (1991) Snoussi <i>et al.</i> (2001)
Eutrophication	Atlantic & Med.	Actual limit CNP ratio not known. Excessive algal growth.	Occurrence of low oxygen and high values of nitrogen in estuaries and lagoons. Increasing of frequency of algal blooms	8	Lefebvre <i>et al.</i> (1996) Benasser (1997)

Table RA 1.1. North West Africa (Morocco), continued.

Coastal Impact/Issue	Local site/Region (contributing river basins)	Critical Threshold (for system functioning)	Distance to Critical Threshold (qualitative or quantitative)	Impact category*	References/ Data source
Pollution Human pathogens Heavy metals Pesticides Hydrocarbons	a. Med. coast b. Atlantic	WMO norms and standards. Baselines concentrations of unpolluted soils of the basin	a. Exceeded, loss of biodiversity. Zn, Cd,Hg , BOD, DOC and pesticides are monitored in the the framework of MedPol Programme. Occurene of red tides twice a year b. Increasing background level of heavy metals by a factor of 2 in most areas. High values in biota mainly bivalves	a. 8 b. 9	MAP Technical Reports Series Snoussi (1992) CNE (1995) Cheggour (1999)
Aquatic weeds (usually water h) also include invasive plant species	Med. Coast	Presence (<i>Callierpa</i>)	Exceeded	7	MAP Technical Reports Series
Biodiversity loss (Loss of biological function)	a. Med. Coast b. Atlantic	Change in species composition and abundance	a. Exceeded. Loss of marine turtles (5000/year), monk seals, and red coral reefs due to overexploitation and pollution. Complete loss of <i>Pisidium</i> . b. Declining of fishery stocks, lobsters (Dakhla Bay), octopus and carpet-shells.	a. 7 b.9	MAP Technical Reports Series Meniou (2001)
Salinisation	Coastal plains of Moulouya, Sebou, and Oualidia	Not known. Excess of salts in wells (water for drinking and irrigation)	Exceeded in most of the irrigated coastal plains, due to over-extraction of groundwater, over-use of fertilizers and droughts.	9	Moussaoui (1994) El Mandour (1998)
Human health issues		Presence of disease	Close to threshold in some areas	6	

Table RA 1.2. North West Africa (Morocco): DPSI matrix characterizing major catchment-based drivers/pressures and a qualitative ranking of related coastal state changes and impact versus catchment size class

P = progressive, D = distinct

Driver	Pressures	State change qualitative index	Impact on the coastal system	Time scale
Damming		Medium basins 10 000 – 200 000 km ²		
	Modification of hydrological regime (runoff)	major	Erosion Biodiversity loss Salinisation Human health issues	D
	Modification of morphological processes	major	Sedimentation Erosion	P
	Modification of water quality	major	Eutrophication Pollution Human health issues Biodiversity loss	D
Deforestation	Dam operation	medium	Flood	D
	Modification of vegetation cover Increasing load of fluvial suspended sediments	major	Erosion/Sedimentation Eutrophication Biodiversity loss	P
	Modification of water quality Waste/nutrients (excess fertilizers)	major	Eutrophication Pollution Aquatic weeds Human health issues	P
Agriculture	Modification of vegetation cover	major	Biodiversity loss Sedimentation Eutrophication Biodiversity loss	P
	Modification of morphological processes	major	Sedimentation Erosion	P

Table RA 1.2: North West Africa (Morocco), continued.

Driver	Pressures	State change qualitative index	Impact on the coastal system	Time scale
Agriculture/ continued	Modification of water quantity (surface or ground water) through irrigation Increase of water extraction	major	Sedimentation / Erosion Salinisation	P
Urbanisation	Modification of water quality: Increase of nutrients, metals and BOD-rich waste effluents. Increasing water extraction	major	Eutrophication Pollution Aquatic weeds Human health issues Biodiversity loss	P
Navigation	Dredging. Waste effluents. Ballast. Coastal engineering works	medium	Eutrophication Pollution Aquatic weeds Human health issues Biodiversity loss	P/D
Aquaculture	Increase of nutrients DBO-rich waste effluents	minor	Eutrophication Pollution Introduction of exotic species	P
Industrial waste	Modification of water quality and quantity	major	Eutrophication Pollution Human health issues Biodiversity loss	D (spill) P (bioaccum -ulation)
Climate change	Modification of hydrological regime Accelerated of sea level rise	minor medium	Sedimentation Erosion Biodiversity loss Salinisation Human health issues Erosion Flood / Saline intrusion Biodiversity change	P P
Mining (sands and gravels from rivers and beaches)	Sediment budget alteration Changes of the morphological processes	medium	Erosion/ sedimentation Biodiversity loss	P

Tables RA 1.3 & 1.4. North West Africa (Morocco): Linking coastal issues/impacts and land-based drivers at the catchment and sub-regional scale.

Overview and qualitative ranking on catchment and sub-regional scale: 1 = minimum, 10 = maximum

Coastal Impact/ Issues	Drivers	Local catchment (allowing within and between catchment comparison)	Trend expectations	References/ data sources
Sebou and Moulaya				
Erosion	Damming	Traps sediment from catchment	9	↑
	Deforestation	Energy demand	6	↑
	Agriculture	Overgrazing, extension of farms	8	↑
	Population & urbanisation growth	Increasing demand for space	6	↑
Sedimentation	Climate change	Short-term climate variation	?	?
	Damming	Silting up of reservoirs Reduced flows allowing marine sediments to accumulate	9	↑
Eutrophication	Sewage	Non-point disposal	9	↑
	Agriculture	Leaching of nutrients	8	↑
Pollution	Industrial and domestic waste	Poor disposal of waste, few treatment plants	8	↑
Aquatic weeds	Active human introduction	Accidental by fishermen	6	↑
	Sewage	Non-point disposal	7	↑
	Agriculture	Leaching of chemicals	6	↑
Biodiversity loss	All drivers listed above	Complex interplays of all factors	8	↑
Salinisation	Drought	Over-extraction of coastal groundwater	9	↑
	Sea-level rise	Over-use of fertilizers		Moussaoui (1994) El Mandour (1995)
	Urbanisation	Increasing evaporation		
Human health issues	Sewage	Disposal of human waste	8	↑

Table RA 1.6. North West Africa (Morocco): Scientific and/or Management RESPONSE to coastal impact/issues.

River catchment	RESPONSE catchment scale	RESPONSE Management	RESPONSE Sub-regional (North West Africa)
River catchment	Scientific	Management	Scientific Management
Sebou	Atlas du Sebou (1970) Etat de qualité des Ressources en eau au Maroc (DRPE 1998). Diagnose de l'Etat de l'environnement dans le bassin du Gharb (Benaissa 1997) Bilan des flux du Sebou (Haida 2000)	The 'Office Régional de Mise en Valeur Agricole du Gharb' (ORMVAG) is in charge of the management of the Sebou basin. The Waters and Forests department and the department of Environment have carried out many project in the basin among them the rehabilitation of the Sebou Basin Project.	Guidelines for Integrated Coastal Zone Management in the Mediterranean Region (UNEP, 1995) L'eau dans le bassin Méditerranéen (Economica) (Margat 1992)
Moulouya	Many reports and papers on how to combat silration of dams, soil erosion and salinisation in the basin	Aménagement du bassin de la Moulouya (Eaux et Forêts, in press)	- Med Campus Project (UE): «Gestion des réserves d'eau souterraine dans les zones affectées par la salinisation ». 1994. -Avicenne Project (UE): «Development of water resources management tools for Problem of seawater intrusion and contamination of fresh-water resources in coastal aquifers ». 1995-1999. -FICU Project: (<i>Fond International de Coopération Universitaire: 'Gestion et protection des ressources en eaux, dans les plaines semi-arides au Maroc et en Tunisie.2000-2002'</i> , MATER Project ADIOS Project

Table RA 1.7. North West Africa (Morocco): Hot spots of land-based coastal impact, gaps in understanding, and an overview of issues to be addressed in future research.

River catchment	Hot spot Catchment scale	Hot spot Sub-regional/ Country scale (e.g., Maputo Bay, SADC region)		Hot spot Regional scale	
		Key issues, trend and gaps	Scientific approach	Key issues, trend and gaps	Scientific approach
Sebou and Moulouya	<p><i>Key issues:</i></p> <ol style="list-style-type: none"> 1. Erosion / sedimentation 2. Pollution / health issues 3. Salinisation 4. Biodiversity loss <p><i>Trend:</i> Increasing</p> <p><i>Gaps:</i> Additional data are required to improve the calculations of natural and anthropogenic fluxes, to better understand the functioning of the estuarine zones and to predict the future potential changes.</p>	<p>Monitoring water and sediment fluxes, and water quality parameters.</p> <p>Development of adequate environmental indicators and precise critical thresholds.</p>		<p>Establishment of socio-economic profiles in relation to population changes, industrialisation, agriculture and forestry, and development of economic cost-benefit analysis.</p> <p>Development of numerical models and GIS in relation to future land-use and climate changes, easily readable by managers.</p>	

Regional Assessment Tables: 2. West Africa by I. Niang Diop, A. Kane, C. Gordon and G. Umoh

Table RA 2.1. West Africa: Major coastal impacts/issues and critical thresholds.

Overview and qualitative ranking: 1 = minimum, 10 = maximum

Coastal Impacts/Issues	Local site/Region	Critical Threshold	Distance to Critical Threshold	Impact category	References/ data source
Erosion	a. Volta b. Senegal c. Niger	a. Greater than 1.5x10 ⁶ t/yr b. Greater than 1.5x10 ⁶ t/yr c. Not known	a. Exceeded b. Not exceeded in terms of catchment influence c. Exceeded (not sure of cause)	a. 8 b. 5 c. 8	a. Gordon (1998) b. Diaw <i>et al.</i> (1988, 1990); Barusseau <i>et al.</i> (1993); Ba <i>et al.</i> (1995); Soumare (1996; Kane (1997) c. NEST (1989)
Sedimentation (referring to marine sedimentation due to reduced freshwater inflow or sedimentation due to inappropriate agricultural practices in catchment)	a. Volta b. Senegal c. Niger	a. 2 km of shoreline development over 10 years b. Marine sedimentation exceeding fluvial sedimentation c. Not known	a. Exceeded b. Exceeded c. Exceeded	a. 7 b. 9 c. 6	a. Gordon (1998) b. Diaw <i>et al.</i> (1988, 1990); Barusseau <i>et al.</i> (1993); Ba <i>et al.</i> (1995); Soumare (1996) c. NEST (1989)
Eutrophication (e.g., algal blooms)	a. Volta b. Senegal (potential issue) c. Niger	a-c. When CNP ratio becomes unbalanced, actual limit not known.	a. Exceeded due to presence of algal blooms (offshore and in coastal lagoon) b. Not exceeded c. Exceeded	a. 7 b. 4 c. 7	a. Entz (1969) b. UNEP (1999) c. NEST (1989)

Table RA 2.1. West Africa continued.

Coastal Impacts /Issues	Local site/Region	Critical Threshold	Distance to Critical Threshold	Impact category*	References/ Data source
Pollution Hydrocarbons (1) Heavy metals (2) Pesticides (3)	a. Volta (3) b. Senegal (3) c. Niger (1, 2) d. Cross (1, 2)	a-d. Generic critical thresholds can probably be derived from literature, but currently site Specific values are not available	a. Exceeded, loss of biodiversity b. Not known c. Exceeded (oil pollution) d. Exceeded (oil pollution)	a. 6 b. – c. 8 d. 9	a. Czerni-Chudnenitz (1971); Amoah (1999) b. – c. NEST (1989); CRP (1999) d. CRP (1999)
Aquatic weeds, including invasive plant species	a. Volta b. Senegal c. Niger (nypa) d. Cross (nypa)	a. Presence b. Presence c. Presence d. Presence	a. Exceeded b. Exceeded c. Exceeded d. Exceeded	a. 7 b. 9 c. 7 d. 9	a. De Graft-Johnson (1999) b. Cogels <i>et al.</i> (1993); BDPA- SCETAGRI <i>et al.</i> (1995); Matera & Malaisse (1999) c. CRP (1999) d. AKS (1989)
Loss of Habitat/biodiversity (Loss of biological function)	a. Volta b. Senegal c. Niger (mangroves loss) d. Gambia (mangroves loss)	a-c. Change in species composition and abundance	a. Exceeded b. Exceeded c. Exceeded	a. 7 b. 8 c. 7	a. Gordon (1999) b. Bouso (1992); Cogels <i>et al.</i> (1993); BDPA-SCETAGRI <i>et al.</i> (1995); c. Ibeanu (2000)
Salinisation	a. Senegal b. Niger c. Cross	a. Not known, because the system is complex b. Not known c. Not known	a. Not exceeded b. Exceeded c. Exceeded	a. 5 b. 7 c. 7	a. BDPA-SCETAGRI <i>et al.</i> (1995); Diouf (1998); Pages <i>et al.</i> 1987; Debenay <i>et al.</i> (1994) c. Ibeanu (2000)

Table RA 2.1. West Africa, continued.

Coastal Impacts /Issues	Local site /Region	Critical Threshold	Distance to Critical Threshold	Impact category*	References/ Data source
Human health issues	a. Volta (Invasion of snails/water related diseases) b. Senegal (Invasion of snails/water related diseases) c. Niger (water related diseases) d. Cross (water related diseases)	a. Presence of disease b. Presence of disease c. Presence of disease d. Presence of disease	a. Exceeded b. Exceeded c. Exceeded d. Exceeded	a. 8 b. 8 c. 7 d. 7	a. Derban (1999) b. Handschumacher <i>et al.</i> (1992); Talla (1993); Niang (1999) c. NEST (1989) d. Ibeanu (2000)

Table RA 2.2. West Africa: DPSI matrix characterizing major catchment-based drivers/pressures and a qualitative ranking of related coastal state changes and impact versus catchment size class

NOTE: Expertise and information for medium and small basins in sub-region West Africa was not available for the workshop.

P = progressive, **D** = distinct

Driver	Pressures	State change	Qualitative index	Impact on the coastal system	Time scale
Damming		Large basins > 200 000 km ²	Medium basins	Small basins:	
	Modification of hydrological regime (runoff)	major		Sedimentation Erosion Aquatic weeds Biodiversity loss Salinisation Human health issues	D
	Modification of morphological processes	major		Sedimentation Erosion	P
	Modification of water quality	major		Eutrophication Pollution Aquatic weeds Human health issues	D
	Dam operation	major		Biodiversity loss Flood	D
	Modification of vegetation cover	major		Sedimentation Erosion	P
Deforestation	Modification of morphological processes	medium		Eutrophication Pollution Aquatic weeds Human health issues	P
	Modification of water quality	major		Biodiversity loss	

Table RA 2.2. West Africa continued.

Driver	Pressures	State change	Qualitative index	Impact on the coastal system	Time scale
Agriculture	Modification of water quality	medium		Eutrophication Pollution Aquatic weeds Human health issues Biodiversity loss	P
	Modification of vegetation cover	major		Sedimentation Eutrophication Biodiversity loss	P
	Modification of morphological processes	major		Sedimentation Erosion	P
	Modification of water quantity (surface or ground water) through irrigation	minor		Sedimentation Erosion	P
Human settlement/ Urbanisation	Modification of water quality	major		Eutrophication Pollution Aquatic weeds Human health issues Biodiversity loss	P
	Reduction ground water quantity (abstraction)	medium		Sedimentation Erosion	P
	Deterioration of human health (e.g. through sewage disposal)			Human health issues	P
	Modification of hydrological regime	minor		Sedimentation Erosion Aquatic weeds Biodiversity loss Salinisation Human health issues	P
Climate change				Erosion Flooding Salinisation Biodiversity change	P
	Accelerated of sea level rise	medium			

Table RA 2.2. West Africa continued.

Driver	Pressures	State change	Qualitative index	Impact on the coastal system	Time scale
Bush fires	Modification of water quality	minor		Eutrophication Pollution Aquatic weeds Human health issues Biodiversity loss	D
	Modification of vegetation cover	medium		Sedimentation Eutrophication Biodiversity loss	D
Industrialisation	Modification of water quality	major		Eutrophication Pollution Aquatic weeds Human health issues Biodiversity loss	D (spill) P (bioaccumulation)
	Modification of water quality	medium		Eutrophication Pollution Aquatic weeds Human health issues Biodiversity loss	P
Mining	Modification of hydrological regime	medium		Erosion Sedimentation Biodiversity loss	P
				Aquatic weeds Biodiversity loss Salinisation Human health issues	
Fishing	Modification of water quality	minor		Pollution Biodiversity loss	P
Active human introduction of weeds	Modification of biodiversity	medium		Aquatic weeds Eutrophication Biodiversity loss	P

Table RA 2.3. West Africa: Linking coastal issues/impacts and land-based drivers at the catchment scale.

Overview and qualitative ranking on catchment scale: 1 = minimum, 10 = maximum

Coastal Impact Issues	Drivers	Motivation	Local catchment = Volta	Impact Category	Trend expectations	References/ Data sources
Erosion	Damming	Traps sediment from catchment	9	↑	↑	Kane (1997); Titiku (1998)
	Deforestation	Energy demand	6	↑	↑	
	Agriculture	Overgrazing; trampling by nomad cattle	8	↑	↑	
	Human settlement	3% population increase per year	6	↑	↑	
	Bush fires	Longer dry season results in fires destroying cover	6	⇒	⇒	
	Climate change	Short term climate variation	?	?	?	
Sedimentation	Damming	Reduced flows allowing marine sediments to accumulate	7	⇒	⇒	Gordon (1998)
	Human settlement (sewage)	Non-point disposal	10	↑	↑	
	Agriculture	Leaching of chemicals	6	↑	↑	
	Bush fires	Nutrient rich ashes carried into water	5	⇒	⇒	
	Industrialisation	Poor disposal of waste (point and non-point)	7	↑	↑	
	Mining, pesticides)	Waste from mining	7	↑	↑	
Pollution (e.g., trace metals, hydrocarbons, pesticides)	Fishing	Use of pesticides for fishing	6	↓	↓	Amoah (1999)
	Active human introduction	Florists	7	↑	↑	
	Human settlement (sewage)	Accidental by fishermen	7	↑	↑	
	Agriculture	Non-point disposal	7	↑	↑	
	Bush fires	Leaching of chemicals	7	↑	↑	
	All listed drivers	Nutrient rich ashes carried into water	7	⇒	⇒	
Loss of habitat/biodiversity	All listed drivers	Complex interplay of all factors	8	↑	↑	Gordon (1999)
	Human health issues (sewage)	Indiscriminate disposal of human waste	8	↑	↑	
Human health issues	Human health issues (sewage)	Indiscriminate disposal of human waste	8	↑	↑	Derban (1999)

Table RA 2.3. West Africa, continued.

Coastal Impact / Issues	Drivers	Local catchment = Senegal		Impact Category	Trend expectations	References / Data sources
		Motivation				
Erosion	Damming*	Catchment derived sediment is trapped by damming		5	⇒	Diaw <i>et al.</i> , (1988, 1990); Barusseau <i>et al.</i> (1993); Ba <i>et al.</i> (1995); Soumare (1996)
	Agriculture	Extension of rice farming in delta increased soil erosion		7	↑	
Sedimentation	Damming*	Reduced river flows allow marine sediments to accumulate in estuaries		9	↑	UNEP (1999)
	Agriculture	Permanence of freshwater		4	↑	
Pollution (e.g. trace metals, hydrocarbons, pesticides)	Damming*	Use of pesticides and fertilizers	-		↑	Cogels <i>et al.</i> (1993); BDPA-SCETAGRI <i>et al.</i> (1995); Matera & Malaisse (1999)
	Urbanisation	Sewage and solid waste	-		↑	
Aquatic weeds/ Invasive plants	Damming*	Permanence of freshwater		9	↓	Ibeau (2000)
		Damming divided system into 2 separate ecosystems, i.e. fresh and marine. No estuarine - destroyed		8	?	
Loss of habitat/ Biodiversity	Damming*	Natural. The anti-salt dam was constructed to prevent further upstream salinisation		5	↑ (downstream part) ⇒ (upstream part)	Pages <i>et al.</i> (1987); Debenay <i>et al.</i> , (1994); BDPA-SCETAGRI <i>et al.</i> (1995); Diouf (1998)
	Drought	Created habitat for snails (on freshwater side) that affect the health of the coastal community		8	↑	
Human health issues	Damming*	Sewage disposal		8	↑	Handscombacher <i>et al.</i> (1992); Talla (1993); Niang (1999)
	Urbanisation					

* To prevent further upstream salinisation in the Senegal River (due to drought) a dam wall was erected. Damming divided the system into 2 separate ecosystems, i.e. fresh and marine. The estuarine ecosystem has been destroyed.

Table RA 2.3. West Africa, continued.

Coastal Impact Issues		Drivers	Motivation	Local catchment = Niger	Impact Category	Trend expectations	References / Data sources
Erosion	Agriculture	Poor land management results in soil erosion		8		↑	AKS (1989)
	Deforestation	Cutting down of trees expose the land and results in erosion		8		↑	AKS (1989); NEST (1989); Okoh & Egbon (1999)
Sedimentation	Damming	Reduced river flows allow marine sediments to accumulate in estuaries		6		↑	NEST (1989)
	Agriculture	Use of fertilizer		7		↑	NEST (1989)
Eutrophication	Urbanisation (sewage)	Non-point sources		7		↑	NEST (1989)
	Industrialisation	Petroleum production		9		↑	NEST (1989); AKS (1989)
Pollution (e.g. trace metals, hydrocarbons, pesticides)	Agriculture	Use of pesticides and fertilizers		7		↑	
	Human health issues	Urbanisation (sewage)	Indiscriminate disposal of human waste	7		↑	NEST (1989)
Aquatic weeds, including invasive plants	Transport	Ballast water		7		↑	NEST (1989)
	All listed drivers	Complex interplay of all factors		7		↑	NEST (1989)
Salinisation	?	?		7		↑	Ibeau (2000)

Table RA 2.3. West Africa, continued.

Coastal Impact/ Issues	Drivers	Local catchment = Cross Motivation		Impact Category	Trend expectations	References/ Data sources
		Motivation	Impact Category			
Erosion	Agriculture	Poor land management results in soil erosion	8	↑	AKS (1989)	AKS (1989) Okoh & Egbon (1999)
	Deforestation	Cutting down of trees expose the land and results in erosion	8			
Sedimentation	Agriculture	Poor catchment management results in soil erosion upstream and sedimentation in coastal zone	6	↑	NEST (1989)	NEST (1989)
	Agriculture	Use of fertilizer	7			
Eutrophication	Human settlements/ Urbanisation (sewage)	Non-point sources	7	↑	CRP (1999)	CRP (1999)
	Industrialization	Petroleum production	9			
Pollution (e.g. trace metals, hydrocarbons, pesticides)	Agriculture	Use of pesticides and fertilizers	7	↑	Ibeanu (2000)	Ibeanu (2000)
	Urbanisation (sewage)	Indiscriminate disposal of human waste	7			
Human health issues	Transport	Ballast water	8	↑	AKS (1989)	AKS (1989)
	Invasive plants	Complex interplay of all factors				
Loss of habitat/ Biodiversity	All listed drivers	Complex interplay of all factors		↑	NEST (1989) Ibeanu (2000)	NEST (1989) Ibeanu (2000)
	?	?				

Table RA 2.4. West Africa: Linking coastal issues/impacts and land-based drivers at the sub-regional scale.

Overview and qualitative ranking on sub-regional scale: 1 = minimum, 10 = maximum

Coastal Impacts/Issues	Drivers	West Africa			Trend expectation	References/Data sources
		Related basins	Impact Cat.			
Damming	a. Volta b. Senegal	5-9		⇒/↑	a. Kalifsi (1999) b. Diaw <i>et al.</i> (1988, 1990; Barusseau <i>et al.</i> (1993); Ba <i>et al.</i> (1993); Soumare (1996; Kane (1997)	
	a. Volta b. Senegal c. Niger d. Cross	6-8		↑		a. Titiriku (1999) b. Kane (1997) c. NEST (1989) d. AKS (1989); Okoh and Egbon (1999)
Erosion	a. Volta b. Senegal c. Niger d. Cross	7-8		↑	a. Titiriku (1999) b. Diaw <i>et al.</i> (1988, 1990; Barusseau <i>et al.</i> (1993); Ba <i>et al.</i> (1993); Soumare (1996; Kane (1997)	
	a. Volta b. Senegal c. Niger d. Cross	6		↑		c. NEST (1989) d. AKS (1989)
Urbanisation/ human settlement	a. Volta b. Senegal	6		↑	a. Osei (1969) b. Kane (1997)	
	a. Volta b. Senegal	6		⇒		a. Titiriku (1999) b. Kane (1997)
Bush fires	a. Volta ?	?		?	a. Amissah (1969) b. NEST (1989)	
	a. Cross	6		↑		a. Gordon (1998) b. Diaw <i>et al.</i> (1988, 1990; Barusseau <i>et al.</i> (1993); Ba <i>et al.</i> (1995); Soumare (1996)
Climate	a. Volta b. Senegal c. Niger	6-9		⇒/I	c. NEST (1989)	
	a. Volta b. Senegal c. Niger	7-10		↑		a. Osei (1969) b. NEST (1989)
Sedimentation	Urbanisation/ Human settlement (Sewage)				a. Evans (1969) b. NEST (1989)	
	a. Volta b. Niger c. Cross					a. Evans (1969) b. NEST (1989)
Eutrophication	Agriculture				a. Addo-Ashong (1969) b. Finlayson (1998)	
	a. Volta b. Niger	6-7		↑		a. UNEP (1999)
Bush fires	a. Volta b. Niger	5		⇒	b. Finlayson (1998)	
	a. Senegal	4		↑		a. UNEP (1999)

Table RA 2.4. West Africa, continued.

Coastal Impacts/Issues	Drivers	Related basins	West Africa Impact Cat.	Trend expectation	References/Data sources
Pollution (e.g., trace metals, hydrocarbons, pesticides)	Industrialisation	a. Volta b. Niger c. Cross	7-9	↑	a. Czernin-Chudenzit (1971) b. NEST (1989); CRP (1999) c. CRP (1999)
	Mining	a. Volta	7	↑	a. Czernin-Chudenzit (1971)
	Fishing	a. Volta	6	↓	
	Agriculture	a. Senegal b. Niger c. Cross	7	↑	a. Titriku (1998) b. NEST (1989); CRP (1999) c. CRP (1999)
	Urbanisation/Human settlement (sewage)	a. Senegal	?	↑	a. -
	Damming	a. Senegal	9		a. Cogels <i>et al.</i> (1993); BDPA-SCETAGRI <i>et al.</i> (1995); Matera & Malaisse (1999)
	Active human introduction	a. Volta	7	↑	
	Urbanisation/human settlement (sewage)	a. Volta	7	↑	a. De Graaff-Johnson (1999)
	Agriculture	a. Volta	7	↑	
	Bush fires	a. Volta a. Niger b. Cross	7-8	⇒	a. CRP (1999) b. AKS (1999)
Salinisation	Transport				a. Pages <i>et al.</i> (1987); Debenay <i>et al.</i> (1994); BDPA-
	Drought	a. Senegal	5	⇒/↑	a. Pages <i>et al.</i> (1987); Debenay <i>et al.</i> (1995); Diouf (1998)
	?	a. Niger	7	↑	a. Ibeau (2000)
Human health issues		a. Volta b. Senegal c. Niger d. Cross	7-8	↑	a. Derban (1999) b. Handschumacher <i>et al.</i> (1992); Talla (1993); Niang (1999) c. NEST (1989) d. Ibeau (2000)
	Urbanisation/human settlement (sewage)				a. Handschumacher <i>et al.</i> (1992); Talla (1993); Niang (1999)
	Damming	a. Senegal	8	↑	

Table RA 2.4. West Africa, continued.

Coastal Impacts/Issues	Drivers	West Africa			Trend expectation	References/Data sources
		Related basins		Impact Cat.		
Industrialisation	a. Volta b. Niger c. Cross	7-8	↑		a. Ghana Ministry of Industries (1964)	
Mining	a. Volta b. Niger c. Cross	7-8	↑		b. Ibeanu (2000) c. Ibeanu (2000)	
Fishing	a. Volta	8	↑		a. Gordon (1999)	
Agriculture	a. Volta b. Niger c. Cross	7-8	↑			
Damming	a. Volta b. Senegal c. Niger	7-8	↑			
Active human introduction of weeds	a. Volta b. Niger c. Cross	7-8	↑		a. De Graft-Johnson (1999) b. Ibeanu (2000) c. Ibeanu (2000)	
Loss of habitat/ biodiversity	a. Volta b. Niger c. Cross	7-8	↑			
Urbanisation/Human settlement (sewage)	a. Volta b. Niger c. Cross	7-8	↑			
Deforestation	a. Volta b. Niger c. Cross	7-8	↑			
Climate change	a. Volta b. Niger c. Cross	?	↑		a. Amissah (1969) b. - c. -	
Drought	a. Volta b. Senegal c. Niger d. Cross	7-9	↑		a. Amissah (1969) b. - c. Ibeanu (2000) d. Ibeanu (2000)	
Transport	a. Niger b. Cross	7	↑		a. Ibeanu (2000) b. Ibeanu (2000)	
Bush fires	a. Volta	8	↑		a. Titiku (1999)	

Table RA 2.6. West Africa: Scientific and/or management response to coastal impacts/issues.

River catchment	RESPONSE		RESPONSE	
	Catchment scale	Scientific Management	Sub-Regional	(West Africa) Management
Volta	Ghana water resources management study (1998) Lower Volta environmental impact study (VBRP, 1996-2001) Ghana coastal wetland management project (1992-1997) GEF Integrated coastal zone management strategy for Ghana (World Bank, 1996)	Ghana water resources management study (1998) Lower Volta environmental impact study (VBRP, 1996-2001) Ghana coastal wetland management project (1992-1997) GEF Integrated coastal zone management strategy for Ghana (World Bank, 1996)	Large marine ecosystem Gulf of Guinea Project (1995-2001) UNIDO-GEF Transboundary diagnostic analysis for the Volta Basin UNEP-GEF (ongoing)	Large marine ecosystem Gulf of Guinea Project (1995-2001) UNIDO-GEF Transboundary diagnostic analysis for the Volta Basin UNEP-GEF (ongoing)
Senegal	Michel <i>et al.</i> (1993) L'Apres Barrage dans la vallee du Senegal EQUESEN (1993) Environnement et Qualite des Eaux du fleuve Senegal SEAH (1996) Transformation des Hydrosystemes lies aux grands barrages en Afrique soudanienne et sahelienne BDPA (1996) Bilan Diagnostic du Delta du Senegal	OMVS (Organisation pour la mise en valeur du fleuve Senegal) Initiatives to combat the invasion by macrophytes; others to combat inundations Danish Project for the elaboration of an integrated management of the delta	Mahe (1993) – study referring to all basins discharging to the Atlantic Ocean	Transboundary diagnostic analysis for the Volta Basin UNEP-GEF (ongoing)

Table RA 2.6. West Africa, continued.

River catchment	RESPONSE Catchment scale	RESPONSE Sub-regional (West Africa)
Niger	Environmental Diagnostic Studies (NDES 1997) Niger Delta Development Cooperation (NDDC 2001)	Environmental Diagnostic Studies (NDES 1997) Niger Delta Development Cooperation (NDDC 2001)
	Federal Environmental Protection Agency (FEPA)	Federal Ministry for Environment
Cross	Control of pollution, flood in the Cross river Basin (CRBDA 1976) Environmental Inventory survey (AKS 1989)	Federal Environmental Protection Agency (FEPA) Control of pollution, flood in the Cross river basin (CRBDA 1976) State Minister of the Environment (AKS 1989)

Republique du Senegal/SGPRE; DHI , PNUE , (2001): Gestion integrée du littoral et des bassins fluviaux (GILIF/IRCAM): programme pilote du delta du fleuve Senegal.

GEF/Programme (1999-2004) : Biological diversity conservation. Through participatory rehabilitation of the degraded land of the semi-arid and transboundary areas of Senegal and Mauritania. UNDP/UNEP/GEF 1999-2004.

Republique du Senegal/ Ministere de la Jeunesse de l'Environnement et de l'Hygiene Publique /SP//CONSERE/Unité de Coordination du projet (UCP) (2001): Projet de gestion de la biodiversité marine et cotière. GEF/ Don TF Q24759 /Banque mondiale.

Table RA 2.7. West Africa: Hot spots of land-based coastal impact, gaps in understanding and an overview of issues to be addressed in future research.

River catchment	Hot spot catchment scale		West Africa sub-region		Hot spot Regional scale	
	Key issues, trend and gaps	Scientific approach	Key issue, Trend and gaps	Scientific approach	Key issue, Trend and gaps	Scientific approach
Volta	Erosion	Measurement of slopes, run-off speed and sediment loads	Erosion	Measurement of slopes, speed of runoff and sediment loads	Erosion	Measurement of slopes, speed of runoff and sediment loads
	Sedimentation	Measurements of sediment loads	Sedimentation	Measurements of sediment loads	Sedimentation	Measurements of sediment loads
	Pollution Pesticides	Monitoring water quality parameters in the Volta Lake/ use of questionnaires	Pollution Pesticides	Monitoring water quality parameters/ use of questionnaires	Pollution Pesticides	Monitoring water quality parameters/ use of questionnaires
	Aquatic weeds including invasive plant species	Assessment of species population	Aquatic weeds including invasive plant species	Assessment of species population	Aquatic weeds including invasive plant species	Assessment of species population
	Loss of habitat/ Biodiversity	Assessment of river biodiversity	Loss of habitat/ biodiversity	Assessment of river biodiversity	Loss of habitat/ biodiversity	Assessment of river biodiversity
	Human Health issues	Socio-economic studies/ questionnaire administration	Human health issues	Socio-economic studies/ questionnaire administration	Human health issues	Socio-economic studies/ questionnaire administration
	Coastal changes	Use of aerial photographs and satellite images Monitoring of the Langue de Barbarie sand spit				
	Sediment and chemical fluxes	Field work with sampling sites				
	Control of pollutants (pesticides and fertilizers)	Sampling and analysis of water samples				
	Inundation control	Monitoring of the technical structures (sand bags mainly) and their efficiency				

Table RA 2.7. West Africa, continued.

River catchment	Hot spot catchment scale	Hot spot	West Africa sub-region	Hot spot	Regional scale
Niger	<p>Water pollution</p> <p>Invasion by exotic weeds (nypa palm and water hyacinth)</p> <p>Oil spillage</p> <p>Silting</p> <p>Health problems</p>	<p>Studies of water quality</p> <p>Assessment of the impact of nypa palm and water hyacinth on aquatic population and rural livelihood</p> <p>Assessment of impact of oil spillage on the environment</p> <p>The study of extent an impact of silting on the coastal environment</p> <p>Study of the impact of environmental pollution on human health</p>			
Cross	<p>Beach erosion</p> <p>Nypa palm invasion</p> <p>Oil pollution</p> <p>Biodiversity loss</p> <p>Earth tremors</p>	<p>Study of the extent an impact of beach erosion on coastal environment</p> <p>Assessment of impact on the biodiversity</p> <p>Assessment of extent and effect of oil pollution on environment and people's livelihood</p> <p>Study of biodiversity loss</p> <p>Geological studies of coastal and oil producing community</p>			

Regional Assessment Tables 3. Congo by P. Morant and Susan Taljaard

Table RA 3.1. Congo: Major coastal impacts/issues and critical thresholds.

*Overview and qualitative ranking: 1 = minimum, 10 = maximum

Coastal Impacts/Issues	Local site/Region	Critical Threshold	Distance to Critical Threshold	Impact category*	References/ Data source
Loss of habitat/Biodiversity	Congo	Not known	?	7	UNEP (1999); Morant (2001); Morant pers. comm.
Pollution – hydrocarbons & heavy metals	Congo	Not known	?	3	

Table RA 3.2. Congo: DPSI matrix characterizing major catchment-based drivers/pressures and a qualitative ranking of related coastal state changes and impact versus catchment size class

P = progressive, **D** = distinct

Driver	Pressures	State change Qualitative index	Impact on the coastal system	Time scale
		Large basin > 200,000 km ²		
Deforestation	Loss of coastal habitat (mangroves)	major	Habitat/biodiversity loss	P
Industrialisation	Modification of water quality (oil)	minor	Pollution Habitat/biodiversity loss	P
Human settlements/urbanisation	Loss of coastal habitat	minor	Habitat/biodiversity loss	P

Tables RA 3.3 & 3.4. Congo: Linking coastal issues/impacts and land-based drivers at the catchment and sub-regional scales.

Overview and qualitative ranking on sub-regional scale, 1 = minimum, 10 = maximum

Coastal Impact/Issues	Drivers	Motivation	Impact Category	Trend expectations	References/ Data sources
Pollution (e.g., trace metals, hydrocarbons, pesticides)	Industrialisation	Ship traffic and associated oil pollution (although not expected to be that severe)	3	?	
Loss of habitat/biodiversity	Deforestation	Almost 40% of the total mangrove surface area near the mouth may have been lost through extensive fuel wood cutting (production of charcoal)	7	↑	UNEP (1999); Morant (2001)
	Human settlements/ Urbanisation	Uncontrolled development (human settlements) is listed as one of the threats to the RAMSAR status of the Parc National des Mangroves	3	↑	Morant (2001)
	Industrialisation	Ship traffic and associated oil pollution	3	↓	Morant (2001); Morant, pers. comm

Table RA 3.6. Congo: Scientific and/or Management RESPONSE to coastal impact/issues

River catchment	Scientific	RESPONSE Management
Congo	?	Provision of technical support to the Democratic Republic of the Congo through the Ministry of the Environment and Tourism has been given to allow it to prevent and/or reduce the pollution and degradation of the coastal environment caused by land-based activities (UNEP 1999).

Regional Assessment Tables 4. South West Africa by Susan Taljaard

Table RA 4.1. South West Africa: Major coastal impacts/issues and critical thresholds.

*Overview and qualitative ranking: 1 = minimum, 10 = maximum

Coastal Impacts/Issues	Local site/Region	Critical Threshold	Distance to Critical Threshold	Impact category*	References/ Data source
Sedimentation	a. Gariep b. Olifants c. Berg River	a. Not known b. Not known c. Not known	a. Not exceeded, but could be near threshold (disturbance of sedimentation process in the mouth area) b. Not exceeded c. Not exceeded	a. 4 b. 3 c. 3	a. DWAF (1989); DWAF (1993) b. Huizinga & Van Niekerk (1997) c. DWAF (1994)
Eutrophication (e.g. algal blooms)	a. Saldanha Bay	a. Occurrence of excessive algal growth (e.g. <i>Amorphaecus</i> sp. and <i>Ulothrix</i>)	a. Occasionally passes critical threshold in the mid-late summer, particularly in more stratified and depositional areas of the bay (more than would have occurred naturally)	a. 4	a. Monteiro & Largier (1999); Monteiro <i>et al.</i> (1999)
Aquatic weeds/invasive plants	a. Table Bay b. False Bay	a. Occurrence of nuisance reed beds b. Occurrence of nuisance reed beds	a. Exceeded in some estuaries due to nuisance reed growth b. Exceeded in some estuaries due to nuisance reed growth	a. 4 b. 4	a. Quick & Roberts (1993) b. Taljaard <i>et al.</i> (2000)
Pollution, e.g. Hydrocarbons (1) Heavy metals (2) Pesticides (3)	a. Gariep (3) b. Olifants (3) c. Berg (3) d. Saldanha Bay (1,2) e. Table Bay (1,2) f. False Bay (1,2)	a-c. Generic critical thresholds can be derived from literature, but currently site specific values are not available d-f. For harbours, critical thresholds have been recommended for trace metals (under the London Convention, 1973).	a. Not exceeded b. Not exceeded c. Not exceeded d-f. Localised areas in harbours are close to or exceeding critical limits	a. 2 b. 2 c. 2 d. 4 e. 4	a. DWAF (1993) b. Taljaard (1997) c. DWAF (1994) d. Monteiro & Largier (1999); Monteiro <i>et al.</i> (1999) e. Quick & Roberts (1993); Monteiro (1997) f. Taljaard <i>et al.</i> (2000)

Table RA 4.1. South West Africa, continued.

Coastal Impacts / Issues	Local site/Region	Critical Threshold	Distance to Critical Threshold	Impact category*	References/ Data source
Salinisation (e.g. associated with reduction in freshwater inflows)	a. Gariep b. Olifants c. Berg	a. Not known b. Not known c. Not known	a. Not exceeded b. Not exceeded c. Not exceeded	a. 3 b. 3	a. DWAF (1989) b. Huizinga & Van Niekerk (1997) c. DWAF (1994)
Loss of habitat/ biodiversity	a. Gariep b. Olifants c. Berg d. Saldanha Bay e. Table Bay f. False Bay	a. Not known b. Not known c. Not known d. Not known e. Not known f. Not known	a. Probably exceeded or near through large salt marsh areas being cut off from river by the coastal road b. Not exceeded c. Not exceeded d. Exceeded in localized areas, e.g. harbour area e. Exceeded in localized areas, e.g., estuaries f. Exceeded in localized areas, e.g. estuaries	a. 6 b. 3 c. 3 d. 6 e. 6 f. 6	a. DWAF (1993) b. Huizinga & Van Niekerk (1997); Taljaard (1997) c. DWAF (1994) d. Monteiro & Largier (1999); Monteiro <i>et al.</i> (1999) e. Quick & Roberts (1993) f. Taljaard <i>et al.</i> (2000)
Human health issues	a. False Bay b. Table Bay	a-b. <i>E. coli</i> counts not to exceed 100 counts/100 ml for 80% of the time and 2000 counts/100 ml for 95% of the time	a-b. Thresholds exceeded in localized areas (within 500 m of river mouths and storm water discharges).	a. 4 b. 4	a. CMC (1999) b. Taljaard <i>et al.</i> (2000)

Table RA 4.2. South West Africa: DPSI matrix characterising major catchment-based drivers/pressures and a qualitative ranking of related coastal state changes and impact *versus* catchment size class.

NOTE: Human settlement/Urbanisation, Industrialisation, Mining and Deforestation are not key drivers associated with coastal impacts from the river basins in south-western Africa. Some of these drivers (particularly human settlement/urbanisation and industrialisation), however, are key drivers of coastal impacts in the urban nodes along this stretch of coast, e.g., Saldanha Bay, Table Bay (Cape Town) and False Bay (Cape Town).

P = progressive, **D** = discrete

Driver	Pressures	State change	Qualitative index	Impact on the coastal system	Time scale
		Large basins > 200 000 km ² (Gariep)	Medium basins 10 000 – 200 000 km ² (Olifants)	Small basins < 10 000 km ² (Berg)	
Damming	Modification of hydrological regime (runoff)	medium	medium	medium	Sedimentation Habitat/biodiversity loss P
	Modification of water quality (e.g. salinity regime)	medium	medium	medium	Habitat/biodiversity loss P
	Modification of morphological regime (sedimentation/erosion)	medium	medium	medium	Sedimentation Habitat/biodiversity loss P
	Modification of hydrological regime (runoff)	minor	minor	minor	Sedimentation Habitat/biodiversity loss P
Agriculture	Modification of water quality	minor	minor	minor	Aquatic weeds Pollution P
	Modification of morphological regime (sedimentation/erosion)	minor	minor	minor	Habitat/biodiversity loss Sedimentation P
Transport	Modification of coastal habitat	medium	minor	minor	Habitat/biodiversity loss Sedimentation P
	Modification of hydrological regime (runoff)	?	?	?	Biodiversity loss Erosion P
Climate change	Sea level rise	?	?	?	Salinisation P

Table RA 4.3. South West Africa: Linking coastal issues/impacts and land-based drivers.

Overview and qualitative ranking on catchment scale: 1 = minimum, 10 = maximum

Coastal Impact Issues	Drivers	Motivation	Impact Category	Trend expectations	References/Data sources
		Gariep catchment			
Loss of Habitat/biodiversity	Damming	Reduced river inflow resulted in changes in habitat characteristics, e.g. changes in the salinity regime and characteristics of the substratum	6	↑	DWAF (1989, 1993)
	Agriculture	Water abstraction for irrigation also alters the freshwater inflow	4	↑	
	Transport	Coastal road cut off flood plain from river, thus damaging the flood plain vegetation (salt marsh)			DWAF (1989)
Sedimentation	Damming	Alterations in river flow regime has altered the sedimentation processes in estuaries, altering the duration and timing of mouth closure/opening	6	↑	DWAF (1989, 1993)
	Agriculture	Water abstraction for irrigation also alters the freshwater inflow (see above)	4	↑	
	Damming	During low flow periods saline intrusion from the sea or as a result of high evaporation may affect the quality of ground water resource	4	↑	DWAF (1989)
Salinisation	Agriculture	Water abstraction for irrigation also alters the freshwater inflow (see above)	4	↑	DWAF (1989, 1993)
	Climate change	Sea level rise may increase upstream saline intrusion	?	?	-
Pollution (e.g. trace metals, hydrocarbons, pesticides)	Agriculture	Catchment supports major agricultural activities probably introducing some pesticides to coastal areas.	2?	↑	-

Table RA 4.3. South West Africa, continued.

Coastal Impact Issues	Drivers	Motivation	Impact Category	Trend expectations	References/Data sources
Olifants catchment					
Loss of habitat/biodiversity	Damming	Reduced river inflow resulted in changes in habitat characteristics, e.g. changes in the salinity regime and characteristics of the substratum	4	↑	
	Agriculture	Water abstraction for irrigation also alters the freshwater inflow	3	↑	
Sedimentation	Damming	Reduced river flows allow marine sediments to accumulate in estuaries and altered the duration and timing of mouth closure/opening	4	↑	Huijzinga & Van Niekerk (1997)
	Agriculture	Water abstraction for irrigation also alters the freshwater inflow	3	↑	
Salinisation	Damming	Reduced river inflow results in increased saline intrusion upstream	4	↑	
	Agriculture	Water abstraction for irrigation also reduces the freshwater inflow	3	↑	
Pollution (e.g. trace metals, hydrocarbons, pesticides)	Climate change	Sea level rise may increase upstream saline intrusion	?	?	-
	Agriculture	Catchment supports major agricultural activities probably introducing pesticides to the coastal zone.	2?	↑	Taljaard (1997)
Berg catchment					
Loss of habitat/biodiversity	Damming	Reduced river inflow resulted in changes in habitat characteristics, e.g. changes in the salinity regime, characteristics of the substratum and mouth dynamics.	4	↑	
	Agriculture	Water abstraction for irrigation also alters the freshwater inflow (as above)	3	↑	DWAF (1994)
Sedimentation	Damming	Reduced river flows allow marine sediments to accumulate in estuaries and altered the duration and timing of mouth closure/opening	4	↑	
	Agriculture	Water abstraction for irrigation also alters the freshwater inflow (as above)	3	↑	

Table RA 4.3. South West Africa, continued.

Coastal Impact Issues	Drivers	Motivation	Impact Category	Trend expectations	References/Data sources
Berg catchment continued					
Salinisation	Damming	Reduced river inflow results in increased saline intrusion upstream	4	↑↑	
	Agriculture	Water abstraction for irrigation reduces the freshwater inflow (as above)	3	↑↑	
	Climate change	Sea level rise may increase upstream saline intrusion	?	?	-
Pollution (e.g. trace metals, hydrocarbons, pesticides)	Agriculture	Catchment supports major agricultural activities probably introducing pesticides to the coastal zone.	2	↑↑	DWAf (1994); Slinger & Taljaard (1994)
Saldanha Bay					
Loss of Habitat/ Biodiversity	Urbanisation	Physical loss of habitat due to development in the coastal zone	3	↑↑	
	Industrialisation	Physical loss of habitat due to development in the coastal zone	3	↑↑	
Eutrophication	Industrialisation	Increase in concentrations of nutrients due mainly to fish factory effluents	6	↑↑	
Pollution (e.g. trace metals, hydrocarbons, pesticides)	Industrialisation	Industries associated with the harbour contributes to toxic pollutant loads (e.g. trace metals and hydrocarbons)	4	↑↑	Monteiro & Largier (1999); Monteiro <i>et al.</i> (1999)
	Urbanisation	Storm water runoff from built-up urban areas contributes to localized toxic pollutant loads (e.g. trace metals and hydrocarbons)	4	↑↑	
Human health issues	Industrialisation	Increase in human pathogens due mainly to fish factory effluents	4	↑↑	
Erosion	Climate change	Sea level rise may result in coastal erosion	?	?	-

Table RA 4.3. South West Africa, continued.

Coastal Impact Issues	Drivers	Motivation	Impact Category	Trend expectations	References/Data sources
Loss of habitat/biodiversity	Urbanisation	Physical loss of habitat due to urban development in the coastal zone.	4	↑	
Sedimentation	Urbanisation	Alteration in the flow regime (increase in runoff due to increase in built-up areas) alters the habitat, e.g., salinity regime			
Aquatic weeds/invasive plants	Urbanisation (sewage)	Poor catchment management results in soil erosion upstream and sedimentation in coastal areas (e.g., estuaries)	3	↑	Quick & Roberts (1993)
Pollution (e.g., trace metals, hydrocarbons, pesticides)	Agriculture	Increase in concentrations of nutrients due to sewage point source and non-point source disposal results in excessive reed growth in some estuaries along the bay	4	↑	
	Industrialisation	Use of fertilizer in the catchment results in excessive reed growth in some estuaries along the bay	4	↑	
Human health issues	Urbanisation	Industries and activities associated with the harbour contributes to localized toxic pollutant loads (e.g., trace metals and hydrocarbons)	4	↑	Quick & Roberts (1993), Monteiro (1997)
Erosion	Climate change	Storm water runoff from built-up urban areas contributes to localized toxic pollutant loads (e.g., trace metals and hydrocarbons)	4	↑	Quick & Roberts (1993)
		Increase in human pathogens due contaminated storm water runoff in localized areas along the coast	?	?	-
		Sea-level rise may result in coastal erosion			

Table RA 4.3. South West Africa, continued.

Coastal Impact Issues	Drivers	Motivation	Impact Category	Trend expectations	References/data sources
Loss of Habitat/ Biodiversity	Urbanisation	Physical loss of habitat due to urban development in the coastal zone	4	↑↑	
Sedimentation	Urbanisation Agriculture	Alteration in the flow regime (increase in runoff due to increase in built-up areas) alters the habitat, e.g., salinity regime Poor catchment management results in soil erosion upstream and sedimentation in coastal areas (e.g., estuaries)	3 3	↑↑ ↑↑	
Aquatic weeds/invasive plants	Urbanisation (sewage) Agriculture	Increase in concentrations of nutrients due to sewage point source and non-point source disposal results in excessive reed growth in some estuaries along the bay Use of fertilizer in the catchment results in excessive reed growth in some estuaries along the bay	4	↑↑	Taljaard <i>et al.</i> (2000)
Pollution (e.g., trace metals, hydrocarbons, pesticides)	Industrialisation	Industries and activities associated with the harbour contributes to localised toxic pollutant loads (e.g. trace metals and hydrocarbons)	4	↑↑	
Human health issues	Urbanisation	Increase in human pathogens due to contaminated storm water runoff to the coastal zone	4	↑↑	
Erosion	Climate change	Sea-level rise may result in coastal erosion	?	?	-

Table RA 4.4. South West Africa: Linking coastal issues/impacts and land-based drivers at the sub-regional scale.

Overview and qualitative ranking on sub-regional: 1 = minimum, 10 = maximum

Coastal Impacts/Issues	Drivers	South-western Africa			Trend expectation	References/data sources
		Related basins	Impact Category			
Erosion	Climate change	a. Saldanha Bay b. Table Bay c. False Bay	?	?	↑	-
	Damming	a. Gariep b. Olifants c. Berg	4-6		↑↑	a. DWAF (1989, 1993) b. Huizinga & Van Niekerk (1997) c. DWAF (1994)
	Agriculture	a. Gariep b. Olifants c. Berg	3	↑↑		
Sedimentation	Damming	a. Berg b. Olifants	4	↑↑		a. Huizinga & Van Niekerk (1997) b. DWAF (1994)
	Agriculture	a. Berg b. Olifants	3	↑↑		
	Climate change	a. Gariep b. Olifants c. Berg	?	?	-	
Salinisation	Industrialisation	a. Saldanha Bay	6	↑↑		a. Monteiro & Largier (1999); Monteiro <i>et al.</i> (1999)
	Pollution (e.g., trace metals, hydrocarbons, pesticides)	a. Saldanha Bay b. Table Bay c. False Bay	4	↑↑		a. Monteiro & Largier (1999); Monteiro <i>et al.</i> (1999) b. Quick & Roberts (1993) c. Taljaard <i>et al.</i> (2000)
	Urbanisation/Human settlements	a. Table Bay b. False Bay	4	↑↑		a. Quick & Roberts (1993) b. Taljaard <i>et al.</i> (2000)

Table RA 4.4. South West Africa, continued.

Coastal Impacts/Issues	Drivers	South western Africa		Trend expectation	References/Data sources
		Related Basins	Impact Category		
Aquatic weeds/ invasive plants	Urbanisation/Human settlements	a. Table Bay b. False Bay	4	↑	
	Agriculture	a. Table Bay b. False Bay	4	↑	
	Urbanisation	a. Table Bay b. False Bay	4	↑	
Human health issues	Industrialisation	a. Saldanha Bay	4	↑	a. Monteiro & Largier (1999); Monteiro <i>et al.</i> (1999)
	Damming	a. Gariep b. Olifants c. Berg	4-6	↑	a. DWAF (1989, 1993) b. Huizinga & Van Niekerk (1997) c. DWAF (1994)
	Agriculture	a. Gariep b. Olifants c. Berg	3	↑	
Loss of habitat/ biodiversity	Human settlements/ Urbanisation	a. Table Bay b. False Bay	4	↑	a. Quick & Roberts (1993) b. Taljaard <i>et al.</i> (2000)
	Industrialisation	a. Saldanha Bay b. Table Bay c. False Bay	4	↑	a. Monteiro & Largier (1999); Monteiro <i>et al.</i> (1999) b. Quick & Roberts (1993) c. Taljaard <i>et al.</i> (2000)
	Transport	a. Gariep	6	⇒	a. DWAF (1989)
Climate change		a. Gariep b. Olifants c. Berg d. Saldanha Bay e. Table Bay f. False Bay	?	?	-

Table RA 4.6. South West Africa: Scientific and/or management response to coastal impact/issues.

River catchment	RESPONSE Catchment scale		RESPONSE Sub-regional (South Africa)	
	Scientific	Management	Scientific	Management
Gariep	-	-		
Olifants	-	-		
Berg	CSIR's catchment-to-coast initiative in this area	Department of Water Affairs and Forestry to initiate a monitoring programme in the area	-	The National Water Act of South Africa (Act 36 of 1998) states that the natural environment has a right to water. As a result, the quantity and quality of water and other resource quality objective need to be determined for river catchments. The national Department of Water Affairs and Forestry are responsible for setting the 'Reserve and Resource Quality Objectives' for catchments, including estuaries. To facilitate implementation of these measures, the law requires that Catchment Management Agency (CMA) and Catchment Management Forums be put in place for each basin.
Saldanha Bay	Joint CSIR – Marine and Coastal Management (Department of Environmental Affairs) Project (Monteiro & Largier, 1999)			
Table Bay	-	-		
False Bay	Review on anthropogenic inputs undertaken in 2000 (Taljaard <i>et al.</i> , 2000)	-		

Table 4.7. South West Africa: Hot spots of land-based coastal impact, gaps in understanding and an overview of issues to be addressed in future research.

Although there are some potential hotspots in this sub-region, these are not as serious as those identified, for example along the other parts of West Africa. If one needs to ID hotspots in this region, it would probably be the two basins Gariep (Priority 2) and Berg (Priority 1), while Saldhana Bay is probably the 'hottest spot' of the 3 coastal nodes.

River catchment	Key issue, trend and gaps	Scientific approach
	Hot spot	Catchment scale
Gariep	<ul style="list-style-type: none"> Impacts of altered freshwater inflow (and possibly also reduced sediment input), as a result of damming and agricultural use, on the coast (as well as associated industries such as diamond mining and fishing) has not been established 	<p>Monitoring required to determine the extent and severity of current impacts on the coast and to establish linkages with catchment-derived drivers</p> <p>Predictive capabilities currently applied in other southern African catchments be implemented and adapted for the Gariep to provide scientific support underpinning effective management</p>
Berg	<ul style="list-style-type: none"> Changes occurred in the hydrological regime (reduction in inflow) and geomorphology due to upstream damming Further damming is under consideration Additional data are required to predict the extent, severity and implication of damming with greater confidence 	<p>The Department of Water Affairs and Forestry is in the process of initiating an extensive monitoring programme.</p> <p>The CSIR is developing numerical tools (through the catchment-to-coast initiative) to provide sound scientific predictive capabilities essential for effective management of coastal issues</p>
Saldanha Bay	<ul style="list-style-type: none"> Increasing urbanisation and industrialization results in impacts, such eutrophication and pollution. Extensive research studies has already provided valuable scientific understanding, but these need to be transformed into effective, practical management plans to address issues. 	<p>The Saldanha Bay Water Quality Forum has been established to coordinate management efforts towards addressing key issues</p> <p>The CSIR has set up sophisticated hydrodynamic and water quality numerical models so as to provide sound scientific predictive capabilities essential for effective management of the area</p>

Regional Assessment Tables 5. Nile sub-region by Hassan Awad

Table RA 5.1. Nile - Major coastal impacts/issues and critical thresholds

*Overview and qualitative ranking: Impact code and relative class of importance: 1 = minimum, 10 = maximum

Coastal Impact/ Issue	Local site/Region (contributing river basins)	Critical Threshold (for system functioning	Distance to Critical Threshold (qualitative or quantitative)	Impact category*	References/ Data source
Erosion	a. Rosetta promontory b. Burullus Lake area c. Damietta promontory	a. Current erosion rate 53-102 m/yr b. Erosion rate: 5.5 m/yr c. Erosion rate: 10.4 m/yr	a. Aswan Dam (1968) prevented sediment discharge (160 Mt/yr) into Mediterranean. b. Frihy & Dowidar (1993) c. Frihy & Komar (1993)	9	a. Hydraulic Resource Analysis (1992; Frihy & Lofty (1994); Frihy <i>et al.</i> (1994) b. Frihy & Dowidar (1993) c. Frihy & Komar (1993)
Sedimentation	All Mediterranean coastal lagoons	Area reduced from 960,000 to 260,000 hectares in last 40 years	Uncontrolled land reclamation; urbanisation	8	Hanafy(1998)
Eutrophication	Abu Qir Bay, adjacent to Nile Delta	High nutrient loads, especially P through agricultural drainage and sewage NH ₄ – 6-14.2 µg/l NO ₃ – 5.7-19 µg/l PO ₄ – 1-4 µg/l O ₂ - <4 mg/l Chl.a : 15-48 µg/l	Redfield ratio is broken C:N:P 82:5.5:1	6	Abdel Aziz & Dorgham (1999); Abdel Aziz <i>et al.</i> (2001); El Rayis <i>et al.</i> (1994)
Alexandria City Coast	Nearshore waters receive 200x10 ³ m ³ of untreated domestic sewage from two outfalls. Around these sites nutrients are normally found in high concentration: NH ₄ – 14.5-38.7 µg/l NO ₃ – 5.7-19 µg/l PO ₄ – 1-6 µg/l O ₂ - <4 mg/l Chl.a : 34-107 µg/l	Redfield ratio is broken C:N:P 218:4:1	Zaghoul & Halim (1992); Dorgham <i>et al.</i> (2001)	5	

Table RA 5.1. Nile, continued.

Coastal IMPACT / ISSUE	Local site/Region (contributing river basins)	Critical Threshold (for system functioning)	Distance to Critical Threshold (qualitative or quantitative)	Impact category*	References/ Data source
Pollution	Mex Bay (River Nile)	Receives 2 bm^3/yr mixed wastewater loaded with $220 \times 10^3 \text{ t}/\text{yr}$ BOD; $75 \times 10^3 \text{ t}/\text{yr}$ COD; $2 \times 10^3 \text{ t}/\text{yr}$ TN; $2.6 \times 10^3 \text{ t}/\text{yr}$ TP & $287 \times 10^3 \text{ t}/\text{yr}$ TSS. Standing stocks: 840 t/yr TN; 30 t/yr TP & 3000 t/yr TSM. The Bay environment also receives $75 \times 10^3 \text{ t}/\text{yr}$ toxic metals (Hg, Cd, Cr, Cu, Zn & Ni) and 1300 t/yr of Oil.	Hot spot in the Mediterranean; alteration in biodiversity; eutrophication; high levels of toxic heavy metals and PAH are frequently detected in marine fauna and flora; negative impact on fisheries and fish speciation.	9	UNEP (1990); Younes <i>et al.</i> (1997); UNEP/WHO (1999)
Alexandria City Coast		Receives 145 Mm^3/yr domestic wastes loaded with $1.5 \times 10^3 \text{ TN}; 2.3 \times 10^3 \text{ t}/\text{yr}$ TP & $8.8 \times 10^3 \text{ t}/\text{yr}$ TTS & 540 t/yr Oil wastes from refineries	Hot spot in the Mediterranean. Health hazards from near shore untreated discharge of sewage. Eutrophication and Red Tide. Negative impact on fisheries and on submerged archaeological heritage.	5	Atta(1985); UNEP(1990); Awad (1995); UNEP/WHO (1999)
Abu Qir Bay (River Nile)		Receives 410 Mm^3/yr mixed wastewater With $90 \times 10^3 \text{ t}/\text{yr}$ BOD; $57.5 \times 10^3 \text{ t}/\text{yr}$ COD; $5 \times 10^3 \text{ t}/\text{yr}$ TN; $8.5 \times 10^3 \text{ t}/\text{yr}$ TP and $120 \times 10^3 \text{ t}/\text{yr}$ TSS.	Hot spot in the Mediterranean. The Bay's environment suffers from high load of industrial wastes and untreated sewage discharge especially black liquor and fertilizer industry wastes	9	El Deeb (1977); UNEP(1990); UNEP/WHO (1999); Younes <i>et al.</i> (1997); Awad & Yousef (2001)
Edku Lake (River Nile)		Agriculture drains receive about $1 \text{ hm}^3/\text{yr}$ drain water. Discharge 400 Mm^3/yr of brackish water into Abu Qir Bay loaded with $12 \text{ t}/\text{yr}$ NO_2 , $8 \text{ t}/\text{yr}$ NO_3 and $9 \text{ t}/\text{yr}$ PO_4 . $\pi = 20-60 \text{ d}$, $p-r = 3.2 \text{ mmol/m}^2/\text{d}$ in summer and $1.3 \text{ mmol/m}^2/\text{d}$ in winter; $n_{fix-denit} = 1.6 \text{ mmol/m}^2/\text{d}$ in summer and $22.7 \text{ mmol/m}^2/\text{d}$ in winter	Nitrogen fixing system frequently its discharged water quality cause eutrophication in the Abu Qir Bay receiving environment	5	Saad (1997); Awad & Hassan (1998); Awad & Yousef (2001)

Table RA 5.1. Nile, continued.

Coastal Impact/ Issue	Local site/Region (contributing river basins)	Critical Threshold (for system functioning)	Distance to Critical Threshold (qualitative or quantitative)	Impact category*	References/Data source
Burdullus Lake (River Nile)	Discharge into Mediterranean 2.2 bm^3/yr brackish water loaded with insignificant N & P; (0.03 t/yr NO_3 ; 0.2 t/yr NO_2 and 0.01 t/yr PO_4)	Clean coastal lagoon considered as natural reserve	0	Saad (1997); Awad & Hassan (1998)	
Manzala Lake (River Nile)	Receives 1.7 bm^3/yr of partially or untreated wastes, discharges 7 bm^3/yr into the Mediterranean loaded with 40 t/yr NO_3 ; 156 t/yr NO_2 and 71 t/yr PO_4	Hot spot in the Mediterranean	9	EEAA (1992); Awad & Hassan (1998)	
Damietta Nile Estuary	Stop discharging freshwater into the Mediterranean following the construction of the El Salam Canal transporting Nile water to Sinai (3.3 bm^3/yr) for irrigation		2		
Baridawil Lake	Sensitive area, hypersaline lagoon, no discharge and free of pollution	Overfishing area (fish catch decreased in 1992 by 40% relative to that of 1970). Biodiversity under threat following the arrival of Nile waters through the El Salam Canal and agriculture activity around the lake with increasing settlement. Impacts on groundwater quality and coastal erosion are predicted.	0	UNEP/WHO (1999)	
Salinisation				EEAA (1992)	

Table RA 5.2. Nile: DPSI matrix characterizing major catchment-based drivers/pressures and a qualitative ranking of related coastal state changes and impact versus catchment size class.

P = progressive, D = discrete

Driver	Pressures	State change	Qualitative index	Impact on the coastal system	Time scale
	Large basins $> 200\,000 \text{ km}^2$	Medium basins 10 000 – 200 000 km^2	Small basins: $> 10\,000 \text{ km}^2$		
Damming	Changing hydrology	major	-	Coastal erosion, land loss Severe reduction in sediment discharge Nutrient supply loss Salinisation	P
Agriculture	Increased nutrient and pesticide fluxes	major	-	Eutrophication Degradation of groundwater quality	P
Urbanisation and Industrialisation	Sewage production Industrial waste production Deterioration in water quality	major	-	Pollution Eutrophication Health hazards Biodiversity Fisheries Recreation	P

Tables RA 5.3 & 5.4. Nile: Linking coastal issues/impacts and land-based drivers at the catchment and sub-regional scales

Overview and qualitative ranking on sub-regional scale: Impact code and relative class of importance: 1 = minimum, 10 = maximum

Coastal Impact/Issues	Drivers	Local catchment (allowing within and between catchment comparison)		Trend expectations	References/ Data sources
		Impact Category			
Erosion	Damming Climate change	Mouths of Rosetta and Damietta distributaries Possible contributor to coastal erosion	8 8	↑ ↑	Sestini (1992); Frihy & Komar (1993); Stanley (1996)
Eutrophication	Agriculture Urbanisation Industrialisation	High consumption of fertilizers Uncontrolled coastal urbanisation without sewage treatment facilities High loaded wastes with organics	? ? ?	? ? ⇒	Awad (1994) EEAA (1996) Awad (1994)
Pollution	Damming Agriculture Urbanisation Industrialisation	Around Hot Spots Around Hot Spots Around Hot Spots	7 7 7	↓ ⇒ ⇒	EEAA (1996) EEAA (1992)
Biodiversity loss	Damming Agriculture Urbanisation Industrialisation	Usage of high quantities of pesticides Landfilling of coastal lagoons Hazardous wastes discharge	? 8 ?	? ↑ ⇒	Hanafy (1998) Awad (1994)
Human health issues	Damming Agriculture Urbanisation Industrialisation	Pesticides usage Discharge of untreated domestic/industrial wastes in coastal lagoons and the river Atmospheric precipitation in industrial zones around coastal lagoons	? 8 8	↓ ⇒ ⇒	Awad (1994) Abo Zahra (2000) EEAA (1992, 1996)

Table RA 5.6. Nile: Scientific and/or management response to coastal impact/issues in African coastal zones on catchment, sub-regional and regional scales

River catchment	RESPONSE Catchment scale		RESPONSE Sub-regional/ Country scale		RESPONSE Regional scale	
	Scientific	Management	Scientific	Management	Scientific	Management
Nile	Nile water quality monitoring. Coastal water quality monitoring.	Legislation and enforcement measures since 1994. Creation of EEAA. (Egyptian Environmental Affairs Agency) and its 8 Regional Branches. National CZM plan and committee. Implementation of national programmes for: -Nile water monitoring -Shoreline protection and planning -GIS data base -Domestic/industrial waste treatment	MedPol programmes MedGOOS monitoring Environmental Information Monitoring Programme	MAP/UNEP MAMA/IOC EIMP/DANIDA	MedPol programmes MedGOOS monitoring	MAP/UNEP MAMA/IOC EIMP/DANIDA

Table RA 5.7. Nile: Hot spots of land-based coastal impact and gaps in understanding as well as a first overview of issues to be addressed in future research.

River catchment	Hot spot Catchment scale		Sub-regional/ Country scale	Hot spot Regional scale	Hot spot National scale
	Key issue, trend and gaps	Scientific approach			
Nile	<ul style="list-style-type: none"> • River water quality • Loss of fisheries • Pollution • Erosion • Land-filling 	<ul style="list-style-type: none"> • Biogeochemical studies especially in coastal lagoons • Modeling of hazardous substances dispersion in coastal waters • Assessment of pollution receiving water assimilation capacity • River, lagoons and coastal living resource management • Biodiversity • Shoreline protection/planning management • Pollution control management • Stakeholders awareness 			

Regional Assessment Tables 6. East Africa *by J. Kitheka, J. Ochiwo and A. Ngusaru*

Table RA 6.1. East Africa: Major coastal impacts/issues and critical thresholds.

Many of the reported coastal issues in this sub-region are linked not to activities within catchments, but rather to land-based activities at the coast itself, notably related to the major urban nodes of Dar es Salaam and Mombasa, and coastal tourism development.

*Overview and qualitative ranking on catchment scale. Impact code and relative class of importance: 1 = minimum, 10 = maximum

Coastal IMPACT / ISSUE	Local site/Region (contributing river basins)	Critical Threshold (for system functioning)	Distance to Critical Threshold (qualitative or quantitative)	Impact category*	References/ Data source
Erosion	a. Tana delta b. North Kenya coast (Shanzu, Kanamai), South Kenya coast (Diani, Likoni); contributing rivers unknown c. Bagamoyo and Dar es Salaam (Ruvu river) d. Rufiji e. Mtwara-Lindi stretch (Mbenkuru and Ruvuma rivers) f. Kilwa (Rufiji river) g. Jambiani, Paje, Maruhubi, Nungwi areas in Zanzibar	a. Not known b. Not known c-g. Not known	a. Not known b. Critical load already passed c. Critical load already passed for Bagamoyo and Dar es Salaam (4m retreat per year) d-f. Erosion considered to be occurring, rate unknown g. Critical load passed for Jambiani, retreat estimate unknown	8	a. Raal & Barwell (1995); b. Knocker (1998) c-g. Mushala (1978); Ross and Saint-Ange (1986); Fay (1987, 1992), Griffiths (1987); Lwiza & Bigendako (1988); Arthurton (1992); Shaghude <i>et al.</i> (1994); Arthurton <i>et al.</i> (1999); ICMP (2000, 2001); Ngusaru <i>et al.</i> (2001); UNEP (2001)
Sedimentation (e.g. marine sedimentation due to reduced freshwater inflow or from agricultural practices)	a. Tana delta and Ungwana Bay b. Sabaki mouth and Malindi Bay c. Port Reitz/Mwache creek d. Rufiji e. Ruvuma	a-b. Unknown but could be about 5% of annual load. Silting of Malindi Bay. Smothering of coral in Malindi Marine Park. d. Smothering of seagrass beds and coral near Rufiji delta and the south of Mafia Island, siltation as far as Mkuranga.	a. Critical load already passed. Tana sediment load 1-8 mt/yr b. Sabaki sediment discharge 2 mt/yr d. Critical load passed e. Unknown	8	a-b. Gibb (1959); ILACO (1971); Dunne (1975); Dunne & Ongwenyi (1976); Edwards (1979); UNEP (1998); Orieno & Maingi (2000). c. Kitheka (2000) d. Francis (1992); Fisher <i>et al.</i> (1994); Ngusaru <i>et al.</i> (2001)

Table RA 6.1. East Africa, continued.

Coastal Impact/ Issue	Local site/Region (contributing river basins)	Critical Threshold (for system functioning)	Distance to Critical Threshold (qualitative or quantitative)	Impact category*	References/ Data source
Eutrophication	a.Tana b.Sabaki	a,b. DO level > 5mg/l and TSSC >0.05 g/l	C:N:P ratio not known	4	a. Kitheka (2000)
Pollution Sewage, industrial and shipping discharge	a.Mfwapa creek b.Makupa creek c.Kilindini channel d. Rufiji and Ruvuma			5-8	a.-c. Rees <i>et al.</i> (1996); Kitheka (2000). d. TCMP (2000, 2001); Ngusaru <i>et al.</i> (2001)
Biodiversity loss (loss of biological function)	a.Ungwana Bay-Tana b.Funzi Bay c.Bamburi-Nyali lagoon d.Diani-Gazi lagoon e. Rufiji-Kilwa-Mafia complex f. Mnazi bay - Ruvuma estuary complex.	a.-d. Fish stock and biological productivity indicators b.-d. Contributing rivers not known	a.d. Fish landing declining over the years – 10,000 t/yr e.f. Biodiversity loss in mangroves, coastal forests, coral habitats	8	Kenya Fisheries Department records; KMFRI database; Mutigha & McClanahan (1987); Wells & Sheppard (1988); McClanahan & Mutere (1994); McClanahan & Obura (1995); Watson (1996); Glaesel (1997); Mvatha (1998); Malleret-King (2000); Ochiowo (2001). e. IUCN (1996); Ngusaru <i>et al.</i> (2001)
Salinisation	a. Tana b.Sabaki c. Rufiji delta				c.Tafe (1990); Ngusaru <i>et al.</i> (2001)
Human health issues	a.Tana b.Sabaki c.Uumba estuary/ Vanga d. Rufiji-Kilwa-Mafia complex e. Ruvuma estuary	Not known but there are: a. Increasing conflicts resulting in loss of human lives a & c. Increased occurrence of water-borne diseases a & c. Reduced productivity due to ill health.		8	a-c. Ochiowo (2001) d-e. Ngusaru <i>et al.</i> (2001)

Table RA 6.2. East Africa: DPSI matrix characterizing major catchment-based drivers/pressures and a qualitative ranking of related coastal state changes and impact *versus* catchment size class

P = progressive, D = distinct

Driver	Pressures	State change			Qualitative index	Impact on the coastal system	Time scale
		Large basins > 200 000 km ²	Medium basins 10 000 – 200 000 km ²	Small basins: > 10 000 km ²			
Damming	Retention of sediment	-	medium	major	Coastal erosion	Nutrient depletion	P/D
	Modification of the water cycle					Salinisation of estuaries and ground water	
Deforestation	Increase in sediment run off	-	major	major	Coastal siltation		P
	Increase in sediment loads					Smothering of coral reefs	
Agriculture	Increased fertilizer and pesticide residues	-	medium	major	Pollution		P
	BOD effluent increase				Eutrophication	Poor water quality	
Urbanisation	Increased soil erosion					Coastal siltation and loss of biodiversity	
	Increased water abstraction					Reduced river flow	
	Nutrient increase and increased discharge of metal-rich and BOD-rich wastes (sewage)	-	medium	major	Deterioration of water quality	Heavy metal pollution	D/P
Industrialisation	Increased water abstraction	-	medium	major		Accelerated rates of biodiversity loss	
	Increased waste and thermal pollution, water abstraction					Saline intrusion of groundwater	
						Heavy metal pollution and reduced discharge	P

Table RA 6.3. East Africa: Linking coastal issues/impacts and land-based drivers at the catchment scale

*Overview and qualitative ranking on catchment scale. Impact code and relative class of importance: 1 = minimum, 10 = maximum

Coastal Impacts / Issues	Drivers	Local catchment		Trend expectations	References / Data sources
		Tana River	Impact Category*		
Erosion	Damming		7	↑	Dunne (1974, 1975); Ewbank & Partners (1974); Edwards (1979); Denga <i>et al.</i> (2000)
	Deforestation		8	↑	Gibb (1959); Dunne (1974, 1975); ILACO (1971); Ewbank & Partners (1974); Edwards (1979)
	Urbanisation		6	↑	Denga <i>et al.</i> (2000)
	Industrialisation		5	↑	Ewbank & Partners (1974)
Sedimentation	Damming		8	↑	ILACO (1971); Ewbank & Partners (1974)
	Agriculture		6	↑	Dunne (1974, 1975); Ewbank & Partners (1974); Edwards (1979); UNEP (1998); Denga <i>et al.</i> (2000)
Pollution	Industrialisation		4	↑	
	Urbanisation		5	↑	Dunne (1974, 1975); Edwards (1979); Denga <i>et al.</i> (2000)
	Agriculture		7	↑	
Biodiversity/ productivity loss	All drivers listed above	Siltation in Ungwana Bay	7	↑	Refer to Table 1; Njuguna (1991); Raal & Barwell (1995); Knocker (1998)
Salinisation	Damming		?	↑	
		Sabaki River	Impact Category*		
Erosion	Damming		7	↑	Dunne (1974, 1975); UNEP (1998); Denga <i>et al.</i> (2000);
	Deforestation	Shoreline progradation and harbour siltation at Mombasa	7	↑	
	Urbanisation		7	↑	
	Industrialisation		6	↑	Artherton (1992); McClanahan & Obura (1995); Kairu & Nyandwi (2000)
	Damming		5	↑	
Sedimentation	Deforestation		7	↑	

Table RA 6.3. East Africa, continued.

Coastal Impacts/Issues	Drivers	Local catchment	Trend expectations	References/Data sources
	Sabaki, continued.			
	Agriculture	7	↑	
Pollution	Industrialisation Urbanisation Agriculture	6 6 6	↑ ↑ ↑	Dunne (1974, 1975); Denga <i>et al.</i> (2000)
Biodiversity/ productivity loss	All drivers listed above	Malindi Bay coral reef smothering	↑	Refer to Table 1; Njuguna (1991); Raal & Barwell (1995); McClaughan & Obura (1995; Knocke (1998)
Salinisation	Damming		↑	
Rufiji River				
		Impact Category		
Erosion	Damming Deforestation	Dams proposed Extensive forest clearance	7 7	Rogers (1977); Euroconsult/DHV (1980); Atkins (1981), Klomp (1985); Mwalyosi (1988, 1990, 1993); Semesi (1992); Fisher <i>et al.</i> (1994); Clarke & Dickinson (1995); TCMP (2000, 2001); Ngusaru <i>et al.</i> (2001)
Sedimentation	Deforestation		7	
Pollution	Agriculture Fisheries Human settlement	Prawn farm development Population growth Use of toxic pesticides	8 7 7	Bernacsek (1980); Boyd (1996); Kulindwa (2000); TCMP (2000, 2001) Kulindwa (2000); TCMP (2000, 2001); Ngusaru <i>et al.</i> (2001) Mwalyosi (1990); Kulindwa (2000); TCMP (2000, 2001)
Biodiversity/ productivity loss	All drivers, especially human settlement and fisheries	Prawn farm development Mangrove clearance Increasing water abstraction	7	CFP/NORAD (1991); Semesi (1991, 1997); IUCN (1996); IUCN & Rufiji Administration (1997); Ngolle & Kiwia (1996); TCMP (2000, 2001); Ngusaru <i>et al.</i> (2001)
Human health issues			7	Wagner <i>et al.</i> (1998); TCMP (2000, 2001); Ngusaru <i>et al.</i> (2001)

Table RA 6.4. East Africa: Linking coastal issues/impacts and land-based drivers at the sub-regional scale.

Overview and qualitative ranking on sub-regional scale. Impact code and relative class of importance: 1 = minimum, 10 = maximum

Coastal Impact/ Issues	DRIVERS	Sub-regional	Trend- expectation	References / Data sources
	East Africa	Category (1 low – 10 high)		
Erosion	Damming	7	↑	Dunne (1974, 1975); Ewbank & Partners (1974); Edwards (1979); Denga <i>et al.</i> (2000)
	Deforestation	7-8	↑	Gibb (1959); ILACO (1971); Dunne (1974, 1975); Ewbank & Partners (1974); Edwards (1979)
	Urbanisation	6-7	↑	Denga <i>et al.</i> (2000)
	Industrialisation	5-6	↑	Ewbank & Partners (1974)
Sedimentation	Damming	5-8	↑	ILACO (1971); Ewbank & Partners (1974)
	Deforestation	7	↑	Dunne (1974, 1975); Edwards (1979)
	Agriculture	6-7	↑	Dunne (1974, 1975); Ewbank & Partners (1974); Edwards (1979); UNEP (1998); Denga <i>et al.</i> (2000)
Pollution	Agriculture	7	↑	Dunne (1974, 1975); Edwards (1979); Denga <i>et al.</i> (2000)
	Urbanisation	5-6	↑	
	Industrialisation	4-6	↑	
Biodiversity loss	Damming			Refer to Table 1; Njuguna (1991); Raal & Barwell (1995); Knocker (1998)
	Deforestation	7	↑	
	Agriculture			
	Urbanisation			
	Industrialisation			
Salinisation	Damming	?	↑	
Human health issues				

Table RA 6.6. East Africa: Scientific and/or management responses to coastal impact/issues at catchment and sub-regional scales.

River catchment	RESPONSE catchment scale	RESPONSE Management	RESPONSE Sub-Regional Management
River catchment	Scientific	Management	Scientific
Kenya coast including Tana and Sabaki (Athi, Galana) river basins	EU-STD II-III and EU-RTD IV project, IOC-SAREC, UNEP-UNESCO, NWP-KWS, Tana Primates World Bank-GEF	Coast Province Administration, District Development Planning, Local Government Authorities, Tana and Athi Rivers Development Authority	UNEP-BADC Eastern Africa Atlas of Coastal Resources – Kenya (1998), – Tanzania (2001). IOC-UNESCO Guidelines for the study of shoreline change in the Western Indian Ocean Region (Kairu & Nyandwi, 2000). Establishment of IOC Western Indian Ocean regional office in KMFRI, Mombasa.
Rufiji	<ul style="list-style-type: none"> • NEMC,TCMP - GISD project (USAID) • REMP (IUCN) • RUBADA • Mangrove management project (NORAD) • FRONTIER • University of Dar es Salaam RIPS (FINIDA) • WWF-Eco region project • Sida-SAREC • Rufiji Flood Plain Project (Irish and Netherlands) 	<ul style="list-style-type: none"> • Rufiji Basin Development Program • Rufiji Environmental Management Program • Mangrove Management Program • Marine and Coastal Research • Rural Integrated Program Support • Coastal Forest Conservation • Rufiji Flood Plain Project • Biodiversity Loss • EIA for Damming • Pesticides and agrochemicals • Impact of Industrial effluents through Rufiji River to the coastal environment • Socio-economic impact Assessment 	

Table RA 6.7. East Africa: Hot spots of land-based coastal impact and gaps in understanding as well as a first overview of issues to be addressed in future research.

River catchment	Hot spot catchment scale		Sub-regional/ Country scale		Hot spot Regional scale	
	Key issue, trend and gaps	Scientific approach	Key issue, Trend and gaps	Scientific approach	Key issue, Trend and gaps	Scientific approach
Tana River	<ul style="list-style-type: none"> • Hydrology, hydrodynamics and water circulation • Deterioration of water quality • River and marine biodiversity loss • Population dynamics of the key fisheries • Socio-economic situations 	<ul style="list-style-type: none"> • Measurements and modeling studies-river discharge dynamics, sediment loads and water exchange in the estuary • Monitoring water quality parameters in the Tana delta • Assessment of river and marine biodiversity • Assessment of dynamics of key commercial species • Study existing socio-economic set-up in the river basin and along the coastal zone 				

Table RA 6.7. East Africa, continued.

River catchment	Hot spot catchment scale	Sub-regional/ Country scale	Hot spot Regional scale
Rufiji River	<ul style="list-style-type: none"> • Nearshore oceanography and coastal processes • Hydrogeology • Sedimentation and water quality related problems • River and marine biodiversity loss and conservation • Trade dynamics of natural resources • Agriculture and livestock development and impact on the environment • Mangrove and estuarine dynamics • Relation between fisheries and the flooding regime • Dynamics of the natural forests and woodlands • Identification of urgent conservation measures 	<ul style="list-style-type: none"> • Fundamental research to support the understanding of intricate ecological processes, which is the key to defining sustainability. • Applied research with case studies of processes (of specific issues or problems of the dynamics) • Predictive models (natural and human-induced ecosystem changes) • Monitoring and feasibility studies • Flows – which include materials, and elements through the system (pollutants, DDT, nutrients, water) • Stocks – in terms of quantity of environmentally provided assets such as forests, wildlife, fisheries, water, wetlands, soil, atmosphere. These provide a flow of useful goods or services. • Status – in terms of measures of specific phenomena (e.g. levels of land based inputs to the sea, carrying capacity, water requirements for the survival of ecosystems, health etc) 	

Regional assessment Tables 7. Central/south Mozambique, by F. Tauacale

Table RA 7.1. Central/southern Mozambique: Major coastal impacts/issues and critical thresholds

*Overview and qualitative ranking on catchment scale: Impact code and relative class of importance: 1 = minimum, 10 = maximum

Coastal IMPACT / ISSUE	Local site/Region (contributing river basins)	Critical Threshold (for system functioning)	Distance to Critical Threshold	Impact category*	References / Data source
Erosion	a. Zambezi b. Limpopo c. Incomati estuary	a. unknown c. unknown	a. unknown c. 4km damming, erosion becomes a continuous process	8 8	a. Gove (1993) c. MICOA (1998)
Sedimentation	a. Zambezi b. Limpopo c. Incomati	a. unknown	a. unknown	a.8 c.9	a. Balek (1972) c. MICOA (1998)
Eutrophication	a. Zambezi b. Limpopo c. Incomati d. Xinavane, over 80km of estuary	a-c. unknown d. Anoxia or low Oxygen in estuary	a-c. unknown d. increased nutrient	a. 2 d.10	a. Mordosova (1980) b. Mordosova <i>et al.</i> (1980); Munga (1987); Caralap <i>et al.</i> (1993); Masundire & Matizza (1995)
Pollution	a. Zambezi b. Limpopo c. Incomati d. Maputo Bay	a,b. unknown	a,b. unknown	d. 8	d. Hoguane (2000)
Biodiversity loss (Loss of biological function)	a. Zambezi delta b. Sofala Bank c. Limpopo d. Incomati	a,b. Ecosystem collapse – sardine fishery, <i>Posidonia</i> disappeared, primary productivity severely reduced - prawn fisheries	a,b. exceeded	a,b. 10	a,b. Da Silva (1986); Gammelstrod (1992, 1996); Hotton & Munguambe (1998); Guale (2000)
Salinisation	a. Zambezi b. Limpopo c. Incomati to 80km from mouth	a. unknown b. unknown	a. unknown b. unknown	c. 10	c. Matola, J. (1999)
Human health issues	a. Zambezi b. Limpopo c. Incomati	a. unknown	a. unknown		

Table RA 7.2. Central/southern Mozambique: DPSI matrix characterizing major catchment-based drivers/pressures and a qualitative ranking of related coastal state changes and impact versus catchment size-class.

P = progressive, D = distinct

Driver	Pressures	State change	Qualitative index	Impact on the coastal system	Time scale
		Large basins $> 200\ 000 \text{ km}^2$	Medium basins 10 000 – 200 000 km^2	Small basins: $> 10\ 000 \text{ km}^2$	
Damming	Reduction in water flow Reduction in sediment discharge Nutrient retention	major	major	- Increased salinisation Changes in coastal morphology, erosion Nutrient depletion	P
Deforestation	Modification of vegetation cover and runoff, soil erosion	minor? (medium)	major	- Sedimentation and habitat modification Erosion evident where mangroves have been clear felled	P
Agriculture	Increased water abstraction Decrease in BOD effluent Increased soil erosion and modified runoff; increased nutrient and pesticide fluxes	minor	medium	- Salinisation Eutrophication, increasing anoxia Habitat loss Degradation in groundwater quality	P
Urbanisation	Increased sewage discharge, pollution in Maputo Bay	minor	medium	- Deterioration in surface and groundwater quality; local eutrophication	D/P
Industry	Discharge of toxic substances in estuary of Maputo Bay	minor	minor	Accumulation of pollutants in coastal sediments	D/P

Table RA 7.3. Central/southern Mozambique - Linking coastal issues/impacts and land-based drivers at the catchment scale.

Overview and qualitative ranking on catchment scale: Impact code and relative class of importance: 1 = minimum, 10 = maximum

Coastal Impact Issues	Drivers	Motivation	Impact Category	Trend expectations	References/Data sources
		Zambezi			
Erosion	Damming	Reduced river inflow has resulted in changes in habitat characteristics, e.g., changes the regime and characteristics of the substratum and increasing erosion downstream.	7	↑	Gove (1993); Masundire & Matiza (1995)
Sedimentation	Damming	Alterations in river flow regime has altered the sedimentation processes downstream and in Zambezi delta, altering the duration and timing of mouth closure/opening	3	↓	Gove (1993); Masundire & Matiza (1995)
	Agriculture	Poor catchment management result in soil erosion downstream and sedimentation in coastal areas (Zambezi delta)	2	↑	Balon & Coche (1974); Brinca <i>et al.</i> (1986); Da Silva (1986); Gammelsrod (1992, 1996); Timberlake (1998)
Loss of habitat /biodiversity	Damming	During flood periods, poor catchment management resulting in high runoff may damage the mangrove and affect productivity of prawn in Zambezi delta.	7	↑	Chonguica (1997); UEM (1999); Tauacale (1999); Guale (2000); JIBS (2001); SRI (2001)
	Agriculture	Use of fertilizer and activities in the downstream results in excessive reed growth along the waters of the Zambezi delta	7	↑	Chonguica (1997); UEM (1999); Tauacale (1999); Guale (2000); JIBS (2001); SRI (2001)
Stream flow (reduction)	Damming	Poor catchment management results in low flow downstream and sedimentation in coastal areas (Zambezi delta)	9		Chonguica (1997); UEM (1999); Tauacale (1999); Guale (2000); JIBS (2001); SRI (2001)
Pollution (e.g. trace metals, hydrocarbons, pesticides)	Agriculture	Catchment supports major agricultural activities probably introducing some pesticides to coastal areas.	2?	↑	Chonguica (1997); UEM (1999); Tauacale (1999); Guale (2000); JIBS (2001); SRI (2001)

Table 7.3. Central/southern Mozambique, continued.

Coastal Impact Issues	Drivers	Motivation	Impact Category	Trend expectations	References/Data sources
Limpopo					
Eutrophication	Agriculture	Poor catchment management and use of fertilizer and activities in the Chokove scheme results in excessive reed growth along the estuary.	2	⇒	Chonguica (1997); UEM (1999); Tauacale (1999); Guale (2000); JIBS (2001); SRI (2001)
Stream flow (reduction)	Damming	Poor catchment management upstream results in low flow downstream.	5	↑	Chonguica (1997); UEM (1999); Tauacale (1999); Guale (2000); JIBS (2001); SRI (2001)
Incomati					
Erosion	Damming	Reduced river inflow has resulted in changes in habitat characteristics, e.g. changes the regime and characteristics of the substratum and increasing erosion downstream.	6	↑	JIBS (2001)
Sedimentation	Damming	Alterations in river flow regime have altered the sedimentation processes downstream in estuary.	2,3	↓	
Eutrophication	Urbanisation Agriculture	Use of fertilizer and activities in the Xinaiane and Maragra scheme have resulted in excessive reed growth along the floodplain and estuary.	5	↑	JIBS (2001); SRI (2001)
Salinisation	Damming	Poor catchment management has resulted in low flow downstream and salinisation in estuary areas	8	↑	SRI (2001)
Pollution (e.g. trace metals, hydrocarbons, pesticides)	Agriculture	Catchment supports major agricultural and mining activities probably introducing some pesticides to coastal areas.	8	↑	Pers. comm.

Table RA 7.4. Central/southern Mozambique: Linking coastal issues/impacts and land-based drivers at the sub-regional scale.

Overview and qualitative ranking on sub-regional scale. Impact code and relative class of importance: 1 = minimum, 10 = maximum

Coastal Impact/Issues	DRIVERS	Central/south –Mozambique	Trend-expectation	References / data sources
	Related basins	Category (1 low – 10 high)		
Erosion	Damming	a. Incomati	6-7	↑ Gove (1993); JIBS (2001)
	Agriculture	a. Zambezi b. Limpopo c. Incomati	2	⇒ Pers. comm.
	Deforestation	a. Limpopo a. Zambezi b. Limpopo c. Incomati	?	
Sedimentation	Damming	a. Limpopo b. Limpopo c. Save	2-3	↓ Pers. comm.; Gove (1993); JIBS (2001)
	Damming	a. Limpopo b. Incomati c. Save	5-9	↑ Chonguica (1997); UEM (1999); Tauacale (1999); Guale (2000); JIBS (2001); SRI (2001)
	Stream flow reduction	a. Limpopo b. Incomati c. Save	2-5	⇒ (↑) Pers. Comm.; SRI (2001); JIBS (2001)
Eutrophication	Urbanisation	a. Limpopo b. Incomati	2-5	⇒ (↑) Pers. Comm.; SRI (2001); JIBS (2001)
	Agriculture			
	Damming	a. Limpopo b. Incomati	5-7	↑ Mordosova (1980); Mordosova <i>et al.</i> (1980); Munga (1987); Caralap <i>et al.</i> (1993); JIBS (2001)
Biodiversity loss	Agriculture	a. Limpopo b. Incomati c. Save	5-7	↑ Brinca <i>et al.</i> (1986); Da Silva (1986); Gammelstrod (1992, 1996); SRI (2001)
	Damming	a. Incomati b. Pungue c. Buze	8	↑ Matola (1999); SRI (2001)
	Salinisation			

Table RA 7.6. Central/southern Mozambique: Scientific and/or management responses to coastal impact/issues at the catchment scale.

River catchment	RESPONSE catchment scale
	Scientific Management
Inkomati	<p>Shared River Initiative Project. RSA. (1999 – 2000)</p> <p>Joint Inkomati Basin study, phase 1-2. Consultec and BK\$ Acres, Final Report (2001)</p> <p>Country situation Report – water Resources – Mozambique vol.1-3- (1998)</p> <p>MBB Consulting Engineers, Acer (Africa) Environmental Management Consultants, AWARD. 2000. Proposal for the Establishment of a Catchment Management Agency for the Inkomati Basin. Final Draft. Prepared for the Inkomati Catchment Management Agency Reference Group, under the auspices of DWAF, Mpumalanga Regional Office. (2000)</p> <p>DNA. 1991. Gestao de Recursos Hidricos na Bacia Hidrografica do Inkomati. Report 56/91</p>
Limpopo	<p>Jamieson, J.G. Planning and management of water resources in Mozambique. DNA (1985)</p> <p>Koudstaal, R. Identification of major issues in Water resources master planning in Mozambique. Delft, Netherlands (1989)</p> <p>DNA, Planning for water resources management. Progress Limpopo Study. Maputo (1991)</p> <p>DNA, Planning for water resources management. Progress Limpopo Study. Maputo (1991)</p>

Table RA 7.7. Central/southern Mozambique: Hot spots of land-based coastal impact, gaps in understanding and a first overview of issues to be addressed in future research.

River catchment	Hot spot catchment scale	Scientific approach	Key issue, Trend and gaps	Hot spot Sub-regional/ Country scale	Scientific approach
Zambezi	<ul style="list-style-type: none"> • Investigate effects of upstream impoundments and flood regulation on the Mozambique coast • Impact of the cessation of silt transport to the Mozambique coast. • Impact of nutrient retention on bio-productivity 	<ul style="list-style-type: none"> • Monitoring and investigative research 			
Incomati	<ul style="list-style-type: none"> • water quantity • water quality • River and marine biodiversity loss • Salt intrusion • Socio-economic situations 	<ul style="list-style-type: none"> • Assessment and modeling studies river health. • Monitoring water quality parameters in Incomati • Assessment of dynamics of salt intrusion and land loss • Study existing socio-economic set-up in the river basin and along the coastal zone 	<ul style="list-style-type: none"> • Deterioration of water quality • River and marine biodiversity loss 	<ul style="list-style-type: none"> • Monitoring water quality parameters in the Maputo Bay • Assessment of river and marine biodiversity 	
Limpopo	<ul style="list-style-type: none"> • Floods regulation • Water quantity • Water quality 		<ul style="list-style-type: none"> • Identification of flood plain risk in coastal zone. • Monitoring water quality and biodiversity loss. • Studies of river health. 		

Regional Assessment Tables 8. South East Africa, by A. Forbes

Table RA 8.1. South East Africa: Major coastal impacts/issues and critical thresholds

*Overview and qualitative ranking 1 = minimum, 10 = maximum

Coastal Impact/ Issue	Local site/Region (contributing river basins)	Critical Threshold (for system functioning)	Distance to Critical Threshold (qualitative or quantitative)	Impact category	References/ Data source
Erosion	a. Tugela b. Great Fish c. Kromme d. Groot Brak	a. 60% existing flow b. Unknown c. Unknown d. Unknown	a. Unknown b. Unknown c. Unknown d. Unknown	a. 3 b. 3 c. 2 d. 2	Tugela (Thukela): Begg (1978); See report in press with Nakamura
Sedimentation (e.g., marine sedimentation due to reduced freshwater inflow or from agricultural practices)	a. Tugela b. Great Fish c. Kromme d. Groot Brak	a. 60% existing flow b. Unknown c. Unknown d. Unknown	a. Unknown b. Unknown c. Unknown d. Unknown	a. 4 b. 2 c. 2 d. 3	Great Fish: Watling & Watling (1983); Allanson & Read (1987); Whitfield (1994); Whitfield, Paterson, Bok & Kok (1994); Allanson & Read (1995); Ter Morshuizen, Whitfield & Paterson (1996); Grange, Whitfield, de Villiers & Allanson (2000)
Eutrophication	a. Tugela b. Great Fish c. Kromme d. Groot Brak	a. Unknown b. Unknown c. Unknown d. Unknown	a. Unknown b. Unknown c. Unknown d. Unknown	a. 3 b. 2 c. 2 d. 4	Kromme: Watling & Watling (1982b); Emmerson & Erasmus (1987); Sowman & Fugle (1989); Adams, Knoop & Bate (1992); Adams & Talbot (1992); Schumann & de Melton (1993); Jerling & Wooldridge (1994); Heymans & Baird (1995); Baird & Heymans (1996); Quinn, Breen, Hearne & Whitfield (1998); Bate & Adams (2000); Scharler & Baird (2000); Snow, Bate & Adams (2000); Strydom & Whitfield (2000); Wooldridge & Callahan (2000)
Pollution	a. Tugela b. Kariega c. Kromme d. Groot Brak	a. Unknown b. Unknown c. Unknown d. Unknown	a. Unknown b. Unknown c. Unknown d. Unknown	a. 4 b. 2 c. 2 d. 3	Groot Brak: Day (1981); Watling & Watling (1982a); Morant (1983); Slinger & Breen (1995); Slinger, Taljaard & Largier (1994); Coetzee, Adams & Bate (1997)

Table RA 8.1. South East Africa, continued.

Coastal Impact/ Issue	Local site/Region (contributing river basins)	Critical Threshold (for system functioning)	Distance to Critical Threshold (qualitative or quantitative)	Impact category	References/ Data source
Loss of biodiversity (loss of biological function)	a. Tugela b. Great Fish c. Kromme d. Groot Brak	a. Unknown b. Unknown c. Unknown d. Unknown	a. Unknown b. Modified by freshwater input c. Functional but marine-dominated d. Unknown	a. 4 b. 3 c. 5 d. 4	
Human health issues	a. Tugela b. Great Fish c. Kromme d. Groot Brak	a. Unknown b. Unknown c. Unknown d. Unknown	a. Unknown b. Unknown c. Unknown d. Unknown	a. 2 b. 2 c. 2 d. 3	

Table RA 8.2. South East Africa: DPSI matrix characterizing major catchment-based drivers/pressures and a qualitative ranking of related coastal state changes and impact versus catchment size-class.

P = progressive, D = discrete

Driver	Pressures	State change	Qualitative index	Impact on the coastal system	Time scale
		Large basins: > 200 000 km ²	Medium basins: 10 000 – 200 000 km ²	Small basins: < 10 000 km ²	
Damming	High freshwater retention in semi arid situation (e.g., Kromme)	-	medium	minor - major	In some cases no freshwater discharge year-long Nutrient depletion in estuaries and coastal waters
Deforestation	Modification of vegetation cover and soil erosion	-	medium	major	Increased sediment discharge and siltation where free from impoundment
Agriculture	Sediment mobilization and modified runoff Increased nutrient and pesticide fluxes	-	medium	medium	Changes in sediment flux, eutrophication, degradation of groundwater quality
Urbanisation	Increase in sewage, deterioration in water quality	-	minor	minor - major	Range from high impact near cities (Durban) to pristine conditions further distant
Industrialisation	Discharge of toxic substances, deterioration in water quality	-	minor	minor - major	Pollution of estuarine waters and sediments

Table RA 8.3. South East Africa: Linking coastal issues/impacts and land-based drivers at the catchment scale.

Overview and qualitative ranking on catchment scale 1 = minimum, 10 = maximum

Coastal impacts/issues	Drivers	Local catchment (allowing within and between catchment comparison)		Trend expectations	References/ Data sources
		Tugela River	Impact Category		
Erosion	Damming	Sediment retention	2-3	\Rightarrow/\uparrow	See Table 1 <i>South East Africa</i>
	Deforestation	Few natural forests	2	\Rightarrow	
	Agriculture		5	\uparrow	
	Urbanisation		2	\uparrow	
	Industrialisation		2	\uparrow	
	Climate change	Unknown	?	\uparrow	
Sedimentation	Damming	Sediment retention; coastal erosion	3	Probable \uparrow	
	Urbanisation	Localised	3	\uparrow	
	Agriculture	Localised – generally low intensity	4	\uparrow	
Pollution	Industrialisation	Localised – low industrialisation	3	\uparrow	
	Urbanisation	Localised	3	\uparrow	
	Mining	Localised	3	\Rightarrow/\uparrow	
Nutrient depletion	Damming	Probable estuary & offshore	4	\uparrow	
Biodiversity loss		Localised	2-3	\uparrow	
Human health issues		Local contamination of water supplies – cholera endemic	4-5	\Rightarrow	
Great Fish/Kromme/Groot Brak Rivers		Impact Category			
Erosion	Damming		2	\Rightarrow	
	Deforestation	Few significant forests	2	\Rightarrow	
	Agriculture	Localised	3	\Rightarrow	
	Urbanisation	Very localised	3	\Rightarrow	
	Industrialisation	Localised	2	\Rightarrow	
	Climate change	Unknown	?	\uparrow	
Sedimentation	Damming	Loss of flood scour; followed by estuarine sediment build-up & mouth closure	1-4	\Rightarrow	

Table RA 8.3. South East Africa, continued.

		Great Fish/Kromme/Groot Brak Rivers continued.	Impact Category	Trend expectations	References/ Data sources
Eutrophication	Urbanisation Agriculture	Localised Localised	1-4 1-4	⇒ ↑	
Pollution	Industrialisation Urbanisation Mining	Localised Localised N/A	1-3 1-3 0	⇒ ↑ ?	
Nutrient depletion	Damming	General	5-8	↑	
Biodiversity loss		Ecosystem switch	5-8	↑	
Human health issues		Variable	3-7	⇒/Increase	

Table RA 8.4. South East Africa: Linking coastal issues/impacts and land-based drivers at the sub-regional scale.
 Overview and qualitative ranking on sub-regional scale: 1 = minimum, 10 = maximum

Coastal Impact/Issues	DRIVERS	Sub-regional		Trend-expectation	References/ Data sources
			Category		
Erosion	Damming	Very localised on coast	1	Possible↑	See Table 1 <i>South East Africa</i>
	Deforestation	Localised	1	⇒	
	Agriculture	Wide-spread	2	⇒	
	Urbanisation	Localised	1	↑	
	Climate change	Unknown	?	?	
Sedimentation	Damming	Estuaries – loss of flood scour	4	↑	
	Deforestation	Localised	2	⇒	
	Agriculture	As in estuaries	4	↑	
		N/A	2	⇒	
Eutrophication	Damming	Unusual – localised estuaries	3	↑	
	Agriculture	Localised – primarily estuaries	3	↑	
	Urbanisation	Localised	4	↑	
	Industrialisation	Localised	4	↑	
Pollution	Agriculture	Localised	4	⇒	
	Urbanisation	Localised	0.8	⇒	
	Industrialisation	Localised	0.7	⇒	
	Mining	Very localised	0.4	⇒	
	Fisheries	Rare	0.2	⇒	
Biodiversity loss	Damming	General	0.5	↑	
	Deforestation	Rare	0.2	⇒	
	Agriculture	Localised	0.3	↑	
	Urbanisation	Localised	0.7	↑	
	Industrialisation	Localised	0.6	↑	
	Mining	Very localised	0.3	⇒	
	Fisheries	Wide-spread	2.8	↑	
Nutrient depletion	Damming	Primarily estuaries, localised offshore	1.4	↑	
	Human health issues	Localised – mainly estuaries	1.3	↑	

Table RA 8.6. South East Africa: Scientific and/or management response to coastal impact/issues in African coastal zones on catchment, sub-regional and regional scales.

River catchment	RESPONSE catchment scale		RESPONSE Sub-regional/ Country Scale (e.g., in SADC region)
	Scientific	Management	
Tugela	Incorporation of estuary as well as coastal and offshore environments into the E.I.A. of the proposed T.W.P. (Thukela Water Project) by the South African Department of Water Affairs and Forestry. Report in press.	Proposed consideration of the design of the impoundments and water release Patterns to allow minimum disruption of natural flow patterns.	Marine processes dominate the very open, high energy South African coastline, with the result that catchment events are far more apparent in estuaries than offshore, although turbidity plumes are a feature of the KwaZulu-Natal coast during the summer rainfall period. Consideration of the effects of land runoff have not been a priority until very recently, culminating in the T.W.P. E.I.A. referred to in this table.
South African estuaries in general			Estuarine studies have, in recent years, focussed progressively more on management objectives, practicalities and techniques and have been fortunate in being able to build on a strong research foundation. The incorporation of this knowledge into management policy and action is now a major priority. Research and management is strongly supported by local funding agencies including the Department of Environmental Affairs and Tourism, the National Research Foundation, The Water Research Commission and the Department of Water Affairs and Forestry (at times with European and British subvention). These organizations work closely with the Consortium for Estuarine Research and Management (CERM) a voluntary network of about 80 researchers working on estuaries throughout the country (For review see SA Waterbulletin 27(6)). A significant attempt to bring estuarine science to the manager has been produced by Breen & McKenzie (2001) which incorporates a summary of the relevant legislation which provides for protection of both the estuarine and the coastal environment. Legislation is covered in more detail by Glazewski (2000) and policy and implementation is reviewed by Boyd, Barwell & Taljaard (2000), Glavovic (2000) and the Department of Environmental Affairs & Tourism (2000).

Table RA 8.7. South East Africa: Hot spots of land-based coastal impact, gaps in understanding and an overview of issues to be addressed in future research.

River catchment	Hot spot Catchment scale		Hot spot Sub-regional/ Country scale	
	Key issue, trend and gaps	Scientific approach	Key issue, trend and gaps	Scientific approach
Tugela, Mkomazi and other major east coast rivers	Effects of land-derived runoff on coastal marine productivity in oligotrophic coastal environments	Primary production studies in the water column; effects of floods, sediment plumes on biological processes in affected areas.		
Rivers (Mkuzi, Mfolozi, Hluhluwe) associated with the Greater St Lucia Wetland Park (a RAMSAR site)	Long term effects of flow reduction and droughts on biological processes in the St Lucia lake.	Analysis of nutrient sources and cycles; levels of primary production in the water column and fringing vegetation; effects of different salinity levels on carbon fixation and sources, carbon and nitrogen flow patterns based on light isotope analyses.		

7. REFERENCES

General references

- Dupra, V., Smith, S.V., Marshall Crossland, J.I. and Crossland, C.J. (eds) 2001 Estuarine systems of sub-Saharan Africa: C, N and P fluxes. *LOICZ Reports & Studies* **18**, LOICZ, Texel, The Netherlands, i+83 pages.
- Dupra, V., Smith, S.V., David, L.T., Waldron, H., Marshall Crossland, J.I. and Crossland, C.J. (eds) 2002 Estuarine systems of Africa (Regional Workshop II): C, N and P Fluxes. *LOICZ Reports & Studies* **20**, LOICZ, Texel, the Netherlands, i+81 pages.
- FAO 1997 Irrigation Potential in Africa – A Basin Approach. *FAO Land and Water Bulletin* **4**; FAO Land and Water Development Division; ISBN 92-5-103966-6; Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00100 Rome, Italy.
- Hong, G.H., Kremer, H.H., Salomons, W., Wong, M.H., Marshall Crossland, J.I. and Crossland, C.J. (in prep.) East Asian Basins: LOICZ Global Change Assessment and Synthesis of River Catchment – Coastal Sea Interaction and Human Dimensions. *LOICZ Reports & Studies*, LOICZ, Texel, the Netherlands.
- de Lacerda, L.D., Kremer, H.H., Kjerfve, B., Salomons, W., Marshall Crossland, J.I. and Crossland, C.J. 2002 South American Basins: LOICZ Global Change Assessment and Synthesis of River Catchment – Coastal Sea Interaction and Human Dimensions. *LOICZ Reports & Studies* No. **21**, LOICZ, Texel, The Netherlands, ii+212 pages.
- Milliman, J.D., Rutkowski, C. and Meybeck, M. 1995 River Discharge to the Sea – A global river index (GLORI); *LOICZ Reports & Studies* No. **2**, LOICZ, Texel, the Netherlands, .
- OECD (Organisation for Economic Co-operation and Development) 1993 OECD core set of indicators for environmental performance reviews. OECD Environmental Monographs No. 83, OECD Paris, 39 pages.
- Salomons, W., Turner, R.K., Lacerda, L.D., Ramachandran, S. 1999 *Perspectives on Coastal Zone Management*. Springer Verlag, Berlin, 386 pages.
- Turner, R.K., Lorenzoni, I., Beaumont, N., Bateman, I.J., Langford, I.H. and McDonald, A.L. 1998 Coastal management for sustainable development: analyzing environmental and socio-economic changes on the UK coast. *Geographical Journal* **164**: 269-281.
- Turner, R.K. and Bower, B.T. 1999 Principles and benefits of integrated coastal zone management (ICZM). Pages 13-34 in Salomons, W., Turner, R.K., Lacerda, L.D. and Ramachandran, S. (eds): *Perspectives on Coastal Zone Management*. Springer Verlag, Berlin, 386 pages.
- UNEP 1999 *Regional overview of land-based sources and activities affecting the coastal and associated freshwater environment in the West and Central African Region*. UNEP/GPA Co-ordination Office and West and Central Africa Action Plan, Regional Co-ordinating Unit. UNEP, Nairobi, 110 pages.
- UNEP/Institute of Marine Sciences, University of Dar es Salaam/FAO/SIDA 1998 Overview of land-based sources and activities affecting the marine, coastal and associated freshwater environment in the Eastern African Region. *UNEP Regional Seas Reports and Studies* No. **167**, UNEP, Nairobi, 31 pages.
- UNEP/PERSGA 1997 Assessment of land-based sources and activities affecting the marine environment in the Red Sea and the Gulf of Aden. *UNEP Regional Seas Reports and Studies* No. **166**, UNEP, Nairobi, 62 pages.

References – Regional Assessment Synthesis and Tables

- Abdel Aziz, N.E. and Dorgham, M.M. 1999 Ecological characteristics of plankton in brackish water, Egypt. *Egyptian Journal of Aquatic Biology and Fish*, **3**(4): 215-242.
- Abdel Aziz, N.E., Fahmy, M.A. and Dorgham, M.M. 2001 Hydrography, nutrients and plankton abundance in the hot spot of Abu Qir Bay, Alexandria, Egypt. *Journal of Mediterranean Science* **2**.
- Abo Zahra, A. 2000 Maruit: a lake in danger. Alexandria Environment Friends Association/GEF (in arabic).
- Adams, J.B. and Talbot, M.M. 1992 The influence of river impoundment on the estuarine seagrass *Zostera capensis* Setchell. *Botanica Marina* **35**: 69-75.

- Adams, J.B., Knoop, W.T. and Bate, G.C. 1992 The distribution of estuarine macrophytes in relation to freshwater. *Botanica Marina* **35**: 215-226.
- Addo-Ashong, F.W. 1969 The effect of flooding on the decomposition of wood. Pages 292-297 in Obeng, L. E. (ed.) *Man-made Lakes: the Accra Symposium*. Ghana University Press, Accra.
- Akwa Ibon State Government (AKS) 1989 Soil and environmental Survey of Akwa Ibon State. AKS Report, 485 pages.
- Allanson, B.R. and Baird, D. (eds) 1999 *Estuaries of South Africa*. Cambridge University Press, Cambridge, 340 pages.
- Allanson, B.R. and Read, G.H.L. 1987 The response of estuaries along the south eastern coast of southern Africa to marked variation in freshwater inflow. Institute for Freshwater Studies, Rhodes University, Grahamstown, Special Report No. 2/87.
- Allanson, B.R. and Read, G.H.L. 1995 Further comment on the response of Eastern Cape estuaries to variable freshwater flows. *Southern African Journal of Aquatic Sciences* **21**: 56-70.
- Amissah, A.N. and De-Heer 1969 Some possible climatic changes that may be caused by the Volta Lake. Pages 73-82 in Obeng, L.E. (ed.) *Man-made Lakes: the Accra Symposium*. Ghana University Press, Accra.
- Amoah, C. A. 1999 Overview of microbiological studies on the Volta Lake. Pages 33-38 in Gordon, C. and Amatekpor, J.K. (eds). *The Sustainable Integrated Development of the Volta Basin in Ghana*. VBRP, Legon.
- Arthurton R.S. 1992 Beach erosion: case studies on the East African coast. Pages 91-5 in *Proceedings of Bordomer 92, International Convention on Rational Use of Coastal Zone*. Intergovernmental Oceanographic Commission and Bordomer, Bordeaux, 282 pages+annexes.
- Arthurton, R.S., Brampton, A.H., Kaaya, C.Z. and Mohamed, S.K. 1999 Late Quaternary coastal stratigraphy on a platform-fringed tropical coast – a case study from Zanzibar, Tanzania. *Journal of Coastal Research* **15**(3): 635-644.
- Atkins 1981 Rufiji Basin Study Program. Study of the impact of the Stiegler's Gorge multipurpose project on fisheries in Rufiji delta and Mafia Channel. Atkins Land and Water Management, Cambridge, England, 127 pages.
- Atlas du Sebou 1970 Rapport général. Développement régional du Sebou, Annexe 10. Rabat, 53 pages.
- Atta, M.M. 1985 Study of the distribution and ecology of microcrustacea in the littoral waters of Alexandria region. PhD thesis, Faculty of Science, Alexandria University.
- Awad, H. 1994 An assessment for pollutants journey to the Mediterranean Sea through River Nile. Colloque Scientifique des 6^{es} Rencontres de l'Agence Régionale Pour l'Environnement (ARPE). Saint-Cyr-sur-Mer, France, 14-15 Nov. 1994.
- Awad, H. and Hassan, M. 1998 Pollution in coastal zone and areas affected by river discharge: The Mediterranean of Egypt case study. Presented at the workshop on cooperation in the field of protection and restoration of coastal shelves and rivers of European countries CEREGE/CEEI, Aix en Provence, France, 16-18 November 1998.
- Awad, H. and Youssef, N. 2001 Nutrient budget in coastal water of Alexandria, Egypt. Presented at the LOICZ/UNEP workshop on estuarine systems of the southern Africa region, Simonstown, South Africa, 3-6 Sept. 2001.
- Ba, M., Diouf, B., Barusseau, J.P., Descamps, C., Diop, E.S., Monteillet, J., Rue, O. and Saos, J.L. 1995 Répercussions de la mise en eau des barrages de Diama et de Manantali sur l'environnement estuaire du fleuve Sénégal. Pages 34-48 in *Coastal ecosystems and sustainable development in Africa*, UNESCO Reports on Marine Science **66**, UNESCO, Paris.
- Baird, D. and Heymans, J.J. 1996 Assessment of ecosystem changes in response to freshwater inflow of the Kromme River estuary, St Francis Bay, South Africa: a network analysis approach. *Water SA* **22**: 307-318.
- Balek, J. 1972 Water balance of the Zambezi basin. Water Resources Report WR8, National Council for Scientific Research, Lusaka, Zambia.
- Balon, E.K. and Coche, A.G. 1974 *Lake Kariba: A man-made tropical ecosystem in Central Africa*. The Hague: Dr. W. Junk b.v. Publishers.
- Barusseau, J.P., Descamps, C., Diouf, B., Kane, A. and SAOS, J-L. 1993 Processus hydro- et morphosédimentaires et stabilité de la façade du delta. Pages 83-99 in Michel, P. et al. (eds) *L'après-barrages dans la vallée du Sénégal*. Presses Universitaires de Perpignan, Perpignan.

- Bate, G.C. and Adams, J.B. 2000 The effects of a single freshwater release into the Kromme Estuary. 1. Overview and interpretation for the future. *Water SA* **26**: 329-332.
- BDPA-SCETAGRI, ORSTOM, SECA, AFID, SERADE 1995 Etude des problèmes d'environnement et de protection des milieux naturels dans le delta du fleuve Sénégal. OMVS-FAC, Dakar, 166 pages.
- Begg, G.W. 1978 The Estuaries of Natal. Natal Town and Regional Planning Report 41, Pietermaritzburg, 657 pages.
- Benasser, L. 1997 Diagnose de l'état de l'environnement dans la plaine du Gharb: suivi de la macro-pollution et ses incidences sur la qualité hydrochimique et biologique du bas-Sebou. Thèse Doctorat d'Etat, Université Ibn Tofail, Kénitra, 177 pages.
- Berg, R.R. 1994 Hydrology of the Berg River Estuary. In: Western Cape System Analysis. Water requirements for the maintenance of the Berg River Estuary. Volume I: Report on work session. NSI Report No. **2095/5131**. Report prepared by Ninham Shand Consulting Engineers for the Department of Water Affairs and Forestry.
- Bernacsek, G.M. 1980 Preliminary assessment of the possible effects of the Mufindi pulp mill on fish yields of the Rufiji basin, Tanzania. Fisheries Division, Ministry of Natural Resources and Tourism and Rufiji Basin Development Authority.
- Boussou, T. 1992 La pêche dans le delta et la basse vallée du fleuve Sénégal: effet des barrages et des aménagements hydro-agricoles. Pages 1-13 in Etude des estuaires du Sénégal: Sénégal, Saloum, Casamance. Les baies de Dakar, Rapport EPEEC, UNESCO/ROSTA, Dakar.
- Boyd, A.J., Barwell, L. and Taljaard, S. 2000 Report on the National Estuaries Workshop, 3-5 May 2000, Port Elizabeth, South Africa. Report No 2, Marine and Coastal Management Implementation Workshop. Department of Environmental Affairs and Tourism, Cape Town.
- Boyd, C.E. 1996 Environmental impact statement for an ecologically responsible shrimp farming project in the Rufiji delta, Tanzania. Auburn, 112 pages.
- Breen, C.M. and McKenzie, M. (eds) 2001 Managing Estuaries in South Africa: An Introduction. Institute of Natural Resources, Pietermaritzburg.
- Brinca, L., Silva, C. and Silva, A. 1986 Report of the survey cruise by the trawler Muleve in July-August 1979 on the Sofala bank. *Revista de investigacao pesqueira (Maputo)* **14**: 87-140.
- Cape Metropolitan Council (CMC) 1999 Cape Town Metropolitan Council Water Quality Annual Report. Publication of the City of Cape Town, South Africa.
- Caralap, M.H., Duprat, J., Labeyrie, L.D. and Peypouquet J.-P. 1993 Palaeohydrological evolution of intermediate waters: Isotopic and microfaunal analyses of Quaternary core in the Mozambique channel. *International Geology Review* **35**(4): 369-385.
- CFP/NORAD 1991 Management plan for the mangrove ecosystem of mainland Tanzania. Vol. 7: Mangrove management plan for Rufiji Delta. Catchment Forest Project/Norwegian Agency for Development Cooperation, Ministry of Tourism, Natural Resources and Environment, Forest and Bee-keeping Division, Dar es Salaam, 28 pages.
- Charrouf, L. 1991 Problèmes d'ensablement des ports marocains sur la façade atlantique. Leur impact sédimentologique sur le littoral. *La houille blanche* No. **1**, 49-71.
- Cheggour, M., Langston, W.J., Chafik, A., Texier, H., Kaimoussi, A., Bakkas, S. and Boumezzough, A. 2000 Metals in the bivalve molluscs *Scrobicularia plana* (Da Costa) and *Cerastoderma edule* (L.) and associated surface sediment from Oumerriba estuary (Moroccan Atlantic coast). *Toxicological and Environmental Chemistry* **77**: 49-73.
- Chonguiça, E. 1997 Impacto, Lda., environmental control plan for the Pequenos Libombos Reservoir and an integrated land and water use plan for the Umbeluzi river basin. Impacto, Lda. Maputo.
- Clarke, G.P. and Dickinson, A. 1995 Status report for 11 coastal forests in coast region, Tanzania. *Frontier-Tanzania Technical Report No. 17*, 113 pages.
- CNE (Conseil National de l'Environnement) 1995 Commission de la prévention et de la lutte contre la pollution et les nuisances. Programme de Surveillance de la Pollution de la Méditerranée (MED-POL). Ministère de l'Environnement, Rabat, 1 et 2 Juin 1995.
- Coetzee, J.C., Adams, J.B. and Bate, G.C. 1997 A botanical importance rating of selected Cape estuaries. *Water SA* **23**: 81-93.
- Cogels, F-X., Thiam, A. and Gac, J-Y. 1993 Premiers effets des barrages du fleuve Sénégal sur le lac de Guiers. *Rev. Hydrobiol. Trop.*, **26**(2): 105-117.
- Constitutional Rights Project (CRP) 1999 Land, oil and human rights in Nigeria Delta Region. CRP, Lagos.

- CSIR 1985 Freshwater requirements of the Orange River Estuary. CSIR Report C/SEA 8533. Stellenbosch, South Africa.
- Czernin-Chudenitz, C.W. 1971 Physico-chemical conditions of Lake Volta, Ghana. FI: SF/GHA10 Technical Report 1. Rome: FAO.
- Da Silva, J. 1986 River runoff and shrimp abundance in a tropical coastal ecosystem. The example of the Sofala Bank (central Mozambique). Pages 329-344 in Skreslet, S. (ed.) *The role of freshwater outflow in coastal marine ecosystems*. NATO Advanced Study Institute Series, Series G, Ecological Science, 7.
- Day, J.H. 1981 Summaries of current knowledge of 43 estuaries in southern Africa. Pages 251-330 in Day, J.H. (ed.) *Estuarine ecology with particular reference to southern Africa*. A.A.Balkema, Cape Town.
- Day, J.H. 2000 Marine and estuarine studies in South Africa: an historical perspective. *Transactions of the Royal Society of South Africa* 55(2): 101-106.
- De Graft-Johnson, K.A.A. 1999 Overview of the weed problems in the Volta basin. Pages 55-62 in Gordon, C. and Amatekpor, J.K. (eds) *The Sustainable Integrated Development of the Volta Basin in Ghana*. VBRP, Legon.
- Debenay, J.P., Pages, J. and Guillou, J.J. 1994 Transformation of a subtropical river into a hyperhaline estuary: the Casamance River (Senegal). Paleogeographical implications. *Paleogeography, Palaeoclimatology and Palaeoecology* 107: 103-109.
- Delft Hydraulics/Resource Analysis (1991) Implication of sea-level rise on the development of the lower Nile Delta, Egypt. Pilot study for a quantitative approach, Final Report. Prepared for the Commission of European Community in cooperation with the Coastal Research Institute, Alexandria.
- Denga, F.O., Ongwenyi, G.S. and Kitheka, J.U. 2000 Erosion and sedimentation problems in arid and semi-arid lands of Kenya. Pages 61-63 in Gichuki, F.N, Mungai, D.N, Gachene, C.K and Thomas, D.B. (eds) *Land and water management in Kenya-towards sustainable land use*. Proceedings of the Fourth National Workshop (Kikuyu, February 15-19, 1993).
- Department of Water Affairs and Forestry (DWAF) 1994 Western Cape System Analysis. Water quality requirements for the maintenance of the Berg River. Volume 1: Report on Worksession. DWAF Report PG000/00/4993. Pretoria, South Africa.
- Department of Water Affairs and Forestry (DWAF) 1989 Orange River Ecology. Assessment of environmental water requirements of the Orange River mouth. Report on Orange River Environmental Workshop, Oranjemund. Compiled by Bruinette Kruger Stoffberg Inc. Consulting Engineers P.O. Box 3173, Pretoria, South Africa.
- Department of Water Affairs and Forestry (DWAF) 1993 Orange River System Analysis: Phase 2. Orange River integrated system analysis. DWAF Report PD000/001/3693. Pretoria, South Africa.
- Department of Water Affairs and Forestry 1996 Orange River Environmental Task Group. Orange River Instream Flow Requirements Meeting. Tanankulu Lodge, Fishoek, South Africa. 1-3 April 1996. Starter Document. Department of Water Affairs and Forestry, Pretoria, South Africa.
- Departmental of Environmental Affairs and Tourism 2000 Key Elements of the White Paper for Sustainable Coastal Development in South Africa. Chief Directorate Marine and Coastal Management, Cape Town.
- Derban, L.K.A. 1999 Public health aspect of the Volta Lake. Pages 25-32 in Gordon, C. and Amatekpor, J.K. (eds) *The Sustainable Integrated Development of the Volta Basin in Ghana*. VBRP, Legon.
- Diaw, A.T., Diop, N. and Thomas, Y.F. 1990 Rupture of the spit of Sangomar – Estuary of the Saalum. *Progr. Astronautics and Aeronautics*, 128: 170-180.
- Diaw, A.T., Mougenot, B., Thiam, M.D. and Thomas, Y.F. 1988 Apports de l'imagerie Spot à la connaissance des milieux littoraux du Saloum (Sénégal). Ed. Cepadues, Toulouse, Colloque CNES "Spot 1, Utilisation des images, Bilan, Résultats", 1131-1141.
- Diouf, P.S. 1998 Biodiversité des poissons des milieux estuariens fluviaux et lacustres du Senegal. CRODT/Senegal, Rapport.
- Dorgham, M.M., Abdel Aziz, N.E., El Dib, K.Z. and Abdel Aziz, M. 2001 Eutrophication problem in the Western Harbour of Alexandria, Egypt. EMECS 2001, 19-22 Nov. 2001, Japan.
- DRPE 1998 Etat de qualité des ressources en eau du Maroc (Année 1995-1996). Direction de la Recherche et de la Planification de l'eau. Rap. Avril 1998, Rabat, 59 pages.
- Dunne, T. 1974 Suspended sediment data for the rivers of Kenya. Washington D.C.
- Dunne, T. 1975 Sediment yield of Kenya Rivers. Report to the Ministry of Water Development, Nairobi, Kenya.

- Dunne, T. and Ongwenyi, G.S. 1976 A new estimate of sediment rates in the Upper Tana River, *Kenyan Geographer* 2(2): 14-29.
- Edwards, K.A. 1979 Regional contrasts in the rates of soil erosion and their significance to agricultural development in Kenya. In Lal, R and Greenland, D.J. (eds) *Soil physical properties and crop production in the tropics*. John Wiley and Sons, London.
- EEAA 1992 Environmental Action Plan in Egypt. Egyptian Environmental Affairs Agency, Cairo.
- EEAA 1996 Framework programme for the development of a National ICZM Plan for Egypt. Egyptian Environmental Affairs Agency, Cairo.
- El Mandour, A. 1998 *Contribution à l'étude hydrogéologique de la plaine de Triffa. Salinisation et modélisation*. Thèse Doctorat d'Etat. Université Mohamed Premier, Oujda.
- El-Deeb, M.K. 1977 Hydrography and chemistry of Abu-Qir Bay. MSc thesis, Faculty of Science, Alexandria University.
- El-Rayis, O.A., El-Sabarouti, M.A., Moussa, A. and Khalil, M. 1994 Changes in Phosphorus Storage in Lake Edku and its Role in Eutrophication of Abu Kir Bay. Pages 56-64 in Proceedings of 1st Arab Conference on Marine Environment Protection, AMTA, Alexandria, Feb. 1994.
- Emmerson, W.D. and Erasmus, T. 1987 The nutrient status of the Kromme estuary, South Africa. *Hydrobiologia* 148: 87-96.
- Entz, B.A.G. 1969 Observations on limnochemical conditions of Lake Volta. Pages 110-115 in Obeng, L.E. (ed.) *Man-made Lakes: the Accra Symposium*. Ghana University Press, Accra.
- Euroconsult/DHV 1980 Identification study on ecological impacts of the Stiegler's Gorge Power and Flood Control Project.
- Evans, W.A. 1969 The value of clearing vegetation from reservoir basins prior to impoundment. Akosombo VLRP, Legon.
- Ewbank and Partners 1974 Preliminary feasibility report on the potential development of Tana Reservoir. A report to the Government of Kenya and TARDA 1: 16-35. Nairobi, Kenya.
- Fay, M.B. 1987 Ancient backshore sediments between Bahari beach and Mbezi. Pages 32-35 in *Beach erosion along Kunduchi beach, north of Dar es Salaam*. Report for National Environmental Management Council by Beach Monitoring Committee, Tanzania.
- Fay, M.B. 1992 Maziwi Island off Pangani (Tanzania): history of its destruction and possible causes. *UNEP Regional Seas Reports and Studies No. 139*. UNEP, Nairobi, 43 pages.
- Fisher, P.R., Dyer, K. and Semesi, A. 1994 Characteristic circulation and sedimentation in the Rufiji delta, Tanzania. *Frontier Tanzania Technical Report*, No. 13, 92 pages.
- Francis, J. 1992 Physical processes in the Rufiji delta and their possible implications on the mangrove ecosystem. *Hydrobiologia* 247: 173-179.
- Frify, O.E. and Dowidar, K.M. 1993 Influence of shoreline erosion and accretion on texture and heavy mineral compositions of beach sands of the Burullus coast, north-central Nile Delta, Egypt. *Marine Geology* 114: 91-104.
- Frify, O.E. and Komar, P.D. 1993 Long-term shoreline changes and the concentration of heavy minerals in the beach sand along the Nile Delta, Egypt. *Marine Geology* 115: 253-261.
- Frify, O.E. and Lotfy, M.F. 1994 Mineralogy and textures of beach sands in relation to erosion and accretion along the Rosetta promontory of the Nile Delta, Egypt. *Journal of Coastal Research* 10: 588-599.
- Frify, O.E., Nasr, S.M., El Hatta, M.M. and El Raey, M. 1994 Remote sensing of beach erosion along the Rosetta promontory, northwestern Nile Delta, Egypt. *International Journal of Remote Sensing* 15: 1649-1660.
- Gac, J.Y., Cecchi, P., Cogels, F.X., Kane, A. and Saos, J.L. 1993 Projet EQUESEN (Environnement et Qualité des Eaux du Sénégal). ORSTOM/FUL/ISRA/UCAD. Programme CEE-ORSTOM N° TS2 0198-F EDB, 6 volumes, Decembre 1993.
- Gammelsrod, T. 1992 Improving shrimp production by Zambezi River regulation. *Ambio* 21(2): 145-147.
- Gammelsrod, T. 1996 Effect of Zambezi River management on the prawn fishery of the Sofala Bank. Pages 119-123 in Acreman, M.C. and Hollis G.E. (eds): *Water Management and Wetlands in sub-Saharan Africa*. IUCN, Gland.
- GERM 1994 Le Maroc Méditerranéen. Quels enjeux écologiques? Publication du GERM.
- Ghana Ministry of Industries 1964 Progress report on the implementation of industrial ... in the Public and Joint Public/Private sectors. Accra.

- Gibb, A. 1959 Upper Tana catchment water resources survey - 1958-1959. Report of the Kenya Government.
- Glaesel, H. 1997 Fishers, parks and power: the socio-environmental dimensions of marine resource decline and protection on the Kenyan coast. PhD thesis, University of Wisconsin-Madison.
- Glavovic, B.C. 2000 Our Coast for Life: from policy to local action. Department of Environmental Affairs and Tourism, Pretoria.
- Glazewski, J. 2000 *Environmental Law in South Africa*. Butterworths, Durban.
- Gordon, C. 1998 Mass transport of major solutes and sediments by the Volta River, Ghana. *Internationale Vereinigung für Theoretische und Angewandte Limnologie* 22.
- Gordon, C. 1999 An overview of the fisheries of the Volta Basin. Pages 75-87 in Gordon, C. and Amatekpor, J.K. (eds) *The Sustainable Integrated Development of the Volta Basin in Ghana*. VBRP, Legon.
- Gove, D.Z. 1993 The coastal zone of Mozambique. Pages 251-273 in Linden, O. (ed.): *Proceedings of the Workshop and Policy Conference on Integrated Coastal Zone Management in Eastern Africa including the Island States*. Report from the Swedish Agency for Research Co-operation with Developing Countries Science Programme.
- Grange, N. and Allanson, B.R. 1995 The influence of freshwater inflow on the nature, amount and distribution of seston in estuaries of the Eastern Cape, South Africa. *Estuarine, Coastal and Shelf Science* 40: 403-420.
- Grange, N., Whitfield, A.K., de Villiers, C.J. and Allanson, B.R. 2000 The response of two South African east coast estuaries to altered river flow regimes. *Aquatic Conservation: Marine and Freshwater Ecosystems* 10: 155-177.
- Griffiths C.J. 1987 Introduction. Pages 1-6 in Beach erosion along Kunduchi beach, north of Dar es Salaam. Report for National Environmental Management Council by Beach Erosion Committee, Tanzania.
- Guale 2000 Environmental water requirement in Pungwe River basin. MSc thesis Research Proposal, Final Draft, Water Resources Engineering and Management Programme, Civil Engineering, University of Zimbabwe, Harare.
- Haida, S. 2000 Transports de matières et bilan de l'érosion mécanique et de l'altération chimique dans un bassin versant de zone semi-aride: le Sebou. Impacts des variations climatiques et des activités humaines. Thesis PhD, Université Ibn Tofail, Kénitra, 255 pages.
- Hanafy, M.H. 1998 Egyptian Red Sea experience. *IOC Report No. 165*, 97-106. Intergovernmental Oceanographic Commission, Paris.
- Handschumacher, P., Herve, J.P. and Hebard, G. 1992 Des aménagements hydroagricoles dans la vallée du fleuve Sénégal ou le risque de maladies hydriques en milieu sahélien. *Sécheresse*, Paris, 3(4): 219-226.
- Heymans, J.J. and Baird, D. 1995 Energy flow in the Kromme estuarine system, St Francis Bay, South Africa. *Estuarine, Coastal and Shelf Science* 41: 39-59.
- Hoguane, A. 2000 Circulation and pollutant dispersion in Maputo Bay. Maputo.
- Hotton, J. and Munguambe, F. (eds) 1998 *The Biological Diversity of Mozambique*. MICOA: Maputo.
- Huizinga, P. and Van Niekerk, L. 1997 The effects of future changes in runoff on the Olifants Estuary. CSIR Report ENV-S-C 97128. Stellenbosch, South Africa.
- Ibeanu, O. 2000 Environmental change and human security in coastal zones perspectives from a developing nation. A paper presented at the 2nd International workshop on Global Environmental Change, Bonn, Germany.
- ILACO 1971 Upper Tana catchment survey. ILACO, Netherlands.
- IUCN 1996 Rufiji delta and floodplain: environmental management and biodiversity conservation of forest, woodlands and wetlands project, Phase 1, April 1996. Nairobi, 47 pages.
- IUCN and Rufiji Administration 1997 Rufiji Delta and Flood Plain Environmental Management and Biodiversity Conservation of Forests, Woodlands and Wetlands Project. Phase One Project Proposal, IUCN-The World Conservation Union, EARO, Nairobi, Kenya, and Rufiji District Administration, Utete, Tanzania, 71 pages + annexes.
- Jerling, H.L. and Wooldridge, T. 1994 The effect of periodic inlet closure on recruitment in the estuarine mudprawn, *Upogebia africana* (Ortmann). Pages 301-306 in Dyer, K. R. and Orth, R. J. (eds) *Changes in fluxes in estuaries: implications from science to management*. Olsen and Olsen, Fredensborg, Denmark.
- JIBS 2001 Joint Inkomati Basin Study, Phase 2. Consultec and BKS Acres, Final Report.
- Kairu, K. and Nyandwi, N. (eds) 2000 Guidelines for the Study of Shoreline Change in the Western Indian Ocean Region. IOC Manuals and Guides No. 40. UNESCO, Paris, 55 pages.

- Kalitsi, E.A.K. 1999 The role of Volta River Authority in the development of the Volta Basin. Pages 13-24 in Gordon, C. and Amatekpor, J.K. (eds): *The Sustainable Integrated Development of the Volta Basin in Ghana*. VBRP, Legon.
- Kane, A. 1985 Le bassin du fleuve Sénégal à l'embouchure. Flux continentaux dissous et particulaires. Invasion marine dans la vallée du fleuve. Thèse 3ème cycle, Université Nancy II.
- Kane, A. 1997 L'apres barrage dans la vallee du fleuve Senegal. Modifications hydrologiques, morphologiques, geochimiques et sedimentologiques. Consequences sur le milieu naturel et les amenagements hydro-agricoles. These de Doctorat d'Etat, Dpt de Geographie, FLSH, UCAD.
- Kitheka, J.U. 2000 A study on water exchange and suspended sediment transport in Port-Reitz ria focusing on the Mwache mangrove wetland, Kenya. International Foundation for Science Report A/2716-1, 35 pages.
- Klomp, R. 1985 Identification of the ecological impacts of Stiegler's Gorge Power and Flood Control Project, Tanzania. Case Study presented at a conference on Environment and Development opportunities in Africa and the Middle East. The Hague, The Netherlands, 22 pages.
- Knocker, W.I. 1998 Effects of the 1997/1998 flooding at the Tana River delta. *EANHS Bulletin* **28**(1): 9-10.
- Kulindwa, K.A., Mgaya, Y.D., Sosovele, H., Taratibu, M., Mwamsamali, M., Kabigumila, J. and Ndangalasi, H. 2000 Tanzania: Rufiji, Ruvu and Wami Mangroves. Pages 309-336 in Wood, A., Stedman, P. and Mang, J. (eds) *The root causes of biodiversity loss*.
- Lahliou, A. 1996 Environmental and socio-economic impacts of erosion and sedimentation in north Africa, erosion and sediment yield. Global and Regional Perspectives. Proceedings of Exeter Symposium, July, No. 236, 491-500.
- Lefebvre, A., Guelorget, O., Perthuisot, J.P. and Dafir, J.E., 1996 Evolution biologique de la lagune de Nador (Maroc) au cours de la période 1982-1993. *Oceanologica Acta* **20**(2): 291-315.
- Lwiza, K.M.M. and Bigendako, P.R. 1988 Kunduchi tides. *Tanzania Journal of Science* **14**: 65-76.
- Mackinnon, E. 1958 Report of the Government of Ghana on agronomic aspects of the Kpong Pilot Irrigation Scheme. *FAO Report No. 903*. FAO, Rome.
- Mahe, G. 1993 Les écoulements fluviaux sur la façade atlantique de l'Afrique. ORSTOM, Paris, Coll. Etudes et Thèses, 438 pages.
- Malleret-King, D. 2000 A food security approach to marine protected area impacts on surrounding fishing communities: the case of Kisite marine park in Kenya. *Ph.D. thesis*, University of Warwick.
- Margat, J. 1992 L'eau dans le Bassin Méditerranéen. Situation et Prospective. Les Fascicules du Plan Bleu 6. Economica.
- Masundire, H. and Matiza, T. 1995 Some environmental aspects of developments in the Zambezi basin ecosystem. In Matiza, T., Crafter, S. and Dale, P. (eds) *Water Resource use in the Zambezi Basin*. Proceedings of a workshop held at Kasane, Botswana. IUCN, Gland.
- Matera, J. and Malaisse, F. 1999 Typha australis: Source d'énergie potentielle pour la production de charbon de biomasse. Inventaire de la biomasse sur la rive gauche du Sénégal. Rapport de mission. Août 1999. Laboratoire d'Ecologie, Faculté des Sciences Agronomiques de Gembloux (Belgique), 38 pages.
- Matola 1995 Um Método para a Determinação da Intrusão Salina em Estuários Aluviais. Sua Aplicação nos Estuários dos Rios Incomati, Limpopo e Púnguè. DNA, Maputo.
- Maxwell, B.A. and Buddemeier, R.W. 2002 Coastal typology development with heterogeneous data sets. *Regional Environmental Change* online March 2002, hard copy in press.
- McClanahan, T.R. and Mutere, J.C. 1994 Coral and sea urchin assemblage structure and interrelationships in Kenyan reef lagoons. *Hydrobiologia* **286**: 109-121.
- McClanahan, T.R. and Obura, D. 1995 Status of Kenya coral reefs. *Coastal Management* **23**: 57-76.
- Menioui, M. 2001 Stratégie et Plan d'Action National sur la biodiversité Marocaine. Publication COP7, Département de l'Environnement, PNUE.
- Meybeck, M. and Ragu, A. 1995 River discharges to the oceans: an assessment of suspended solids, major ions and nutrients. Environmental information and assessment. UNEP/WHO (Draft).
- Michel, P. and Sall, M. 2000 Hydrologie. Pages 14-16 in *Les Atlas de l'Afrique. Sénégal*. Editions Jeune Afrique, Paris.
- Michel, P., Barusseau, J.P. , Richard, J.F. , Sall, M.M.P. 1993 Projet Campus. L'apres barrage dans la vallee du Senegal. Modifications hydro-dynamiques et sedimentologiques. Consequences sur le milieu et

- les aménagements hydro-agricoles. Ministere de la Cooperation et Presses Universitaires de Perpignan.
- MICOA 1998 *Erosao em Moçambique*. Maputo.
- Moffat, D. and Linden, O. 1995 Perception and reality: assessing priorities for sustainable development in the Niger River delta. *Ambio*, **24**(7-8): 527-538.
- Monteiro, P.M.S. 1997 Table Bay sediment study Phase III (1997). A quantitative assessment of the impact of land based discharges of organic matter and trace metals on the sediment characteristics of Table Bay. *CSIR Report ENV-S-C 97085*. Stellenbosch, South Africa.
- Monteiro, P.M.S. and Largier, J.L. 1999 Thermal stratification in Saldanha Bay (South Africa) and subtidal, density-driven exchange with the coastal waters of the Benguela upwelling system. *Estuarine Coastal and Shelf Science* **49**: 877-890.
- Monteiro, P.M.S., Luger, S., Pretorius, P.J. and Van Ballegooyen, R. 1999 Simulation of eutrophication and particle dynamics in a bay system in order to predict the transport and fate of trace metals linked to urban, industrial and port developments. In: *Proceedings of Pollution 99*. Lemnos, Greece.
- Morant, P.D. (pers. comm.) Personal observation made during a site visit to the Congo River mouth in June 2001. CSIR, Environmentek Stellenbosch, South Africa.
- Morant, P.D. 1983 Estuaries of the Cape. Part II: Synopses of available information on individual systems. Report No. 26: Olifants (CW10). *CSIR Research Report No. 425*. Stellenbosch, South Africa.
- Morant, P.D. 1983 Report No. 20: Groot Brak (CMS 3). In Heydorn, A. E. F. and Grindley, J. R. (eds) Estuaries of the Cape. Part 2. Synopses of available information on individual systems. *CSIR Research Report No. 419*.
- Morant, P.D. 2001 Description of the Coastal and Marine Environment of the Republic of the Congo. *CSIR Report ENV-S-C 2001-017*. Stellenbosch, South Africa.
- Mordasova, N.V. 1980 Chlorophyll in the southwestern Indian Ocean in relation to hydrological conditions. *Oceanology* **1**: 116-122.
- Mordasova, N.V., Poluyaktov, V.F. and Druzhinin, A.D. 1980 Hydrochemical regime of waters off East Africa and in the Mascarene Ridge area. Pages 18-26 in *Fishery Investigations in the western Indian Ocean*. Collection of scientific papers published by VNIRO, Moscow.
- Moussaoui, A. 1994 Pollution nitrique actuelle et vulnérabilité des eaux souterraines de Mnasra. *Thèse Sci. Agronomiques*, Rabat.
- Munga, D. 1987 Nutrient and hydrocarbon concentrations in the Mozambique Channel. Article 13 in: *Annual Report of the Kenya Marine Fisheries Research Institute, Mombasa*.
- Mushala, H.M. 1978 Coastal processes along Kunduchi beach. *Journal of Geological Association of Tanzania*.
- Muthiga, N.A. and McClanahan, T.R. 1987 Population changes of a sea urchin (*Echinometra mathaei*) on an exploited fringing reef. *African Journal of Ecology* **25**: 1-8.
- Mwalyosi, R.B. 1993 *Management of the Rufiji Delta as a wetland*. Pages 115-124 in Kamukala, G.L. and Crafter, S.A. (eds) *Wetlands of Tanzania*. IUCN Wetlands Programme, 169 pages.
- Mwalyosi, R.B.B. 1988 Environmental impact of the proposed Stiegler's Gorge Hydropower project, Tanzania. *Environmental Conservation* **15**: 250-254.
- Mwalyosi, R.B.B. 1990 Resource potentials of the Rufiji River basin, Tanzania. *Ambio* **19**(1): 16-20.
- Mwatha, G.K. 1998 Aspects of the reproductive biology and fishery of the Blue Marbled Parrot Fish, *Leptoscarus vaigiensis* (Quoy and Gaimardi, 1824), in Kenya shallow waters. *MSc thesis, University of Nairobi*.
- Ngoile, M.A.K. and Kiwia, M.A. 1996 The development of the Mafia Island Marine Park: a case study. Pages 124-132 in Linden, O. and Lundin, C.G. (eds): *Proceedings of the National Workshop on Integrated Coastal Zone Management in Tanzania, 8-12 May 1995*. The World Bank, Washington.
- Ngusaru, A.S., Mgaya, Y.D., Francis, J. and Sosovele, H. 2001 Root causes of biodiversity loss in Rufiji-Kilwa and Mnazi Bay-Ruvuma estuary in Tanzania. *Consultancy report prepared for the WWF East Africa Marine Ecoregion (EAME) Programme*, 63 pages.
- Niang 1999 Suivi de l'environnement et gestion qualitative des eaux du lac de Guiers. Approche globale et perspectives de la télédétection et des systèmes d'information géographique. *Thèse 3ème cycle, Géographie Physique, Université de Dakar*.
- Nigerian Environmental Study/Action Team (NEST) 1989 *Nigeria's threatened environment: a national profile*. Ibadan, 288 pages.

- Njuguna S.G. 1991 Tana River delta wetlands. Pages 139-146 in Crafter, S.A., Njuguna, S.G. and Howard, G.W. (eds): *Wetlands of Kenya*. Gland, Switzerland: IUCN.
- Ochiewo, J. 2001 Socio-economic aspects of water management along the coast of Kenya. *Hydrobiologia* **458**: 267-273.
- Ojany, F.F. and Ogendo, R.B. 1986 *Kenya: A study in physical and human Geography*. Longman Kenya, Nairobi, 228 pages.
- Okemwa, E., Kairu, K. and Munyao, T. 1994 National report: Status of coastal changes in Kenya and its implications on sustainable coastal zone development and management. Pages 4-28 in IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts. *IOC Workshop Report No. 96* – Supplement 1. UNESCO, Paris.
- Okoh, R.N. and Egbon, P.C. 1999 Fiscal federalism and resource share: poverty of the Niger delta. Pages 405-420 in: *Fiscal Federalism and Nigerian Economic Development*. Nigerian Economic Society.
- Osei, D.M. 1969 Akosombo - prospects of growth as urban area: a study of some factors that will influence its urbanization. *Thesis, Kumasi, University of Science and Technology*.
- Otieno, F.A.O. and Maingi, S.M. 2000 Sedimentation problems of Masinga Reservoir. Pages 43-46 in Gichuki, F.N., Mungai, D.N., Gachene, C.K and Thomas, D.B. (eds): *Land and water management in Kenya - towards sustainable land use*. Proceedings of the Fourth National Workshop (Kikuyu, February 15-19, 1993).
- Pages, J.J., Debenay, J.P. and Lebrusq, J.Y. 1987 L'environnement estuarien de la Casamance. *Rev. Hydrobiol. Trop.*, Paris **20**(3-4): 191-202.
- Peters, J.J. 1978 Discharge and sand transport in the braided zone of the Zaire Estuary. *Netherlands Journal of Sea Research* **12**(3/4): 273-292.
- Pinay, G. 1988 *Hydrological assessment of the Zambezi River system*. A review working paper on interim reports on work of the International Institute for Applied Systems Analysis, Laxenburg, Austria.
- Probst, J.L. and Amiotte-Suchet, P. 1992 Fluvial suspended sediment transport and mechanical erosion in the Maghreb (North Africa). *Hydrological Science Journal* **37**(6): 621-637.
- Quick, A.J.R. and Roberts, M.J. 1993 Table Bay, Cape Town, South Africa: Synthesis of available information and management implications. *South African Journal of Science* **89**: 276-287.
- Quinn, N.W., Breen, C.M., Hearne, J.W. and Whitfield, A.K. 1998 Decision support systems for environmental management: A case study on estuary management. *Orion* **14**(2): 17-35.
- Raal, P. and Barwell, L. 1995 Application of integrated environmental management to the Tana River delta and its linkage with the Indian Ocean large marine ecosystem. In Okemwa, E., Ntiba, M.J., Sherman, K. (eds): *Status and future of large marine ecosystems of the Indian Ocean*. A report of the International Symposium and Workshop. *Marine Conservation Development Report No. 221*. IUCN, Gland, Switzerland.
- Reddering, J.S.V. and Esterhuysen, K. 1983 Sedimentation in the Kromme estuary. *ROSIE Report No. 6*, University of Port Elizabeth, Port Elizabeth, South Africa.
- Rees, J.G., Williams, T.M., Nguli, M.M., Kairu, K.K. and Yobe, A.C. 1996 Contaminant transport and storage in the estuarine creek systems of Mombasa, Kenya. *BGS Technical Report WC/96/42*, British Geological Survey, Keyworth.
- Rodgers, W.A. 1977 The Stiegler's Gorge Dam and environmental values of the Rufiji Basin. *BRALUP Research Report No. 27*, 22 pages.
- Rooseboom, A. 1992 Sediment transport in rivers and reservoirs. A South African perspective. Report to the Water Research Commission. *WRC Report No. 297/1/92*. Pretoria, South Africa.
- Ross, G. and Saint-Ange, K. 1986 Report on coastal erosion in Zanzibar and north Dar es Salaam. *Report for the Ministry of Lands, Housing and Urban Development, Dar es Salaam, Tanzania*, 17 pages.
- Saad, M.H. 1997 Inland Waters. Pages 28-45 in *Proceedings of Decision-makers Capacity Building Programme in Coastal Management*. Alexandria University/Euro-Arab Center/Netherlands Embassy in Cairo, 2-9 May 1997. Alexandria, Egypt.
- Scharler, U.M. and Baird, D. 2000 The effects of a single artificial freshwater release into the Kromme estuary. 1. General description of the study area and physico-chemical responses. *Water SA* **26**: 291-300.
- Schumann, E.H. and de Meillon, L. 1993 Hydrology of the St Francis Bay marina, South Africa. *Transactions of the Royal Society of South Africa* **48**: 323-337.

- Semesi, A.K. 1991 Management plan for the mangrove ecosystem of mainland Tanzania. In: *Mangrove management plan of all coastal districts, Vol. 11*. Ministry of Tourism, Natural Resources and Environment, Forest and Bee-keeping Division, Dar es Salaam.
- Semesi, A.K. 1992 The mangrove resource of the Rufiji Delta, Tanzania. Pages 157-172 in Matiza, T. and Chambwela, H.N. (eds): *Wetlands conservation conference for southern Africa*. IUCN Wetlands Programme, 224 pages.
- Semesi, A.K. 1997 *Coastal Ecosystems of Tanzania*. UNEP, Nairobi.
- Sestini, G. 1992 Implication of climatic changes for the Nile delta. Pages 535-601 in Jeftic, J., Milliman, D. and Sestini, G. (eds): *Climate Change and the Mediterranean*. Edward Arnold, New York.
- Shaghude, Y.W., Mutakyahwa, M.K.D. and Mohammed, S.K. 1994 National report on the status of coastal erosion, sea-level changes and their impacts, Tanzanian case. Pages 85-106 in Proceedings of Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts. IOC Workshop Report No. 96 – Supplement 1. IOC-UNESCO, Paris.
- Slinger, J.H. and Breen, C.M. 1995 Integrated research into estuarine management. *Water Science and Technology* **32**: 79-86.
- Slinger, J.H. and Taljaard, S. 1994 Preliminary investigation of seasonality in the Great Berg Estuary. *Water SA* **20**(4): 279-288.
- Slinger, J.H., Taljaard, S. and Largier, J.L. 1994 Changes in water quality in response to a freshwater flow event. Pages 51-56 in Dyer, K.R. and Orth, R.J. (eds) *Changes in fluxes in estuaries: implications from science to management*. Olsen and Olsen, Fredensborg, Denmark.
- Snooussi, M. 1992 Modalités de transfert des métaux à l'interface continent-ocean. Quelques exemples. *Hydrocol. Appl.* **4**(2): 215-226.
- Snooussi, M., Haïda, S. and Imassi, S. 2001 Effects of the construction of dams on the Moulouya and the Sebou rivers (Morocco). In *Regional Environmental Change*, Special Issue. Berlin: Springer-Verlag.
- Snooussi, M., Jouanneau, J.M. and Latouche, C. 1990 Flux de matières issues de bassins versants de zones semi-arides (Bassins du Sebou et du Souss, Maroc). Importance dans le bilan global des apports d'origine continentale parvenant à l'Océan Mondial. *Journal of African Earth Science* **11**(1/2): 43-54.
- Snow, G.C., Bate, G.C. and Adams, J.B. 2000 The effects of a single freshwater release into the Kromme Estuary. 2: Microalgal response. *Water SA* **26**: 301-310.
- Soumare, A. 1996 Etude comparative de l'évolution géomorphologique des bas estuaires du Sénégal et du Saloum; approche par les données de terrains et la télédétection. Thèse 3ème cycle Géographie, Université de Dakar, 265 pages.
- Sowman, M.R. and Fuggle, R.F. 1989 An approach to determining water surface zoning systems. The case of the Kromme estuary. *Journal of Town and Regional Planning* **22**: 13-19.
- SRI 2001 *Shared River Initiative Project*. RSA, Maputo.
- Stanley, D.J. 1996 Nile delta: an extreme case of sediment entrapment on a delta plain and consequent coastal land loss. *Marine Geology* **129**: 189-195.
- Strydom, N.A. and Whitfield, A.K. 2000 The effects of a single freshwater release into the Kromme Estuary. 4: Larval fish response. *Water SA* **26**: 319-328.
- Tafe, D.J. 1990 Zooplankton and salinity in Rufiji River delta, Tanzania. *Hydrobiologia* **208**: 123-130.
- Taljaard, S. 1997 The effects of future changes in runoff on the Olifants Estuary. Phase 1. Water quality parameters. *CSIR Report ENV-S-C 97127*. Stellenbosch, South Africa.
- Taljaard, S., Van Ballegooijen, R.C. and Morant, P.D. 2000 False Bay Water Quality Review. Volume 1: Executive Summary and Volume 2: Specialist Assessments and Inventories of Available Literature and Data. Report to the False Bay Water Quality Advisory Committee. *CSIR Report ENV-S-C 2000-086/1 & 2*, Stellenbosch, South Africa.
- Talla, I. 1993 L'épidémie de bilharziose intestinale à Richard-Toll. Pages 275-281 in Diaw, A.T. et al. (eds): *Gestion des ressources côtières et littorales du Sénégal*. IUCN, Gland.
- Tanzania Bureau of Statistics 1992 *Tanzania Census 1992*.
- Tauacale, F. 1999 Determinacao do caudal ecologico da bacia do rio Incomati. *Tese. UEM*, Maputo.
- TCMP 2000 Issue and proposed goals and objectives of a National Coastal Management Policy. *Tanzania Coastal Management Partnership Working Document 5014*, Dar es Salaam.
- TCMP 2001 *State of the Coast 2001: People and the Environment*. Tanzania Coastal Management Partnership, Dar es Salaam, 50 pages.

- Ter Morshuizen, L.D., Whitfield, A.K. and Paterson, A.W. 1996 Influence of freshwater flow regime on fish assemblages in the Great Fish River and estuary. *South African Journal of Aquatic Sciences* **22**: 52-61.
- Timberlake, J. 1998 Biodiversity of the Zambezi Basin Wetlands, Phase 1. A review and preliminary assessment of available information. Volume 1. *Report for IUCN Regional Office for Southern Africa, Harare*.
- Titiriku P.K. 1999 Agriculture in the Volta Basin: problems and prospects. Pages 107-118 in Gordon, C. and Amatekpor, J.K. (eds): *The Sustainable Integrated Development of the Volta Basin in Ghana*. VBRP, Legon.
- UEM 1999 *Esquemas de irrigação no vale do Limpopo*. UEM, Maputo.
- UNEP 1989 Implications of expected climate changes in the Mediterranean Region: An overview. *MAP Technical Reports Series No. 27*. UNEP, Athens, 52 pages.
- UNEP 1989 State of the Mediterranean marine environment. *MAP Technical Reports Series No. 28*. UNEP, Athens, 225 pages.
- UNEP 1990 Technical annexes to the report on the State of the Marine Environment. *UNEP Regional Seas Reports and Studies*, No. **114**/1. UNEP, Nairobi.
- UNEP 1995 Guidelines for integrated management of coastal and marine areas. *UNEP Regional Seas Reports and Studies No. 161*, UNEP, Nairobi.
- UNEP 1995 Proceedings of the Workshop on Application of Integrated Approach to Development, Management and Use of Water Resources. *MAP Technical Reports Series No. 94*. UNEP, Athens, 214 pages.
- UNEP 1996 State of the Marine and Coastal Environment in the Mediterranean Region. *MAP Technical Reports Series No. 100*. UNEP, Athens, 142 pages.
- UNEP 1998 *East Africa Atlas of Coastal Resources – Kenya*. UNEP, Nairobi, 119 pages.
- UNEP 1998 Strategic Action Programme to Address Pollution from Land-Based Activities. *MAP Technical Reports Series No. 119*. UNEP, Athens, 178 pages.
- UNEP 1999 Overview of land-based sources and activities affecting the marine, coastal and associated freshwater environment in the west and central African region. *UNEP Regional Seas Reports and Studies No. 171*. UNEP, Nairobi.
- UNEP 1999 Overview of land-based sources and activities affecting the marine, coastal and associated freshwater environment in the west and central African region. *UNEP Regional Seas Reports and Studies No. 171*. UNEP, Nairobi.
- UNEP 1999 Proceedings of the Workshop on Invasive *Caulerpa* Species in the Mediterranean, Heraklion, Crete, Greece, 18-20 March 1998. *MAP Technical Reports Series No. 125*, UNEP, Athens, 317 pages.
- UNEP 2001 *East Africa Atlas of Coastal Resources – Tanzania*. UNEP, Nairobi.
- UNEP/FAO 1989 Biogeochemical cycles of specific pollutants (Activity K). *MAP Technical Reports Series No. 32*. UNEP, Athens, 139 pages.
- UNEP/FAO/WHO 1996 Assessment of the state of eutrophication in the Mediterranean sea. *MAP Technical Reports Series No. 106*. UNEP, Athens, 456 pages.
- UNEP/WHO 1996 Survey of pollutants from land-based sources in the Mediterranean. *MAP Technical Reports Series No. 109*. UNEP, Athens, 188 pages.
- UNEP/WHO 1998 MED POL Phase III. Programme for the Assessment and Control of Pollution in the Mediterranean Region (1996-2005). *MAP Technical Reports Series No. 120*. UNEP, Athens, 120 pages.
- UNEP/WHO 1999 Identification of priority pollution hot spots and sensitive areas in the Mediterranean. *MAP Technical Reports Series No. 124*. UNEP, Athens.
- UNEP/WMO 1997 The Input of Anthropogenic Airborne Nitrogen to the Mediterranean Sea through its Watershed. *MAP Technical Reports Series No. 118*. UNEP, Athens, 95 pages.
- Wagner, S., Mchallo, I. and Tobey, J. 1998 Socio-economic assessment of Tanzania's coastal resources. *Tanzania Coastal Management Partnership*, Working Document 5006, Dar es Salaam.
- Watling, R.J. and Watling, H.R. 1982a Metal surveys in South African estuaries. III. Hartenbos, Little Brak and Great Brak Rivers (Mossel Bay). *Water SA* **8**: 108-113.
- Watling, R.J. and Watling, H.R. 1982b Metal surveys in South African estuaries. V. Kromme and Gamtoos Rivers (St Francis Bay). *Water SA* **8**: 187-191.
- Watling, R.J. and Watling, H.R. 1983 Metal surveys in South African estuaries. VII. Bushmans, Kariega, Kowie and Great Fish Rivers. *Water SA* **9**: 66-70.

- Watson, M. 1996 The role of protected areas in the management of Kenyan reef fish stocks. PhD thesis, University of York.
- Wells, S. and Sheppard, C. (eds) 1988 *Coral Reefs of the World, Volume 2. Indian Ocean, Red Sea and Gulf*. UNEP Regional Seas Directories and Bibliographies. IUCN, Gland/Cambridge; UNEP, Nairobi.
- Whitfield, A.K. 2000 Available scientific information on individual South African estuarine systems. Water Research Commission Report No. 577/3/00. <http://www.wrc.org.za>
- Whitfield, A.K. 1994 Abundance of larval and 0+ juvenile marine fishes in the lower reaches of three southern African estuaries with differing freshwater inputs. *Marine Ecology Progress Series* **105**: 257-267.
- Whitfield, A.K., Paterson, A.W., Bok, A.H. and Kok, H.M. 1994 A comparison of the ichthyofaunas in two permanently open eastern Cape estuaries. *South African Journal of Zoology* **29**: 175-185.
- Wooldridge, T.H. and Callahan, R. 2000 The effects of a single freshwater release into the Kromme Estuary. 3: Estuarine zooplankton response. *Water SA* **26**: 311-318.
- Younes, W.A.N., Saad, M.A.H. and Abdel-Moati, M.A.R. 1997 An ICZM approach: land-based sources of pollution and their effect on the submerged archaeological sites of Alexandria. Proceedings of the International Conference on the Mediterranean Coastal Environment “ MEDCOAST 97”.
- Zaghoul, F.M. and Halim, Y. 1992 Long-term eutrophication in a semi-closed bay: the Eastern Harbour of Alexandria. *Science of the Total Environment*, Supplement 1992, Elsevier Science Publishers B.V., Amsterdam.
- Zourarah, B. 1994 La zone littorale de la Moulouya (Maroc nord-oriental). Transits sédimentaires, évolution morphologique, géochimie et état de la pollution. Thesis, No. 1250, Université Mohamed V, Rabat, 197 pages.

APPENDICES

Appendix I

Human dimensions of land-based fluxes to the coastal zone: the LOICZ-Basins approach

by H.H. Kremer, Wim Salomons and C.J. Crossland

The following appendix provides an introduction in methodology of the regional assessment and synthesis of human dimensions of land-based fluxes to the coastal zone as performed in the LOICZ-Basins core project. In using a common methodology, harmonized assessment protocols and project designs for research on global scales, the LOICZ-Basins framework aims to assist in interregional exchange and acquisition of funding opportunities on local, sub-regional and regional scales.

Background

Coasts worldwide are subject to many pressures which are expected to continue or increase in the future. Natural flows of water, nutrients and sediments to the coast are largely and increasingly influenced by past and planned physical changes in rivers (e.g., damming). In addition, the increase in tourism, fisheries, urbanization and traffic will offer challenges for the coastal zone managers and regulators. The management issues and their solutions require an integrated approach of the natural and socio-economic sciences (Turner *et al.* 1998; Salomons *et al.* 1999). Numerous studies (often mono-disciplinary) have been conducted to deal directly with these issues but could benefit from more integrated assessment. This integration of the results of past studies requires a simple and harmonized framework for assessment and analysis. For the integration LOICZ-Basins uses the DPSIR framework:

LOICZ-Basins faces three major challenges:

- 1) to determine the time delay between changes in land-based material flows (due to socio-economic activities, morphological changes or regulatory measures) and their impact on the coastal zone system.
- 2) to generate an improved understanding of the complexities of the coastal sea environments and to derive from this complex environment the “critical loads”.
- 3) to consider the multiplicity of interests and stakeholders affected by transboundary issues, particularly when local, regional, national, and multi-national governmental bodies with conflicting interests are involved.

The DPSIR framework

The Driver-Pressure-State-Impact-Response or DPSIR scheme (Turner *et al.* 1998; Turner and Bower 1999), provides a standardised frame for site assessment and evaluation. It ultimately enables the calculation and modelling of the impacts of change on the delivery and use of environmental goods and services expressed in scientific and monetary terms. The scheme sets up a platform for independent review and feedback evaluation of political and managerial response and options. The elements of this framework are:

Drivers: resulting from societal demands the sectoral activities with consequences for the coastal zone include:

- urbanisation
- aquaculture
- fisheries
- oil production and processing
- mining
- agriculture and forestry
- industrial development
- land use change.

Pressures: processes affecting key ecosystem and social system functioning (i.e., natural and anthropogenic forcing affecting and changing the state of the coastal environment):

- damming and other constructions
- river diversion, irrigation and water abstraction
- industrial effluents (industrialisation), agricultural and domestic wastes (urbanisation)
- navigation and dredging
- sea-level rise induced by land-based activities and affecting the coastal zone (e.g., decrease of riverine sediment load leading to instability of coastal geomorphology)
- other forcing functions (not primarily anthropogenic) such as climate change.

State and State change: the indicator functions and how they are affected:

- water, nutrient and sediment transport (including contaminants where appropriate) observed in the coastal zone as key indicators for trans-boundary pressures within the water pathway. Indicators are designed to give an overview of the environmental status and its development over time and enable ultimately derivation of critical load information
- geomorphologic settings, erosion, sequestration of sediments, siltation and sedimentation
- economic fluxes relating to changes in resource flows from coastal systems, their value, and changes in economic activity including the valuation of natural resources, goods and services.

Impact: effects on system characteristics and provision of goods and services:

- habitat alteration
- changes in biodiversity
- social and economic functions
- resource and services availability, use and sustainability
- depreciation of the natural capital.

Response: action taken on political and/or management level:

- scientific response (research efforts, monitoring programs)
- policy and/or management response to either protect against changes such as increased nutrient or contaminant input, secondary sea level rise, or to ameliorate and/or rehabilitate adverse effects and ensure or re-establish the chance for sustainable use of the system's resources.

The pressures are manifold, so we narrow them down within the LOICZ context, which deals with changes in biogeochemical cycles as major indicators. The LOICZ-Basins project therefore deals with the impact of human society on the material transport such as water, sediments, nutrients, heavy metals and man-made chemicals to the coast. It assesses the loads and their coastal impact and tries to provide feasible management options together with an analysis of success and failure of past regulatory measures. Since changes in fluxes are mostly land or catchment-based, the catchment–coastal sea system is treated as one unit – a water continuum. In applying this scale to loads and coastal change phenomena this means that beyond activities from agriculture, fisheries, urban development, industry, transport, tourism also morphological changes made to a catchment (e.g. damming) have to be taken into account.

In particular the following parameters will be assessed:

- material flow of water, sediments, nutrients and priority substances (past, current and future trends);
- socio-economic drivers which have changed or will change the material flows;
- indicators for impacts on coastal zone functioning; and to derive from them
- a "critical load" for the coastal zone and "critical thresholds" for system functioning.

Linking coastal response to socio-economic drivers

This critical load and threshold concept being developed within the UN/ECE CLRTAP convention will develop this link. (The “United Nations Economic Commission for Europe’s convention on Long-Range

Transboundary Air Pollution" has held several workshops and produced handbooks on the critical load concept for terrestrial and freshwater systems. In LOICZ-Basins these concepts are extended to the marine environment). In a systems approach it can be used (as has been done for atmospheric pollution abatement) for a cost-benefit analysis of management options. Scenario-building is an integral part of this analysis. Critical loads provide key information for the development and application of indicators for monitoring purposes as required, for example for the implementation of the Coastal Global Observation System, C-GOOS, of UNESCO's IOC.

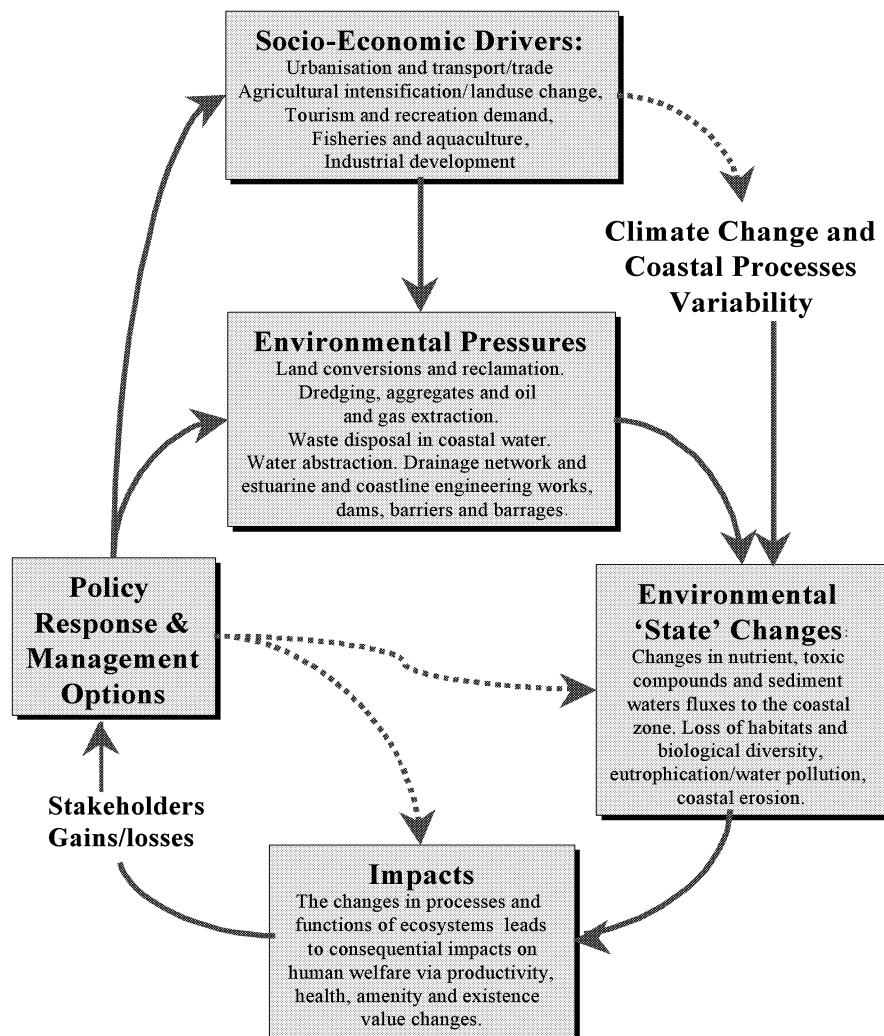


Figure A1.1. Description of the Driver-Pressure-State-Impact-Response (DPSIR) Framework.

LOICZ-Basins employs different approaches to identify **targets and indicators** for the coastal response:

- The most simple "policy-oriented" approach is taking the critical loads which have been agreed upon in international treaties (e.g. the 50% reduction scenario within the Rhine Action Plan, also adopted for the North Sea).
- The "ecosystem" approach uses historical data on the response of the coastal system to changing loads and identifies indicators. This approach will incorporate an attempt to discriminate between the natural state and an anthropogenically altered state.
- The "regional management" approach is based on consultation with local authorities and identifies their criteria for indicators or critical loads. This incorporates other indicators than those based on scientific arguments alone.

The indicators and targets will be used to derive critical concentrations. Taking into account transformations and dispersion in the coastal environment, a critical load to the coastal zone can be calculated. This critical load, the **critical outflow** of the catchment, is a combination of inputs by socio-economic activities and transformations in the catchment and its delta/estuary. Once these links and the

transformations of the loads have been established it will be possible to carry out scenarios for cost-benefit analysis and trade-offs. This will require the integration of existing modelling tools from the natural and social sciences.

The DPSIR framework is applied to determine critical loads of selected substances, under different development scenarios, with diverse biophysical and socio-economic settings, triggering the discharge into the coastal seas. It aims to provide the interdisciplinary platform for participatory approaches jointly with natural, social and economic scientists, and to incorporate representatives of stakeholders including industry, agriculture, environmental organizations and citizens.

Large catchments seem to be obvious examples to be addressed within a global LOICZ synthesizing effort (e.g. Amazon, Nile, Yangtze, Orinoco). However, from the perspective of coastal change, the major influence from land-based flows is generated in small to medium catchments with high levels of socio-economic activity. Changes in land cover and sectoral use need much shorter time-frames to translate into coastal change and usually exhibit more visible impacts than in large catchments where the “buffer capacity” against land-based change is higher simply as a function of catchment size. Thus, small and medium catchments are of priority to the global LOICZ-Basins assessment. They dominate the global coastal zone (in Africa, for example, they characterize extensive parts of monsoon-driven runoff to the Indian Ocean). In island-dominated regions such as the South Pacific or the Caribbean frequently a whole island is a catchment affecting the coastal zone and influences are generated by both anthropogenic drivers and global forcing.

The approach

Regional networks, assessment workshops/desk studies

Through two-stage regional workshops, LOICZ-Basins builds up regional multidisciplinary networks of scientists who bring their experience and existing information into the synthesis process. The first workshop identifies the pertinent regional issues and provides a first ranking order of current and predicted impacts with trend analysis, based on expert judgement and published scientific information. A second workshop finalizes the first regional synthesis, improves the geographical and thematic coverage and assists in preparing research proposals for local and regional funding. Emphasis is given to close coupling of biogeochemical and physical sciences with human dimensions. Workshops have been held and networks established in Europe, Latin America, East Asia and Africa, while desk studies cover the Caribbean, Oceania and the Russian Arctic. In February 2001 the European Catchments (EuroCat) project, funded by the European Union, started (<http://www.iia-cnr.unical.it/EUROCAT/project.htm>) as a direct result of a LOICZ assessment. The EuroCat design, objectives and modelling approaches serve as templates for the development of other regional catchment-coastal zone projects currently being developed for Africa, Latin America and East Asia.

A **LOICZ Basins** WWW page is now available at the GKSS Research Center, Geesthacht, Germany, (http://w3g.gkss.de/projects/loicz_basins/) and through the LOICZ web-site (www.nioz.nl/loicz/). It is updated continuously and provides copies of reports for downloading.

Proposals and projects that develop from regional LOICZ-Basins efforts contribute to the global LOICZ assessment. They also contribute to the Integrated Coastal Area Management initiative, ICARM, as well as to the Coastal GOOS “Global Ocean Observing System” of UNESCO/IOC. Links to the typology up-scaling effort considering global river run off and coastal biogeochemistry (a joint project of LOICZ and BAHC through the University of New Hampshire) are being pursued. Watching briefs exist with other global efforts such as GIWA, the WWAP and Millennium Assessment. Increasing the links with the Regional Seas initiatives under UNEP and the GPA is under consideration.

The framework for LOICZ Basins Synthesis and Project Development

Since LOICZ-Basins workshops have a regional focus, assessment and ranking follow a hierarchy of scales finally allowing a full regional picture to be generated – the scales increase from:

- local catchments via
- sub-regional or provincial scales up to
- regional scale which could be a country (e.g., Brazil) or a sub-continent or continent.

To facilitate thinking and to guide the evaluation of existing information, the Driver/Pressure/State/Impact/Response scheme (DPSIR) has proven to be an appropriate descriptive framework. The steps taken are:

- a) set up a **list of coastal change issues** of and **related Drivers** in the catchment (plenary-task).
- b) characterize and rank the various issues of change based on either **qualitative information** (i.e., expert judgment - if there are no hard figures) or **hard data** coming from investigations or archived material; this includes identifying **critical load** and **threshold** information for system functioning.
- c) derive a list of current or prospective “hot spots” representative of a type or class of catchment-coast system, from which to develop a **proposal** for future interdisciplinary work.

In other words LOICZ-Basins aims to provide an **expert typology** of the current state and expected trends of coastal change under land-based human forcing and natural influences. The assessment follows a set of key questions which cover the various aspects and scales of the DPSIR analysis and follow a sequence of **assessment tables**, participants are asked to fill in prior to the workshops. A generic scheme is shown below. All major assessment tables closely follow this scheme, and allow inner and interregional comparison within the global LOICZ-Basins effort, although the entries to the tables can be different.

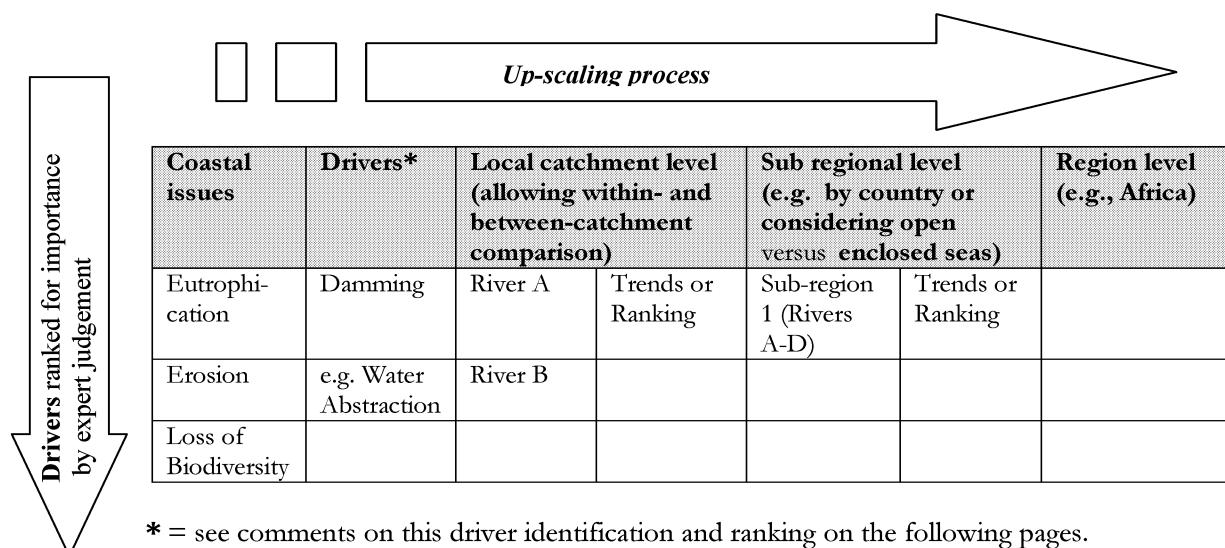


Figure A1.2. Basic schema of assessment tables.

Ranking and classification

The OSPAR 2000 quality status report (<http://www.ospar.com>) lists human pressures on the coastal sea in a ranking order with four classes according to their relative impact on the regional ecosystem - including sustainable use. Pressures are attributed to various drivers or pressure classes.

Table A1.1 shows a few examples compiled along the OSPAR guidelines, adapted to fit the LOICZ-Basins concept. It focuses on issues which link to land-based activities.

Table A1.1. Examples of impacts, pressures and driver/pressure settings in the LOICZ context.

Impact priority	Priority Classes of Human Pressures	Driver/Pressure settings - sectoral; land- or catchment- or sea-based
A (highest impact)	Input of organic contaminants – land-based	Various economic sectors
	Inputs of nutrients – land-based	Various sectors, urbanization, (wastewater, agriculture)
B (upper intermediate impact)	Input of oil and PAH – land-/sea-based	Oil industry/Shipping
	Input of other hazardous substances – land-/ sea-based	Industry/Shipping/various sectors
C (lower intermediate impact)	Input of nutrients, organic material, antibiotics etc.	Mariculture
	Mineral extraction – land/ sea based	Engineering, Mining
	Inputs of radio nuclides from land	Energy and other sectors
D (lowest impact)	Input of waste/litter	Recreation, Tourism

From these and other examples, adapted to the LOICZ needs and relying strongly on regional expert judgement and - if available - regional quality standard protocols and agreements, the LOICZ-Basins task group has developed a set of **Basins Regional Assessment tables** for global application.

LOICZ-Basins Regional Assessment Tables (RA 1- 7) and key questions for workshops, synthesis and project development

The tabulated DPSIR analysis has proven to be an appropriate descriptive framework for this purpose. The questions leading through the tables have usually been addressed in the first phase of the Basins workshops. The tables ensure a standardize approach within the global LOICZ-Basins effort. They allow integration of the regional assessments and expert typologies into the global scales and help to fill gaps and harmonise the synthesis. Data included in the first workshop are reviewed and confirmed in light of new information delivered to the second workshop. Detailed source references for data or critical load information are included wherever possible.

Table Input

Major data needed for the assessment are material flows and loads (historic data and those of relatively unimpacted systems if possible). Fluxes to be considered are:

- Water
- Sediments
- N, P, C (Si)
- Contaminants

The trend information on expected changes in the DPSIR scenarios across the various scales (how will drivers change and will this affect the loads to the coastal sea?) provide preliminary assessment that sets the stage for dynamic scenario analysis.

The critical thresholds information can be derived from: ecological (State/Impact relationship) as well as political and managerial information (Response) which refers to environmental quality standards, regulations, water directives and other comparable instruments.

The following steps are taken:

Table RA1. Major coastal Impacts/issues and critical thresholds in coastal zones – Overview and qualitative ranking
based on change in the region following the key questions

- What are major impacts (coastal issues) along the coastal zone?
- How close are they to a critical threshold of system functioning?

Coastal impact/issue e.g.	Local site / region (contributing river basins) e.g.	Critical Threshold (for system functioning) e.g.:	Distance to Critical Threshold (qualitative or quantitative) e.g.:	Impact category (Impact code and rank of importance e.g. 1- 10)	References/ data source
Erosion (coastal geomorphology)	River ABC - Delta	<ul style="list-style-type: none"> For coastal stability; Sustained delivery of xy t per year 	Qualitative information about the amount needed for coastal security. (e.g., no distance since the sediment delivery due to damming has been reduced to such a level that coastal erosion becomes a continuous process)	Erosion - 10	Database xyz, Reference abcd, 19.....
Eutrophication (habitat loss)	Bay ACEF – (rivers draining into the Bay a,b,c,...)	<ul style="list-style-type: none"> Seagrasses show signs of destruction; Occurrence of anoxia or low oxygen in estuaries; Nutrient load is at the threshold. 	Further increased nutrient load by 20-30% will change the system	Eutrophication - 8	
Pollution	Rivers XYZ				

Notes for use

This table is a first priority list of issues for the regional coast based on riverine (i.e. catchment-based) forcing. It serves to compile as much information as possible on critical fluxes, loads and thresholds for systems functions. It provides a first overview of a remaining capacity for material input or withdrawal that a target ecosystem might be able to handle without observable change. This can refer to a single function such as the stability of a coastal area against erosion. It can also refer to a multicausal impact affecting for example fisheries or water quality. These critical load and threshold estimates return in tables 6 and 7 as part of the “hot spot” and response assessment.

The ranking involves 4 main categories: values 1-3 no or minor importance, values 4-6 = medium importance, values 7-9 = major importance and value 10 = critical.

Table RA2. DPSI matrix characterizing major catchment-based Drivers/Pressures and a qualitative ranking of related coastal State changes Impacting the coastal zone versus catchments size class.

State change dimension: major; medium ; minor ; no impact; ? = insufficient information.

Time scale: p = progressive (continuous); d = discrete (spontaneous) n.a. = not applicable

Key questions and examples:

- What are the major (max. 10) driver/pressure settings on river catchment level causing coastal change?
- Can we identify spatial scales on which certain driver/pressure settings dominate coastal issues?

Driver	Pressures		State change	(qualitative index)	Impact on the coastal system	Time scale
			Large basins	Medium basins	Small basins: active coast	Small basins: passive coast
Agriculture	■ Waste/nutrient (excess fertilizer) ■ Increasing sediment transport ■ Water extraction	minor	medium	major	major	p ■ Eutrophication; Contamination; Siltation, etc...
Damming	■ Nutrient and sediment sequestration ■ Changing hydrological cycles	?	major	n.a.	medium	d ■ Coastal erosion; Nutrient depletion; Salinization
Deforestation	■ Sediment budget alteration ■	minor	major	major	major	p ■ Silatration; Sediment accretion/ Erosion
etc	etc				etc	

Notes for use

Please refer to the basins in your sub-region or for which you have information and make a judgement on how intense the effects of the various drivers on these catchments are and to what extent this may impact on the coastal zone. Ranking is in three categories (also used in tables 1 and 3-5); those are: minor importance equals 1-3, medium importance equals 4-6, major importance equals 7-10.

State changes in coastal zones driven by a catchment – based process will vary according to catchment size, for example: Deforestation even on large scale if conducted in a huge catchment such as the Amazon or Congo will cause a rather moderate if any coastal signal as compared to effects originating from pressures on small catchments where even minor deforestation can dramatically influence the sediment budget in the coastal zone. So, deforestation in the Amazon would score a “minor” while in a small catchment it could go score a “major” ranking. Where your information is referring to only one catchment type or class (e.g., large >200,000 km², medium 10,000 – 200,000 and small <10,000 km²), delete or ignore the other columns.

Active/passive coast refers to geomorphology, tectonics and climate. Small rivers along the African East coast for example are in a tectonically rather passive area with high seasonality in runoff (monsoonal influence) while small rivers in other areas e.g. the South American West coast are located in a tectonical rather active area exhibiting high slopes but they also feature high amplitudes of seasonal runoff run off variation on a yearly time-scale. South America’s East coast features passive areas and moderate run off schemes.

Table RA3. Linking coastal issues/Impacts and land based Drivers in coastal zones – Overview, qualitative ranking and trend expectations on local or catchment scale.

Key questions:

- What are the major pressure/driver settings at catchment level causing coastal impacts?
- What are the future trends (based on hard data or expert judgement)?

Coastal Impact/issues	Drivers	Local catchment (allowing within and between catchment comparison)	Trend expectations	References/ Data sources
Erosion	Damming	River A • Area... • Volume... • Run off reduction... •	Category (1 low – 10 high) 10	Increasing
	Deforestation	River A • Area... • Residual TSS production... •	8	stable
	Diversion	River A • Little, area...; effect on water flow... •	4	decreasing
Erosion total	All drivers	In River A River A	Ranking weighted from information above	Overall trend
Eutrophication	Agriculture	Residual nutrient production...	Category	9
	Mariculture	Local residual nutrient production...		5
	Municipal waste	Local urbanisation areas... ; xy t/year/10 residual production		
Eutrophication total	All drivers	In River A	Ranking weighted from information above	Overall trend
Further issues	etc			

Notes for use:

After finishing River A, continue with River B,C etc. Where possible please treat pollution separately from eutrophication.

The ranking involves four main categories with values 1-3 = no or minor importance; values 4-6 = medium importance; values 7-9 = major importance and value 10 = critical.

Table RA4. Linking coastal issues/Impacts and land-based Drivers in coastal zones – Overview, qualitative ranking and trend expectations on country or sub-regional scale;

Key questions and example:

- What are the major pressure/driver settings on country or sub-regional level causing coastal impact observed?
- What are the future trends (based on hard data or expert judgement)?

Coastal impact/ issues	Drivers	Sub-regional (i.e. by country or comparing open versus enclosed seas)	Trend-expectation	References/ data sources
Erosion	Damming	Sub Region A ● Catchments involved ● Area... ● Volume... ● Run off reduction... ● Area... ● Residual TSS production... ● Little, area...; effect on water flow...	5 Category (1 low – 10 high) 8 4	stable increasing increasing
Erosion (total in sub region A)	All drivers and rivers weighted	b Region A	Ranking weighted from information above	
Eutrophication	Agriculture Mariculture Municipal waste	Residual nutrient production... Local residual nutrient production... Local urbanisation areas... ; xy t/year residual production	9 5 10	
Eutrophication (total in sub region A)	etc.	etc.		

Notes for use:

If you have information about more than one sub-region e.g. north-west Africa or north-east Brazil, please treat them separately. Information involved here should summarize the coastal issues for the whole region and consider all the rivers reaching the coast.

The ranking involves 4 main categories: values 1-3 = no or minor importance, values 4-6 = medium importance, values 7-9 = major importance and value 10 = critical.

Table RA5. Linking coastal issues/Impacts and land-based Drivers in coastal zones – Overview, qualitative ranking and trend expectations on whole regional or continental/sub-continental scale;

Key questions:

- What are the major pressure/driver settings at whole regional, continental/sub-continental level causing coastal impact observed?
- What are the future trends (based on hard data or expert judgement)?

Coastal impact/issues	Drivers	Full regional		Trend-expectation	Reference/ data source
		(continent or sub-continent)	Category (1 low – 10 high)		
Erosion	Damming	<ul style="list-style-type: none"> • Sub-regions involved • Area... • Volume... • Runoff reduction... 	2	increasing	
	Deforestation	<ul style="list-style-type: none"> • Area... • Residual TSS production... 	8	stable	
Erosion (total in the region)	Diversion All Drivers and Rivers weighted	<ul style="list-style-type: none"> • Little, area...; effect on water flow... 	4	increasing	Ranking weighted from info above
Eutrophication	Agriculture	<ul style="list-style-type: none"> • Residual nutrient production... 	4		
	Mariculture	<ul style="list-style-type: none"> • Local residual nutrient production... 	5		
	Municipal waste	<ul style="list-style-type: none"> • Local urbanisation areas... ; xy t/tear 	10		residual production
Eutrophication (total in the region)	etc.	etc.			

Notes for use:

This table should be filled in during the workshop since it will help synthesising the working group discussions on up-scaling individual catchment and sub-region based information.
The ranking involves 4 main categories: values 1-3 = no or minor importance, 4-6 = medium importance, 7-9 = major importance and 10 = critical.

Table RA6. Scientific and/or management Response to coastal impact/issues in (continental region) coastal zones on catchment, sub-regional and regional scale.

Assessment of scientific and/or management Response on the various scales: overview of monitoring programmes and scientific investigations as well as (if applicable) management interventions, environmental quality standards, legislation, river and other commissions).

Key questions:

- What is the current status of response taken at scientific policy and/or management levels against the major coastal issues in the region?

River catchment	RESPONSE catchment scale		RESPONSE Sub-regional/ country scale		RESPONSE Regional scale	
	Scientific	Management	Scientific	Management	Scientific	Management
River A	e.g. monitoring programme 19-2001, Data: ...; Source:	e.g. commission established; thresholds set; legislation in place... e.g. (combining catchments A-B-... Programs? Data? Source: Source: e.g. ...			e.g. UNEP Regional Seas programme Source: Source: e.g. quality criteria for the regional waters?	e.g. quality criteria for the regional waters?
River B						
River C						
River D						
River E						

Notes for user:

This table describes the current activities dealing with the issues on either a scientific or a policy level. This can include databases and monitoring efforts, local GOOS networks or simply investigations. On policy and management levels, this focus can be on guidelines, threshold values and environmental standards (political critical loads). The scale to which these measures are being applied or should apply should be mentioned.

The information and ranking of DPSIR scenarios (tables 1-5) together with this “Response” information should lead to the identification of “hot spots” to be listed in Table 7.

Table RA7. “Hot spots” of land-based coastal Impact and gaps in understanding; a first overview of issues to be addressed in future research (identifying the appropriate scale for the design of a new scientific effort).

Key questions:

- What are the major gaps in our current understanding of river catchment - coastal sea interactions?
- Which “hot spots” should be addressed in a future integrated scientific effort (natural and socio economic disciplines)

River catchment	“Hot spot” catchment scale	“Hot spot” sub regional/ country scale e.g. Maputo Bay or SADC region	“Hot spot” regional scale
River A	Key issue, trend and gaps	Scientific approach	Scientific approach
	...	<ul style="list-style-type: none"> • Biogeochemical studies • Residual calculation by economic sectors • Critical flux investigation • Stakeholder and scale analysis • ACTION • ... 	<ul style="list-style-type: none"> Key issue, Trend and gaps e.g... ...
River B			
River C			
River D			

Notes for next:

This table extracts from the regional assessment the potential demonstration sites, which can be included in a proposal for a future Regional Catchment/Coast Assessment Project – “...Cat”. Ideally the sites should represent different settings which are typical for a special sub-region. This would allow up-scaling of the findings to comparable “classes” of catchment/coastal systems at a later stage. An accompanying note may be given informing about ongoing activities, link suggestions and key contact persons. Emphasis should be on the human dimensions of catchment–coastal sea interaction considering the co-evolution of natural and societal systems (i.e. involving natural and socio-economic sciences).

Appendix II Meeting reports

AfriBasins I Workshop (contributor – O. Martins)

During the first LOICZ AfriBasins workshop, held in Nairobi 25-28 July 2000, a comprehensive scientific and institutional network was established, including representatives of GEF (Biodiversity and Land Degradation), the World Bank (African Water Resources Management Forum Interim Task Force) and UNEP/DEIA&EW and the Division of Policy Development and Law. Divided in three sub-regional working teams taking into account the heterogeneous features of North Africa, West Africa and East/Southern Africa, the network concentrated on establishing a data and information base considering the existing knowledge and the major gaps in “catchment–coastal sea” interaction issues. The DPSIR (Drivers, Pressure, States, Impacts, Response) scheme provided a practical framework facilitating the review of drivers of change at the catchment level and the identification of and first efforts to categorise key pressures on the coastal systems.

The regional assessment will continue to develop a synthesis of horizontal material fluxes, changes to African coastal zone resources and characteristic system functions, and how these link to pressures on the catchments. Where possible it will be highlighted how changes in the coastal zone may feed back on the human system. Following a classification of pressure - state scenarios as well as trend analysis on expected change, a set of indices will be developed to allow regional and finally global up-scaling of the information within the global LOICZ/BAHC typology effort.

As in other regional LOICZ-Basins meetings, the African group identified possible demonstration sites in each region with which to start the development of project proposals. The objective is to address a representative range of regional sites through interdisciplinary studies allowing for the development of indicators for sustainable use of coastal zones. Following the critical load concept, they are aimed at reflecting the human dimensions of catchment processes and coastal zone responses. The projects should be able to employ standardised assessment and modelling tools in both the biogeochemical and socio-economic fields as developed under LOICZ and build on earlier interdisciplinary efforts such as the modelling of residual productions of material fluxes as in the South East Asian project, SWOL. The proposals can be developed in consultation with other Basins projects such as EuroCat.

A major criterion for site selection is their potential for up-scaling, i.e. a set of systems that represents a reasonable coverage of “types” of DPSIR scenarios and related coastal issues allowing comparison on regional and broader scales. While valuable to the LOICZ typology effort, this approach has considerable potential for co-operation with other global IGBP projects such as BAHC, LUCC and PAGES. As well as their contribution to aspects of global change, the studies are expected to be relevant for the issues of ICAM processes in Africa.

The AfriBasins network acknowledged the holistic character of the LOICZ-Basins effort. The site studies to be developed from this context can prove valuable to complement the objectives of various ongoing or planned river-catchment initiatives. Potential for synergies was seen with activities combined under the African Water Resource Management Initiative – West & Central Africa and the Integrated Land and Water Management Action Program for Africa (initiated mainly through the implementing agencies of the GEF). For successful implementation of a continued AfriBasins in the region, it was however regarded as equally important to strive for African “ownership” of this LOICZ approach. UNEP/ROA offered to assist by providing a link to the African Ministerial Conference on the Environment, AMCEN. Through AMCEN’s Water Forum and in cooperation with START, an appropriate coordination structure would be established to support the implementation of LOICZ AfriBasins as a complementing effort and to cover the various training and capacity-building needs involved. The meeting also agreed that the committee, with PASS and LOICZ, investigates potential synergies and supplementation with efforts such as IOC-ICAM and GOOS, determining how LOICZ-Basins might best complement them, and forge the appropriate links.

AfriBasins II Workshop (contributors – H. Kremer and R. Arthurton)

Opening the AfriBasins II Workshop, held in Nairobi 29 October – 1 November 2001, Mrs Rungano Karimanzira (ROA) welcomed the participants on behalf of the UNEP hosts. She stressed the importance of the Water sector to UNEP and stated her willingness to convey the workshop output to the AMCEN process. She referred to the forthcoming Johannesburg Summit meeting, noting the importance of water-related issues in the Johannesburg Action Plan.

Dr Eric Odada, representing PASS, drew attention to other major initiatives involving water including GIWA and highlighted the importance of coming to terms with the impacts of global change on water quality and availability. He noted the present lack of integrated knowledge and management between catchments and oceans, and drew attention to a need to link AfriBasins with other global science system initiatives in and around Africa.

Dr Hartwig Kremer, representing LOICZ, set the context for AfriBasins as a LOICZ core project that considered the human dimensions of land-ocean flux. The AfriBasins II workshop was building on the foundations established by the African coastal science and socio-economic community during AfriBasins I. The project focused on changes in the environmental state of the coastal zone, the receiving body for catchment processes and activities. The IGBP Open Science Meeting, held earlier this year, recognized the importance of coastal science in understanding the wider Earth System. He noted the links with IOC through the GOOS and, particularly, ICAM programmes, connecting scientific synthesis to management issues. Dr Isabelle Niang Diop spoke on behalf of IOC, drawing attention to the linkage between AfriBasins and the GOOS and ICAM programmes in Africa.

As with LOICZ-Basins projects elsewhere, standardization of the assessment using the DPSIR framework and upscaling from individual catchment to regional scales were recognized as keys to the success of AfriBasins. The aim was for AfriBasins to serve two goals. On the one hand it sought to enhance LOICZ science and thus inform the Global Change Science community; on the other, it aimed to provide a scientific basis for informing policy making and management organizations with a view to formulating appropriate response strategies. There would be an opportunity for AfriBasins to add value to GIWA, with its inventory approach to the water cascade between catchment and ocean. The output from AfriBasins would identify and prioritize cases for study under an AfriCat proposal that would be designed to examine the relationships between catchment drivers and their coastal impacts in a number of representative African catchments. The current EuroCat project would provide a model for the proposal.

Drawing on the work by the network of African scientists in AfriBasins I and attempting to fill the disciplinary and knowledge gaps identified at that workshop, AfriBasins II aimed to finalise the preliminary integrated regional assessment and to provide a link to the first global LOICZ-Basins synthesis. A state-of-the-art regional overview and an identification of “hot spots” to be picked up in a proposal for future regional integrated research were the immediate products expected from the workshop.

The AfriBasins II workshop adjusted the sub-regional divisions that had been suggested in AfriBasins I, now recognising a total of eight sub-regions (see 2.3). Using standardised *pro forma* tables based on the DPSIR framework, two working groups completed the assessment compilations at catchment and sub-regional levels for the western and eastern/north-eastern coasts of Africa respectively. The emphasis throughout was on a close coupling of the physical and biogeochemical sciences with the human dimensions both of the driver-pressure settings in the catchments and of the issues and impacts at the coast. Finally the sub-regional assessments were scaled up to the regional level.

From the results of the DPSIR assessment, the workshop identified river catchments within the region that would be proposed for detailed study, examining various aspects of the driver-impact linkage. This output is aimed to feed the planned “AfriCat” proposal, envisaged as providing a conceptual umbrella covering individual study proposals, that will be developed concurrently by the AfriBasins scientists’ network.

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Appendix IV Workshop agenda

AfriBasins II, UNEP Headquarters, Nairobi, 29 Oct – 1 Nov 2001

Sunday 28 October

Informal get together and briefing for the workshop – Hotel lobby 19:30

Monday 29 October

9:00 – 9:30 Registration

9:30 – 10:00 Opening Session:

Local Host – UNEP/ROA – Rugano P. Karimanzira

Pan African START secretariat, PASS – Eric Odada

UNEP – Salif Diop (Division EWA)

IGBP/LOICZ Focus 1 representative and LOICZ IPO – H. Kremer

10:00 – 11:00 Introduction (workshop background and goals)

- LOICZ-Basins, background, approach, results of other regional LOICZ-Basins activities, products, timelines and outlook
- Status and achievements of AfriBasins I
- Links to international organisations here: UNESCO'S IOC and regional

By: LOICZ/local host –*Rugano P. Karimanzira, Hartwig Kremer, Salif Diop*

11:00 – 11:15 *Coffee break*

11:15 – 12:30 1. Plenary Session

- identify chairs and rapporteurs
- regional assessment AfriBasins I; (*Sub-region Co-ordinators/LOICZ*)
- gaps and needs to refine the synthesis
- introduction to LOICZ-Basins assessment tables (background of the tables, how they have been developed). Discussion on parameterisation and ranking for upscaling and comparison of Basins information (deeper insight into the DPSIR tables, how to fill in and synthesise on various scales, subject to what has been provided to the meeting in preparation)
- discussion

12:30 – 14:00 *Lunch*

14:00 – 15:30 2. Plenary session continued

- Presentations of results of the AfriBasin II preperation (tables), executive summaries and/or personal involvement and background in LOICZ-Basins issues including **socio-economic aspects** (ca 15+5 minutes each): (Diop (also for IOC) Gordon, Kabuta (Euro/AfriCat), Nakamura (ICARM), Ochiewo, Sunday Umoh, Taljaard, Tauacale)

15:30 – 15:50 *Break*

15:50 – 16:30 Plenary session 2 continued and

- comments and additions from AfriBasins I participants invited

16:30 – 17:15 3. Plenary session – future projects

- regional LOICZ – “Cat” projects – design and goals

- AfriCat – draft and comments by participants (Forbes, Taljaard, Kremer (for Snoussi), Kabuta, Tauacala and others)

17:15 – 17:30 Plenary continued

- wrapping up
- briefing for the next day
- working groups and chairs and rapporteurs

Tuesday 30 October

“Regional Assessment of Catchment/Coast interaction and Human Dimensions”

09:00 – 09:15 1. Plenary Session – recall the last day and organisation of working groups:

09:15 – 17:00 2. Two working groups (Chairs & Rapporteurs TBA):

- on Coastal Issues, Drivers, Pressures and State/State-Changes in Africa – Filling in regional assessment tables 1-7 distributed prior to AfriBasins II, new information and ranking, refined regional synthesis and gaps along the following steps assessment tables 1-7.
- organisation of groups (along division of the coastal zone by sub-regions or coastal issues - see AfriBasins I – here e.g., a) Mediterranean Sea and Atlantic; b) East Coast).

11:45 – 12:30 brief reporting back of the groups in plenary - optional

DPSIR Assessment steps in detail (see also the attached methodology outline):

1) Assessing Issues/Impacts (and critical thresholds/loads) in the region (**Table 1**), key questions:

- What are major impacts (coastal issues) on the coastal zone and do we know anything on
- How close they are to a critical threshold of system functioning?

2) Assessment and synthesis of (max. 10) major Driver/Pressure settings generating the coastal Impact/Issues (**Table 2**), key questions:

- What are the major (max. 10) driver/pressure settings on catchment level causing coastal change?
- Can we identify spatial scales on which certain driver/pressure settings dominate coastal issues (relative size classes of catchment basins for example)?

3) Assessment and synthesis of links between coastal issues/impacts and land based pressures and drivers on catchment, sub regional and full regional scale (**Tables 3-5**), key questions:

- What are the major pressure/driver settings on catchment level causing coastal impact observed and what are the future trends?
- What are the major pressure/driver settings on sub-regional/island or country level causing coastal impact observed and what are the future trends?
- What are the major pressure/driver settings on regional (sub-continental) level causing coastal impact observed and what are the expected future trends?
- Can we develop a first typology of catchment-coastal sea interaction in Africa and what are trend expectations for future change?

4) Assessment of scientific and/or management response on various scales, major regional “hot spots” (current or future) and gaps in understanding giving reason for further investigation in a holistic multidisciplinary scientific “AfriCat” project (**Tables 6-7**), key questions:

- What is the current status of response taken on scientific or policy/management levels against the major coastal issues in the region?
- What are the major gaps in our current understanding of river catchment - coastal sea interaction and human dimensions and which “hot spots” should we address in a future integrated scientific effort (including natural and socio-economic disciplines)?

17:00 – 17:30 3. Plenary Session on Coastal Issues, Drivers, Pressures and State/State-Changes in Africa
– reporting back from the working groups

- chairs/rapporteurs report back
- revised shortlist of projects suggestions
- discussion and briefing for Wednesday

20:00 - *Workshop dinner*

Wednesday 31 October – “Synthesis and Future Projects”

09:00 – 09:45 1. Morning Plenary (report by chairs and rapporteurs)

- Recall key findings of the assessment process (the first full regional assessment results and ways ahead - drawing a qualitative and/or semi-quantitative, typological African Basins picture; key question).
- Can we develop a first issue-based rank order of catchment coastal sea interaction in Africa and what are the sub-regions involved? and
- Report back in particular on response, research needs and potential methodologies (available data) in view of human dimensions and ongoing or planned efforts, i.e. leading over to the proposal development

09:45 – 10:45 Plenary continued

- goals, design and sites for a future “AfriCat” project – Introduction and working group tasks (incl. potential templates from other implemented Basins related studies, such as EuroCat, SWOL)
- Discussion – response success and failure, types of change, pilot sites,
- Links and synergies with IOC C-GOOS and ICAM, UNEP ICARM etc.
- plenary approval on suggested sites and studies
- briefing for working groups

10:45 – 11:00 *Coffee Break*

11:00 – 12:30 2. Two working groups on “AfriCat” proposals (Chair & Rapporteur: TBA):

- evaluation of inputs to the “AfriCat” draft
- developing/refining the suggestions for demonstration project/s and drafting a first design for the local or sub-regional studies (ref. To AfriBasins I)

12:30 – 14:00 *Lunch*

14:00 – 15:30 3. “AfriCat” working groups continued

15:30 – 15:50 *Tea break*

15:50 – 16:30 4. “AfriCat” working groups continued:

- developing/refining the suggestions for demonstration project/s and drafting a first design for the studies

16:30 – 17:30 5. Plenary session: Reporting back and discussion

Thursday 01 November “Proposals, study design, implementation and final results”

09:00 – 09:30 1. Plenary:

- recall key results of the project development process of the last day;
- questions – suggestions - discussion

09:30 – 10:45 2. “AfriCat” working groups continued

- finish the draft of the proposal and site studies including work packages and partners
- Identify the co-ordinator person responsible for the finishing of the site studies and following up with national funding bodies (GEF on a national basis for example)

10:45 – 11:00

Coffee Break

11:00 – 12:30 3. Plenary:

- Chairs and rapporteurs to report back from the working groups and presenting of the study proposals, discussion (involve presentations from IOC, GEF and UNEP representatives and LOICZ):
- Discussion:
 - What,
 - Why (Regional and Global Relevance),
 - Where,
 - How, (incl. Structure),
 - Who, (identify co-ordinators and get commitment to finish and submit proposal/s),
 - Funding,
 - Timelines,
- Approval on site relevant issues for participants who leave after the morning session

12:30 – 14:00

Lunch

14:00 – 15:00 4. Final Plenary with Dr Sekou Toure and Dr. H. Haidara, UNEP-ROA

- Approval of products, proposal suggestions, commitments and timelines by the plenary
- Strengthening the AfriBasins Network
- Conclusion (synthesis and proposals)
- Outlook
- Closure of the meeting

Afternoon or next day(s)- departure of participants

(key persons local and external to continue as a drafting team for the report).

Appendix V Terms of Reference

LOICZ AfriBasins II
African River Catchment/Coastal Zone Interaction and Human Dimensions
(Impacts of land -based activities on coastal seas of Africa)
UNEP headquarters, Nairobi, Kenya,
29 October – 01 November 2001

1) Introduction - the LOICZ-Basins Background

The discussion on global change issues in coastal zones and integrated management issues increasingly recognises the interplay between river catchments and the coastal sea as of a single water continuum system. This is reflected in increasing numbers of targeted programs and key actions such as the European Water Framework Directive and UNESCO-, UNEP- and GEF-based/supported initiatives. The International Geosphere Biosphere Programme, IGBP, puts considerable emphasis on the human dimension of global change issues taking the whole water cascade as a scale. Since 1998 LOICZ contributes to the respective IGBP “water group” on various levels like the Sediment/Runoff Group (J. Syvitski) and the LOICZ-Basins core project (Wim Salomons, Hartwig Kremer). In the future of Earth system science, “water” will be the key target for a joint IGBP/WCRP/IHDP cross-cutting exercise to which LOICZ can contribute scientific assessment results generated through its regional Basins core project.

2) The LOICZ-Basins core project - Regional Assessment and Synthesis

In principle the LOICZ-Basins core project is working *inter alia* to develop a global evaluation of the importance of coastal seas as receiving bodies of land-based and naturally driven changes of horizontal material fluxes such as carbon, nitrogen and phosphorus as well as water and sediments. The scale applied to assess these pathways including groundwater is the river catchments (or whole islands, as appropriate). Priority attention is paid to the relative importance of these materials and their biogeochemical cycles as indicators representing environmental functioning and sustainable provision of goods and services under dynamic natural and human forcing. This is usually referred to as the human dimension of coastal change. Changing fluxes impacting the state of the environment and their feedback on the socio-economic system functioning are to be reviewed against the conceptual question of critical loads reaching the coastal zone and their potential to pass those thresholds beyond which systems tend to flip.

The assessment follows the DPSIR framework (adapted from “OECD core set of indicators for environmental performance review” – OECD/GD(93) 179, Paris 1993 and LOICZ R&S No. 11, 1998). It focuses on catchment based *drivers, pressures and state changes* (fluxes and material cycles) from which to derive indication of *critical loads* or distance to critical thresholds for coastal functions based on

- a) political regulations,
- b) environmental monitoring including historical information, and
- c) stakeholder perception and requirements for coastal use (land- and sea-based).

This descriptive framework helps to sketch the various natural and social boundary conditions of systems interaction. In a mid-term perspective it may enable assessment and quantitative modelling of the effects of coastal change on delivery and use of environmental goods and services, their scientific and monetary equivalents and allow to evaluate the costs and benefits of political *response* and options.

LOICZ’s commitment to global assessment of coastal change requires a serious basis for interregional and global comparison and upscaling. Regional LOICZ-Basins assessments therefore follow a standardized approach. Based on the DPSIR framework, they continue to provide qualitative or semi-quantitative ranking of catchment/island-based drivers and pressures and to reveal their relative contribution to change and impact observed in the coastal zone. This encompasses biogeochemical state parameters as well as impacts on human use. The ranking of pressures and changes in a comparable manner globally may subsequently be used for upscaling and comparison in the LOICZ typology clustering tool development. This effort is conducted in co-operation with parts of the IGBP BAHC (Biosphere Aspect of the

Hydrological Cycle) programme (see www.nioz.nl/loicz/, <http://www.kgs.ukans.edu/Hexacoral/Tools/tools.htm> or <http://water.kgs.ukans.edu:888/public/Typpages/index.htm>).

3) Links, Synergies and Futures

Within the broader context of the IGBP (current and future phases) the LOICZ-Basins project provides the scientific frame in which mid and long term collaboration with other core projects such as BAHC (Biospheric Aspects of the Hydrological Cycle), LUCC (Land Use and Cover Change) and PAGES (Past Global Changes) as well as with the IHDP and WCRP will be developed and strengthened.

With its issue-driven direction on regional and local scales, the LOICZ-Basins assessment enters the realm of coastal zone management. Engaging with users in policy and private sector advisory groups are consequent requirements for the resulting demonstration projects. An operational example on European scales can be found in the EUROCAT project <http://www.iaa-cnr.unical.it/EUROCAT/project.htm>. This approach and its results may prove valuable to the objectives of intergovernmental organizations such as UNESCO/IOC. LOICZ therefore continues to build working relationships with the IOC's ICAM (Integrated Coastal Area Management) and C-GOOS (Coastal Global Oceans Observing System) programmes.

A global synthesising experiment such as LOICZ can thus provide global monitoring efforts and the decision-making process with relevant scientific indicators and trend analysis. In doing this it maintains a neutral platform for joint discussion aiming to generate joint ownership of issues among science and users. Examples of applied LOICZ-Basins research can be found in a Rotterdam–Rhine project dealing with forecasting of sediment quality under different catchment management and use scenarios (http://w3g.gkss.de/i_a/dredged_material/index.html).

4) Specific Workshop objectives are

1. based on the AfriBasins I interim results and the new standardised LOICZ regional assessment tables, to provide a refined state of the art report of river catchment – coastal sea interactions including the human dimensions of coastal change issues and a first ranking of key pressures and state change settings providing a data entry for upscaling purposes on regional scale (see 2);
(this includes refinement of the regional data and information base for the first global LOICZ synthesis to be included in the synthesis book (see LOICZ newsletter No 17 – 12/2000) to be published in 2003. Regional contribution/authorship will be fully acknowledged).
2. to up-scale the information to broader sub-regional and finally regional synthesis by identifying and clustering areas of similar coastal change features using the DPSIR framework and the ranking for classification of sites and regions (see also LOICZ-Basins regional assessment tables).
3. to confirm or reconsider the set of focussed pilot areas, for which to develop proposals for specific case studies integrating natural and socio-economic sciences aimed to elaborate on the “human dimensions” of global change along the whole water continuum (This will be based in particular on table 6 and 7 of the assessment tables).
4. to strengthen an African LOICZ-Basins network with a commitment to continue the proposal development and project co-ordination and to improve existing and seek new value-added links to other projects and organisations such as UNEP, GIWA, UNESCO-IOC (GOOS and ICAM), START and IHDP. This will be facilitated through the LOICZ platform.

5) Focus of workshop

To achieve the objectives outlined, AfriBasins II will follow the DPSIR scheme in the process of *assessment, analysis, categorisation and ranking*. The tabulated LOICZ assessment approach applied in other regional LOICZ-Basins studies and addressing a set of key questions (See attachment: LOICZ-Basins regional assessment tables Annex II) will be used.

Briefly, the nomenclature of DPSIR is as follows:

DRIVERS in this context are **catchment-based activities (land use and land use change)** with consequences for the coastal zone such as:

- Damming;

- River diversion and effects of irrigation and water supply activities (abstraction);
- Agriculture/urbanisation (industrial, agricultural and domestic wastes);
- Mining activities.

They cause **PRESSURES** on ecosystem and social system functioning, affecting and perhaps changing the **STATE** of the coastal environment additional to natural forcing. Following the scientific guidelines of the LOICZ global synthesising experiment:

- Water, nutrient and sediment transportation throughout the catchments are key pressure indicators for coastal change driven along the boundaries of the whole water pathway. (they should enable derivation of critical load information and ranking of observed coastal issues linked to pressures);
- The dynamics and geomorphologic settings along the catchment (retention times in the catchment) are to be considered; as are
- Economic fluxes relating to changes in resource flows from coastal systems, their value and changes in economic activity.

IMPACTS are observed effects on coastal systems showing up for instance as habitat-loss/modification, changes of biodiversity, changes of social and economic functioning and resource and service availability and use. They translate into the **COASTAL ISSUES** from which the assessment process (in Table 1) embarks. Finally, the

RESPONSE reflecting action taken (including coastal management) to either protect against change such as eutrophication or pollution, erosion by means of reduced sediment loads or sea-level rise, ameliorate adverse effects and ensure sustainable use of resources.

6) Products and Expectations

Based on the preparatory work in Phase I, AfriBasins II is expected to lead to:

- a **LOICZ Reports & Studies (R&S) series volume** (which also forms the basis for part of the LOICZ synthesis in 2002) covering the following topics:
 1. Coastal impact/issues (environmental and socio economic focus)
 - 1.1 Development of qualitative indices
 - 1.2 Categorise the relevance of Impacts
 2. Drivers
 3. Pressures
 - 3.1 Development of qualitative indices
 - 3.2 Categorise the relevance of Pressures
 4. States and state-changes (Fluxes, material cycles)
 5. Response
 - 5.1 Socio-economic and political/legal settings and change
 - 5.2 Scientific and/or monitoring Response
 6. Regional up-scaling
 - 6.1 Typology development, comparing and upscaling DPSIR parameters of coastal change and scenarios by simple approximation and cluster analysis
 - 6.2 Types/classes of regional features;
 7. Trend analysis
 - 7.1 Defining Change - the “delta” of key parameters and derive a trend prediction;
 8. Gaps
 - 8.1 Data and information gaps;
 - 8.2 Efforts/commitments needed to fill these gaps;
 9. Outlook for future research (a proposal for an African catchment/coast project “Africat”).
- a draft follow-up proposal aimed at cross-disciplinary (i.e. combining natural and social science) pilot studies complementing parallel developments in the other regional Basins efforts – as a template the European “EuroCat” project may be used.

(Priority for site selection is the potential for upscaling i.e. to identify areas representative for a certain type

of catchment - coastal sea - driver interaction characteristic in a sub-region).

7) Workplan (tentative) and documents

- The workshop is planned for 29 October to 1 November 2001, at UNEP Headquarters, Nairobi, Kenya.
- Background documents:
 - AfriBasins I interim report (draft),
 - LOICZ R&S No 11 on Integrated Modelling and the DPSIR, available for downloaded as a pdf file from <http://wwwnioz.nl/loicz/>,
 - LOICZ-Basins regional assessment tables (including templates from earlier workshops in South America and East Asia as guidelines);
 - draft design for an AfriCat proposal to be completed during the workshop;
- the LOICZ (R&S) volume should be ready for publishing jointly with the partner organisations within four months after the workshop. A lead editor (to be identified) will have the responsibility for the drafting process and keeping timelines. Individual authorship of sections of the final document will be acknowledged.
- Special publications in peer-reviewed journals (e.g., Regional Environmental Change by Springer) are encouraged.
- The meeting will be asked to agree on timelines and approve the schedule and contents for/of products to be delivered.
- Pilot areas will be identified at the meeting and drafting of the proposal will be a participants' task following approval by the meeting. Commitment of task leaders to pursue the proposal development will be sought and approved and LOICZ as a platform will support and seek support from partner organisations involved in the submission process.

8) Participants

The workshop is highly product-oriented and has to be run on a tight budget. Attendance will therefore be limited to a maximum of 15 to 20 participants, including resource scientists and organisers plus technical secretarial support (preferably asked from the local organiser).

The scientists who will be approached for expression of interest are: AfriBasins I task-leaders and those researchers from Africa and elsewhere, who are exposed through their work field to issues that have not been covered adequately in Phase 1.

They are asked to fill in the tables, to comment on the proposal draft and to provide a 4-5 pages extended executive summary on their work/experience in LOICZ-Basins related work-field (if not done in Phase 1) prior to the meeting. This is a vital prerequisite to finish the regional assessment process along the key questions during the first half of the meeting and to continue with the proposal development.

Invitation and support will be based on scientific review of pre-filled tables and comments on the draft proposal design (applying to all participants) and extended executive summaries (applying to those scientists only who have not been involved in Phase 1). These documents are to be submitted to the organisers as outlined in the letter asking for expression of interest.

An invitation list will be finalised subject to expression of interest and accordance with these Terms of Reference returned to the organisers.

9) Concluding Remarks

Appropriate involvement of **socio-economic information** into the assessment and development usually turns out to be the major challenge showing biggest gaps in appropriate networking. This should therefore be a priority issue in this phase of network formation and further development. The network is strongly encouraged to identify relevant capacities in their surrounding and encourage their participation.

In the process of verifying and approving demonstration sites for future holistic project proposals along the LOICZ design emphasis will have to be on both, the up-scaling and management relevance as well as on broader contribution to global efforts. Examples are those launched through UNESCO's IOC (Integrated Coastal Area Management ICAM, Coastal Global Ocean Observation System, C-GOOS) as well as the

regional efforts for synthesis and capacity building launched for example through the START network. In principle existing and/or planned regional efforts should be complemented.

Appendix VI List of important acronyms and abbreviations

ACOPS	Advisory Committee for the Protection of the Sea
AMCEN	African Ministerial Conference on the Environment
BAHC	Biospheric Aspects of the Hydrological Cycle (IGBP core project)
C-GOOS	Coastal Module of the Global Ocean Observing System (IOC)
DPSIR	Driver-Pressure-State-Impact-Response assessment framework
GEF	Global Environment Facility
GIWA	Global International Waters Assessment
GOOS	Global Ocean Observing System
ICAM	Integrated Coastal Area Management
ICARM	Integrated Coastal Area and River Basin Management
IGBP	International Geosphere Biosphere Project
IOC	Intergovernmental Oceanographic Commission of UNESCO
LOICZ	Land-Ocean Interactions in the Coastal Zone (IGBP core project)
LUCC	Land-Use/Cover Change (IGBP co-sponsored core project)
NGO	Non-governmental Organisation
NORAD	Norwegian Agency for Development Cooperation
OECD	Organisation for Economic Cooperation and Development
PAGES	Past Global Changes (IGBP core project)
PASS	Pan-African START Secretariat
RIKZ	Rijksinstituut voor Kust en Zee (The Netherlands National Institute for Coast and Sea)
ROA	Regional Office for Africa (UNEP)
SADC	Southern Africa Development Council
SAMBas	South American Basins (LOICZ-Basins core project)
START	Global Change System for Analysis, Research and Training
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organisation