Integrated Wetlands and Water Resources Management

Proceedings of a Workshop held at the 2nd International Conference on Wetlands and Development (November 1998, Dakar, Senegal)

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Ger Bergkamp, Jean-Yves Pirot and Silvia Hostettler
May 2000

Foreword

The 2nd International Conference on Wetlands and Development took place in November 1998 in Dakar (Senegal). Although the production of these Proceedings has been delayed, much work has been done to make use of the conclusions and recommendations of this workshop on integrated wetlands and water resources management.

The results of this workshop were used to provide input into the 7th Conference of the Contracting Parties to the Convention on Wetlands (1971, Ramsar, Iran) which took place in May 1999 in San José (Costa Rica). Results from this workshop also contributed to the discussions held during the 13th Global Biodiversity Forum organised in May 1998 prior to Ramsar COP7. Furthermore, many draft papers as well as the workshop findings and recommendations were used extensively for the production of the *Vision for Water and Nature – A World Strategy for Conservation and Sustainable Management of Water Resources in the 21st Century*, which was presented and subsequently endorsed by the 2nd World Water Forum (The Hague, March 2000).

The outcome of this workshop forms part of the strategy of IUCN - The World Conservation Union to raise awareness on crucial water management issues and to bring these to the forefront in discussions outside the traditional nature conservation arena. With respect to the numerous actions that are required to alleviate the water crisis, IUCN recognises that actions taken by the wetland conservation community will have a limited effect when compared to the huge investments made by major players in the water development sector. Partnerships between the former and the latter are therefore essential to further promote and implement sustainable water management practices, which will in turn foster improved conservation of freshwater ecosystems. It is my hope that these Proceedings will contribute to this endeavour.

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Introduction

The workshop was organised by G. Bergkamp (Wetlands and Water Resources Programme, IUCN - The World Conservation Union, Switzerland) and chaired by T. Matiza Chiuta (IUCN Regional Office for Southern Africa, Zimbabwe). Workshop sessions were chaired by S.M. Donkor (UN-Economic Commission for Africa, Ethiopia), P. Denny (IHE, The Netherlands), D. Ngantou (IUCN Waza Logone Project, Cameroon) and J. Kusler (Assn. of State Wetlands Managers, USA). Rapporteurs for the workshop were O. Laye (UN-Economic Commission for Africa, Ethiopia), R. Braund (IUCN Waza Logone Project, Cameroon), M. Acreman (Institute of Hydrology, UK), I. Mat Dia (IUCN - Senegal) and C. Morry (IUCN - Canada).

The workshop examined local, national and regional experiences with integrated management of wetlands and water resources with the aim of defining needs, potential, policies and future strategies to avert further degradation of freshwater ecosystems.

The objectives of the workshop were:

- to examine the current water and wetlands management practices at different levels with a primary focus on the African region;
- to identify opportunities, problems and threats to the integrated wetlands and water resources management and conservation, especially within the African region;
- to define a coherent set of actions to consolidate favourable processes and to reverse declines in water and wetlands resources in the African region.

The workshop was organised in four sessions dealing with various aspects of integrated management of wetlands and water resources including: planning and institutional aspects, project management, capacity building and international co-operation.

This meeting was organised in response to the continued and increasing pressure on wetlands due to misuse and mismanagement of their resources which occurs widely in many of the Earth's dryland areas. On the African continent, a downward spiral in human welfare is apparent as a result of rapid population growth, stagnating per capita food production and accelerating environmental degradation. Many believe that deteriorating environmental conditions will soon cause more people to become refugees than any other factor, and satisfying these refugees' basic needs will at the same time become increasingly difficult. Serious environmental degradation stems from the reduction in floodplain inundation caused by river flow regulation and from the decline of water quality due to pollution by urban and industrial effluents. These interrelated phenomena will sharply reduce the productivity of floodplains and threaten the provision of clean water in many areas.

The loss of wetlands together with many of their functions represents a threat to the sustainable development of many developing countries. Wetlands in dryland areas are particularly vulnerable as they function under extreme climatic conditions and very often constitute the socio-economic foundation of local communities.

Synthesis and Conclusions of the Workshop

The workshop revealed that we still have a long way to go to achieve integrated management of wetlands and water resources. Great efforts are required to establish both horizontal and vertical integration. Horizontal integration requires the development of exchange mechanisms between various sectors. Vertical integration needs the exchange of information between local, national and regional institutions and the involvement of local people in planning, decision making and management based on the principle of subsidiarity.

Throughout the discussion the need for empowerment of people from developing countries active in wetlands and water resources management was emphasised. This requires them and donor agencies to become involved more in activities that build upon the expertise and experience available in these countries and to use the external advisory skills more to support them in developing and implementing integrated wetlands and water resources management. An important feature of the workshop was the majority participation of policy makers, managers and scientists from developing countries (almost 70%).

Decision making and planning for integrated management of wetland and water resources

Little integrated planning and decision making is taking place to combine wetland management and the use of water resources. The main reason is the sectoral organisation of water management and the lack of integrating mechanisms throughout the world. Also there exists a deficiency in appropriate governance and legislation combined with effective implementation. Several key issues hinder an improvement in decision making and planning in relation to the environment. They include; the absence of an understanding of the water-requirements for maintaining well functioning ecosystems; the lack in capacity to carry out these assessments and; the poor level of development planning. Furthermore, there continues to be little awareness of the values of wetlands and of the role they play in maintaining or in being the resource base of many communities. The very limited application of economic valuation within the planning process indicates that these values are mostly ignored. Poor communication within many developing countries also contributes significantly to a lack of awareness about the functions of wetlands and their importance in water resources management.

Integrating catchment, land and water use management

Implementation of integrated management of wetlands, water and land resources at the project level is often missing. Many projects are indeed sector oriented and focus on the development of water resources in a very limited way without taking into account the impacts on other uses and the environment. This practice contributes often to the development of gridlock patterns in which newly designed projects evolve along similar pathways as projects that are known to have been unsuccessful in developing integrated and sustainable resource use practices.

The limited integration at the project level is partly due to a lack of comprehension and management skills at local levels. Frequently, the profile of the manager and the choice of experts contribute to the low degree of integration within a project. At a technical level the absence of ecological evaluation, hydro-dynamic models and capacities to use appropriate monitoring and evaluation techniques repeatedly constrain the implementation of an integrated project management strategy. Also contributing to the limited integration is the low degree of education, awareness and communication on the importance of integrated management at project level.

Capacity building for integrated wetlands and water resources planning and management

Integrated wetlands and water resources management is a multi-facetted, cross-sectoral discipline in which capacities are limited, especially in the developing countries. On the African continent the lack of capacities is eminent in cross-sectoral co-ordination and planning, in understanding the importance of wetlands and in communicating with local communities. Although primary education has improved in the last decades, tertiary education on environmental engineering, environmental sciences and related subjects has hardly improved. In many countries, the national environmental research capacity is limited both in terms of the number of studies carried out as in the quality of the work. Capacities are also lacking at the planning, decision making and implementation levels. The lack of communication with resource users at the local level often hinders the effective implementation of activities. The difficulties with communication at regional and national scales forms an important constraint in learning from experiences elsewhere.

The main reasons for the shortage of research activities supporting integrated management carried out by scientists from developing countries are mainly the insufficient funding into tertiary education and under-funding of local research. In consequence, planning, decision making and project implementation continues to depend on technical assistance by experts from developed countries using most of the financial resources available for integrated management. During the numerous consultations carried out by foreign experts only little of the totality of the local cultures and the traditional, social and aesthetic values within the area are assimilated. This often leads to controversial assessments, development proposals and implementation practices. Despite the fact that some experience and expertise might be available within the region, little use is made of this due to a lack of knowledge of its existence and the absence of financial resources to access it.

International co-operation for integrated wetlands and water resources management

International co-operation from a water management perspective is much related to the functioning of regional river basin organisations. Although they play an important role in integrated management of wetlands and water resources, they often lack credibility in this field as they traditionally focus on water management in the irrigation and hydropower sub-sectors. In many cases collaboration with NGOs and local communities has been weak, resulting in little support from these institutions for river basin organisations. From an environmental point of view, international co-operation is much related to the implementation of environmental conventions, such as Ramsar, CBD, FCCC and CCD, but at the national and local levels this has been slow.

One of the main reasons for a lack of co-operation between river basin organisations and NGOs and local communities has been an absence of adequate communication. Often river basin organisations do not have the capacity to reach out to the water users or their representatives at local levels. Insufficient financial support to river basin organisations contributes to the shortages in resources and capacities of these institutions. Furthermore, little information is shared between the various NGOs active in a specific basin and only few joint activities are developed. With respect to the implementation of environmental conventions, the slow progress has much to do with the division of responsibilities for implementation between different ministries. In the absence of co-ordinating mechanisms and capacities to develop coherent plans for integrated implementation progress has not been impressive.

Recommendations of the Workshop

Integrated management

Integrating mechanisms or partnerships should be established between governments, NGOs, private sector organisations and communities involved in wetland use and water planning, decision making and management. Based on this, the participation of stakeholders should be improved while governance is strengthened.

Where legislation is absent, weak or largely overlaping, improvements need to be made which can be based on experiences elsewhere. In many areas, Environmental Impact Assessments need to be improved and more consistently followed up by amendments to the planned activities or by implementation of compensation measures.

Guidelines for integrated planning and management of floodplains should be used by basin organisations, governments and local authorities as a tool for establishing more integrated practices.

Integrated management needs an openness of project managers for experimental management and for adopting a 'learning-by-doing' approach.

At a technical level, integrated management within a project needs ecological analysis and hydro-ecological modelling to be carried out in collaboration with local or foreign research institutions, universities or consultants.

Governments and NGOs should accept the role of river basin organisations and actively contribute to their functioning. The establishment of an NGO forum within a river basin could assist with improving the relationship with the river basin organisation and provide a means to contribute to improved decision making.

With respect to environmental conventions, a joint action plan at national and provincial levels should be developed in close collaboration with local NGOs and communities. At the international level NGOs (e.g. IUCN, Wetlands International, WWF) should co-operate more intensively on the implementation of environmental conventions.

Capacity building and training

Action is required to improve capacities in cross-sectoral co-ordination and planning, including for instance in environmental costing. Much of this requires on the job training of currently sector oriented specialists involved in planning and decision making.

To establish a process of integration at the project level, capacities need to be built supporting adjustments in the profile of managers and staff favouring an integrating attitude rather than strict sector oriented visions.

Scientific communities in developing countries and development agencies have to recognise the need for 'scientific empowerment' in developing countries. They should take up their responsibilities and include integrated wetlands and water resources management in hydrological and engineering curricula and support the development of expertise of local research institutions and local consultants.

Awareness, information and networks

Campaigns are needed to raise awareness on integrated planning amongst NGOs and governmental institutions at various levels and within various sectors.

The communication of results and experiences should form a central component of any integrated project. Therefore, the set-up of an environmental training programme within the project area and the development of a local dialogue and co-operation with other development institutions is of crucial importance.

To develop further co-operation at the river basin level, programmes should be developed for exchanges at technical levels, including the exchange of hydrological data, water managers, experts and scientists.

A database containing information on all projects and activities in the basin should be developed to foster exchanges and the development of joint activities.

High priority should be given to the development of local, national and regional networks that share experiences in integrated wetland and water resources management. Good examples of these networks include the IUCN *Sahelian Floodplain Network* and the *Global Water Partnership* regional networks that are currently being developed.

Part I:

Decision making and Planning for Integrated Management of Wetland and Water Ressources

Article 1.1

Integrated Water Resources Management in Africa: Issues and Options

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Keywords: water resources, private sector, cooperation, transboundary agreements.

In Africa, distribution of water is characterised by complex patterns and striking paradoxes which exhibit an abundance of rainfall over the equatorial zone contrasted by the extensive and extreme aridity of the Sahara desert in the north and the Kalahari desert in the south. The non-uniformity of water resources requires special attention if the resource base is to be managed sustainably. Current problems constraining a sustainable and integrated water resources management in Africa include: an increasing population pressure, scarcity of water, insufficient services, a lack of data and information and a lack of co-operation and all levels.

To improve this situation institutional and legal infrastructure has to be improved and water resources planning needs to be better linked to national macro-economic planning. This requires a considerable investment in human resources development. To develop sustainable water management, private sector investment is essential to ensure the implementation of more service oriented approaches. This requires however guarantees that investments are profitable and secure. Co-operation at local level, with local people and especially women, participating in decision making is vital. At international levels, more transboundary agreements are needed if sustainable and integrated water resources management is to be established.

Gestion intégrée des ressources en eau en Afrique: questions et options

Mots-clés: ressources en eau, secteur privé, cooperation, accords transfrontaliers.

En Afrique, la distribution de l'eau se caractérise par des configurations complexes et des paradoxes saisissants qui démontrent une abondance de précipitations au-dessus de la zone équatoriale contrastée par une sécheresse étendue et extrême au nord (Sahara) et au sud (Kalahari). L'irrégularité des ressources en eau exige une attention particulière pour que les ressources de base puissent être gérées de manière durable. Les problèmes actuels contraignants à une gestion des ressources en eau durable et intégrée en Afrique incluent: une pression de la population croissante, une pénurie en eau, des services insuffisants, un manque de données, d'information et de coopération à tous les niveaux.

Pour améliorer cette situation, l'infrastructure institutionnelle et légale doit être améliorée et la planification des ressources en eau doit être mieux liée à la planification macro-économique nationale. Ceci exige un investissement considérable dans le développement des ressources humaines. Pour développer la gestion durable de l'eau, l'investissement du secteur privé est essentiel pour assurer la mise en place d'approches plus orientées vers le service. Cependant, ceci exige que les investissements soient profitables et sûrs. La coopération au niveau local, avec les communautés locales et particulièrement les femmes, participant à la prise de décision est essentielle. Aux niveaux internationaux, plus d'accords transfrontaliers sont nécessaires si la gestion durable et intégrée des ressources en eau doit être realisée.

1. Introduction

Africa has over 50 significant water basins spanning nearly all the 53 countries. For 14 of these, almost their entire national territories fall within shared river basins. There are also large inland water bodies such as Lake Victoria, Lake Chad and the Kariba reservoir. Yet for most of the shared rivers there are no inter-governmental agreements for their management for mutual benefit. Only a few, such as Senegal, Gambia, Chad and Kagera have some kind of institutional agreements for consultation and co-operation on the management and sustainable development of their shared water resources. The Niger basin has also an organisation but is going through major difficulties. Governments within the Nile, Zambezi and Zaire basins are working towards establishing co-operative mechanisms.

In Sub-Saharan Africa (SSA), international river basins constitute the principal source of water resources. About one-third of the world's international river basins are found in SSA. 35 countries in the region share the 17 major river basins. International rivers also include 11 river basins between 30,000 and 100,000 km^2. There are a number of important considerations associated with these international rivers that have implications for long-term management of water resources.

An analysis of the current situation reveals the absence of suitable maps, a lack of hydrological data and undetermined local parameters for estimating run-off and groundwater flows and a lack of technological knowledge. This makes it extremely difficult, if not impossible, to establish relationships between time series, parameters and physiographic characteristics. Some of these drawbacks result from the rapid increase of demands in the post-independence period accompanied by adverse economic conditions (i.e. international market share dropped from 3% in 1960 to about 1% in 1988, debt increase from $6 billion in 1979 to $130 billion in 1987, lack of industrial base, lack of resources, low food production per capita).

Water activities are often split among a number of ministries and departments at the national level. The fragmentation of responsibilities among sectoral ministries and administrative agencies has hindered co-ordination and impeded the attempts to integrate water management activities within the sector itself and with other sectors at the national level, often leading to a duplication of responsibilities.

In many African countries, the role of national hydrological services changed as external consulting companies and experts carried out a large portion of the contracts in the water sector for donor agencies. As a consequence, the activities of local water resources engineers and hydrologists were reduced to collection and analysis of data with limited resources. At present, there are many African geologists, water resources engineers, soil and water engineers, natural resources managers who possess the required technological knowledge to assess water resources. Respective governments should depend more on local technical expertise and less on long-term technical expatriate support. Moreover, governments need to create a favourable climate in which it is possible for those who have the technological know-how to cooperate with local people as well as the private and public sectors.

Water-related conflicts involve not only competing water claims but also conflicts arising from the interactions between forest, land, and water. Lessons could be learned from indigenous institutions which, at the subregional level (ethnic groupings) have the necessary mechanisms for conflict identification, characterisation, and resolution.

The broad objectives of water management cover the utilisation and development of water resources in an efficient, environmentally sound, equitable and reasonable manner in order to satisfy society's demand for water, water-related goods and services, as well as to safeguard the ecological functions of water resources. Integrated planning of water resources seeks to include socio-economic, environmental and technical aspects into a decision-making framework. This is how it can take into account all short-term needs and effects, ensure users' interests while maintaining ecosystem integrity and biological diversity, and find an appropriate balance between conflicting interests, at the national and international level.

Proposed activities in a catchment area that could adversely affect the conditions of aquatic ecosystems in terms of water quality and quantity, biological communities and its integrity are already subject to an environmental impact assessment (EIA) in some countries. Water abstraction is also subject to an EIA in some countries, if the intake is on transboundary waters or water is abstracted in significant amounts from other aquifers and surface waters. Non-water-management activities that may have an adverse impact on water resources are also subject to an EIA in some countries. These include, for example, the construction of oil and gas pipelines, open-cast mining and sludge-storage areas.

Inter-basin transfer may be the answer for long-term solution to drought hazards in certain parts of Africa. The possibility of establishing links between basins should be considered which would mean that large volumes of water could be retained within Africa, especially in the interior basins that are currently drying up. Ground-water recharge could help in increasing irrigation potentials and thereby curb the impact of drought. Benefits can also be derived from regional transfers involving a large number of countries. Of course, there will be need to solve problems of national, bilateral and multi-lateral issues to enhance the co-ordination and joint management of the inter-basin water transfer systems.

Four main principles need to be applied in taking action to achieve integrated water resources development and management. These are known as the Dublin principles and include (ACC/ISGWR 1992; U.N. 1992a):
Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment;

Water development and management should be participatory, involving planners and policy makers at all levels;
Women play a central role in the provision, management and safeguarding of water;
Water has an economic value in all its competing uses and should be recognised as an economic good.

2. Water resources availability and assessment in Africa

In Africa, distribution of water is characterised by complex patterns and striking paradoxes which exhibit an abundance of rainfall over the equatorial zone contrasted by extensive and extreme aridity of the Sahara desert in the north and the Kalahari desert in the south. In between these extremes are the semi-arid zones where rainfall shows wide fluctuation from year to year and between seasons. These areas cover about 57 per cent of the land surface and the soils in these areas can hold moisture to support growth up to 180 days.

The distribution of surface water is also highly non-uniform. About 50 per cent of the total surface water resources of the continent are found in one single river basin, the Congo, and 75 per cent of the total water resources are concentrated in eight major river basins, the Congo, the Niger, the Ogoague (Gabon), the Zambezi, the Nile, the Sanga, the Chari-Logone and the Volta. Only a minimal amount of the total freshwater resources in Africa can currently be used and several rivers and lakes have undergone marked reduction in flow rates and surface area during the last decades. Groundwater resources are also constantly threatened by desertification and their consequent depletion has accelerated the migration of pastoralists into marginal lands. During the last 20 years, available freshwater resources in Africa have greatly diminished due to the frequency of severe and prolonged droughts.

The sharp decline in availability of fresh water supply due to hydrologic, climatic and environmental changes is visible even in the Congo basin. Meanwhile, the demand has increased due to population growth, urbanisation, industrialisation, irrigation requirements, and fisheries and livestock development. Consequently, there are chronic as well as seasonal water shortages in most African countries and the situation becomes critical as the demand continues to increase and supply diminishes. This has serious implications on economic development and food security in several subregions of the continent.

Water resources assessments, including the identification of potential sources of fresh water, is of primary importance for sustainable water management. The determination of water resources, their extent, dependability and quality as well as the impact of human activity on available water is crucial for sustainable economic growth. Data on total water availability in different African countries is extremely scarce and therefore, does not allow comparison throughout the continent. Since most African countries have poor hydrological networks, only a handful have been able to make large scale resource assessment as a basis for national water master plans and development plans in general. The rest of the countries are applying traditional methods for water balance estimates based on generalised hydrological information from existing observation networks. Such estimates have limited precision and can only be used as first indicators for overall water availability.

2.1 Surface water

Rivers are the main sources of fresh water. Forty per cent of the world's population depends on fresh water from rivers and about two-thirds of this population lives in developing countries. As population increases relative to available water resources, the maximum per capita demand that a country can support decreases correspondingly.

World-wide there are fifty two major international rivers with catchment areas exceeding 100,000 km^2 of which seventeen are in sub-Saharan Africa. These rivers derive their run-off mainly from highland areas that form the upper catchment and little inflow is contributed from tributaries other than those that are generated in the highland areas. An exception to this generalisation is the region in and around the Congo basin where heavier and less seasonal rainfall creates and ensures a pattern of perennial watercourses. Several African rivers and lakes are undergoing a marked reduction in flow rates and water levels. Lake Chad, for example, is facing a most serious problem as in less than one hundred years, it has been reduced to only 40 per cent of its original water surface (Jauro 2000).

2.2 Ground water

Present knowledge of the availability of groundwater in the African region is not adequate to permit a detailed quantitative appraisal of the resource. However, groundwater exists in almost all parts of Africa and constitutes about 20% of the total water resources of the continent. In some areas, groundwater provides only limited supplies for drinking and for small-scale irrigation while in others it is the main source of supply. Most groundwater occurs in non-sedimentary Precambrian crystalline rock formations whose water holding capacity is not good, except where there are fissures, joints, faults and weathering. Along the coasts in west, central and eastern Africa, groundwater occurs in sedimentary formations. These formations have better yields but are affected in some cases by intrusion of saline water.

Since the 1950s, groundwater exploration and exploitation in Africa has increased following the advancement of technology for its investigation and improved capacity for identification. Information systems based on hydrogeological surveys, maps and reports are presently available in many African countries. Groundwater has become a prominent feature of mining industries and in general has undergone a growing exploitation. For many large cities, rural communities and various industrial establishments, it has become an important source of supply. The Great man-made River of

Libya is an example of a giant project transferring fossil water from the heart of the Sahara to the northern part of the country to be used for various socio-economic development programmes.

2.3 Water uses and management

Water is the most important ingredient that finds its application in all socio-economic development activities and in maintaining the ecological balance. It has a central role in meeting the requirements for food security and in the activities for the protection and conservation of the environment. The importance and linkage water has with human activities and the overall nexus issues of food security, environment and population, particularly in the context of the current situation in Africa, makes integrated water resources management an issue that should be accorded utmost priority. Chapter 18 of Agenda 21 (U.N. 1992) provides a comprehensive framework for action that envisages the areas where environment and development intersect. It outlines the basis for action, objectives, activities and the means of implementation, including estimates of required financial outlays.

The major water-consumptive uses in Africa are for agriculture and human settlements. Industry is a sector where there is an increasing use of water often affecting its quality. Requirements for other sectors like hydropower generation, fisheries, recreation and navigation, while representing a significant part of the water resources, have a very low consumption rate. Therefore, the analysis of water withdrawal in subsequent paragraphs focuses mainly on agriculture and human settlements.

3. General problems and constraints

In terms of resource potential, Africa is one of the richest continents in the world. Despite this fact, the standard of living of the majority of the population is below the poverty line. African countries are thus facing a challenge to improve the living conditions of the majority of their population through well-planned development strategies guided by comprehensive policy directives. Water resources play a key role in this.

Africa's varied climatic and diverse ecological zones provide great potential for the production of a variety of crops and livestock development. Its coastline, lakes, rivers and streams have potentials for freshwater and marine food production. Yet the region continues to be faced with food shortage crisis and increased dependence on imported food. It has been estimated that food imports by the year 2000 will amount to 49 million tons. Because of this situation, the nutritional level in the region is below the global average.

In the area of drinking water supply, about two thirds of the rural population do not have facilities. Notwithstanding some major undertakings in various water development programmes, hardly a dent has been made to bring the available water and natural resources to productive use. Thus, the region suffers from gross under utilisation of its water resources potential. Various issues are threatening a further sustainable development and use of the water resources including population pressure, water scarcity and lack of services, and lack of data and information.

3.1 Population pressure

The 1999 population in Africa of 771 million is increasing at an average rate of about 2.5 per cent per annum, and is expected to reach 979 million by the year 2010 (PRB 1999). This high population growth rate far exceeds the development pace and is putting pressure on land and water resources. The demand of the population for basic needs is also increasing at a faster rate than the countries are able to cope with. In the struggle for survival, the population depletes and degrades resources with the consequent negative impact on the environment. One of the major challenges therefore is controlling the population growth.

3.2 Water scarcity and lack of services

Hypothetically, there is more than enough water to meet the development requirements in Africa. However, uneven temporal and spatial distribution of water resources prevails in several subregions. There is also a considerable seasonal variation in rainfall between the subregions that aggravates the water situation thus creating conditions of water scarcity in many parts. From a regional water perspective, it is evident that parts of the continent are faced with a water crisis: (a) on permanent basis because demand is outstripping available resources e.g. North Africa or because water resources are deficient e.g. Sahel; (b) on non-permanent basis which is either seasonal e.g. Ghana or recurrent e.g. lake Chad basin, Ethiopia. One or both of the above conditions effects all African countries.

With increasing population the use of water in agriculture, industry, and human settlement will significantly reduce the available fresh water resources. The 1993 Population Action International Study projected that by 2025, fifteen countries in Africa will face water scarcity and another eleven countries will be water stressed. This poses a serious problem to the region. There is a major challenge for countries to launch water harvesting and conservation programmes, minimise losses through improved management and efficient use, recycle used water, develop non-conventional sources, and encourage use of inferior quality of water for irrigation and industry. Where feasible, transfer of water from those regions with excess water to the water-deficient regions can also be an option.

With respect to the provision of services, it is known that the large majority of the rural population (i.e. 65 per cent according to the 1996 Sector Status report by WHO, UNICEF and the Collaborative Council) are without water supply service (Yilma & Donkor 1997). Numbers for sanitation coverage are even worse. Consequently, water-borne diseases account for about 80 per cent of all sicknesses. With regard

to community and urban water services, the International Drinking Water Supply and Sanitation Decade (IDWSSD, 1981-1990), has produce significant results with respect to water supply. During the 1980s, a network of External Support Agencies (ESAs) and a Collaborative Council was set-up to stimulate action in the water supply and sanitation sector. To date, the Council brings together multilateral and bilateral agencies, banks, Non-Governmental Organisations (NGOs) and members from developing countries. Water use sectors related to industry and energy are the ones that attract external support from private investors. Drinking water supply and sanitation are generally subordinated to these investments posing increasingly problems for the continued provision of services to people in urban areas.

3.3 Lack of water resources data and information

No amount of information can substitute the lack of long time series and up-to-date data collected through a comprehensive network of hydrological and meteorological stations. Data are prerequisite for water resource development planning, design, operation and maintenance. This aspect while being of fundamental importance, has not received enough attention. Progress made in the 1960s and 1970s has been lost and many stations have become non-operational. This situation seriously affects development efforts in the water sector. The need for establishing adequate networks for water resources assessment, monitoring water quality and management is a challenge facing most African countries.

4. Options for promoting integrated water resources management

In many countries, institutions for water resources planning and management have their responsibilities fragmented among various sectoral ministries and administrative agencies. This has resulted in the proliferation of authorities and uncoordinated planning for water development with a serious overlap of activities and a waste of scarce resources. The lack of co-ordination has impeded attempts to integrate water management activities within the sector itself and with other sectors. The lack of co-ordination of water management can often partially be attributed to the absence of a comprehensive national water policy. Where existing, this type of policy can accommodate integrated water resources management in the context of harmonising national economic development plans and water sector plans.

Another institutional blockage for integration, is the lack of proper linkages between the water agencies and economic sectors in which water plays a role. Similarly, the lack of appreciation of the impact of water management on land and vice versa has further compounded the issue. Consequently, the environmental impacts of water and land development on each other have not been taken as integral parts of such development. In a similar way, inadequate legislation has been a serious impediment to sustainable water resources development and optimal use. Water legislation in many countries is fragmented in various enactments, some of which are not even known. In many instances, regulations have not been passed to enable the enforcement of laws.

The ultimate goal of the Mar del Plata Action Plan (MPAP) of the UN Water Conference 1977 (UN 1977) was to bring about a better economic and social progress through accelerated development of water resources. The realisation of this goal was to be achieved by means of an appropriate institutional and legal infrastructure set up for the administration, planning and management of water resources. It emphasised the need for harmonisation of water activities among all national institutions responsible for water affairs and for each country to review the water legislation and enhance co-ordinated planning.

Experience from the past decades have shown that introducing individual policy elements such as legislation or water pricing alone are not effective. Real change can only be established when a comprehensive approach is adopted that has a balanced mix of policy measures in different fields incorporating water management, macro and sectoral policies as well as a legal and institutional framework.

4.1 Emerging institutional and legal infrastructures

To improve the situation, several countries in Africa including for example Egypt, Ethiopia, Ghana, Chad, Lesotho and South Africa, have carried out institutional and legal reforms either on their own or forced by circumstances. In this respect some countries have strengthened their water institutions, others have created new ones like central policy-making and co-ordinating bodies and semi-autonomous public agencies. Other countries have reassigned functions among institutions and others still have reassigned ministerial responsibilities to water agencies.

A study conducted by DTCD/DIESA (1990) reported that three main types of institutional and legal infrastructures exist at the national level. Although variations were found in each type the main groups can be described as:

Type I: An institutional infrastructure within which policies continue to be fragmented in various ministries dealing with water as expressed in legal enactments or administrative directives of agencies operating under these Ministries. Examples of this type were in Ghana, Lesotho, Sierra Leone and others.
Type II: An infrastructure that is characterised by an overall policy making and co-ordinating body for water under a Ministry which has responsibilities other than water. The Ministry of Water Resources, Forestry, and Fisheries in the Gambia was an example. Other examples were found in Uganda, Zambia and Malawi.
Type III: An infrastructure in which a ministry for water resources has been set up to direct the policy for planning and management of water resources. Examples were identified in Burkina Faso, Kenya, Nigeria and Ethiopia.

In spite of the continuous efforts countries are making to restructure their institutions and strengthen their laws several problems still persist. Many countries have not established overall policy-making and co-ordinating bodies to provide a central direction to water resources utilisation and conservation. Besides, water resources development and management responsibilities continue to be divided among a number of ministries or departments who perform functions which are overlapping. So far not all countries in Africa have key legislation covering water rights, and control of water/effluent discharges and land degradation. In most countries including Ethiopia, Ghana and Lesotho, linkages among agencies and sector ministries are weak, due to a lack of capacity within planning units at agency and sector levels. This sector- level shortage sometimes contrasts with the planning capacities existing for economic development at national level. The main reason is the lack of adequately trained staff due to countries seeking external assistance from foreign consultants, often because of conditionalities for aid for their sector and project level planning.

Apart from introducing tariff structures, most demand management mechanisms in several African countries are weak because of an absence of rules and regulations. Although the need for cost recovery is being realised by many countries including Egypt, Ethiopia, Ghana, Lesotho and Chad, the service situation lacks sustenance to justify setting appropriate tariffs. There are also cultural, religious and other factors against implementing water tariffs.

The issue of provision of water has been politicized in almost every country and most governments are caught up in very difficult situations between the need and the possibilities. Inadequate funds together with lack of trained personnel have resulted in unsatisfactory operation and maintenance of water supply and sanitation systems in most countries like Chad, Ethiopia, Egypt, Ghana and Lesotho. Despite the issuance of declarative policies, the lack of key water legislation in several countries continues to undermine effective environmental protection of surface and groundwater.

Mechanism for integrated multi-purpose development of river basins as a basis for socio-economic development remains undefined in several countries. This is demonstrated by the absence of co-operative arrangements in the majority of trans-boundary basins in Africa. The question of explicit identification of the agencies that should represent the countries on studies and development of water resources they share with other neighbouring states is still outstanding.

4.2 Water sector planning and financial resources

In several countries, the problems that led to the preparation and implementation of national water-master plans in the early years of the MPAP have continued to persist. The major problems relate to insufficient cross-sectoral harmonisation and reconciliation with the national development targets at the macro-economic level. This has resulted in a too ambitious development of water sector projects as part of water programmes of the 3 or 5 year National Development Plans. Often the projects were too big to be absorbed by the national capacities, even when external assistance was provided. The problem of planning and implementation is a major difficulty in most countries of the region. The situation of Northern Africa is at a more advanced level. In the past few years, attempts to correct the ills of the economies of a number of African countries, through Structural Adjustment Programmes (SAP) of the IMF and the World Bank have provided an indirect opportunity to deal with some of the weaknesses of the water sector plans. Among the measures of the SAP are; arresting the balance of payment deficits and running down of government expenditures to levels that can be sustained by available resources. Consequently, the water sector is being reviewed in terms of objectives, targets, plans and resources to determine what can be funded on the basis of national resources and external investment funds. This has resulted in the scaling down of a number of water development plans. At the project level, planning and preparation continue often to be weak although the SAP and the consultative meetings are helping to bring about improvements. During the 1980s, the implementation of the SAPs by most countries including Chad, Ethiopia, Lesotho and Ghana to correct their economic problems continued. These invariably have resulted in cuts in government expenditures. The implication is that new projects are either delayed or are not started. Moreover, many existing systems are running down due to inadequate maintenance.

On the external side, the UN organisations increased their disbursements from $31 million in 1973 to $184 million 1985. With respect to loans and credits from the World Bank, International Development Association (IDA), and the International Fund for Agricultural Development (IFAD) total funding for water projects increased from $504 million in 1976 to $1748 million in 1985. Of the total disbursements of $10,956 million over the 1976-85 period 54.6% went to agriculture, 28.7% went to drinking water supply and sanitation, 15.4% to hydropower and 1.3% to navigation.

Loans and credits to African countries for irrigation projects were mainly given to countries north of the Sahara because of investments elsewhere were considered less viable. Drinking water supply disbursements to Africa concentrated on urban water supply and sanitation projects in countries where sufficient financial returns could be generated (e.g. Cote d'Ivoire, Kenya and Nigeria). Rural areas where the socio-economic viability and cost recovery are questionable were much less considered. In spite of some financial disbursements from the international community, the levels of achievement have been much below what was estimated at the time of the UN Water Conference in 1977.

From 1995 until present, the Special Initiative of the UN Secretary-General on Africa describes a much greater importance to food and water security as key elements for sustainable development (U.N. 1997; UN. 1997a). The target by 2010 is to ensure household water security for drinking and sanitation for at least 80 percent of the population. The

objective is to bring about rapid, significant and durable impact on socio-economic improvement in Africa. Concrete steps are being taken to mobilise support for the implementation of programmes in food and water security in Africa. All UN organisations have expressed commitment to co-ordinate their efforts towards helping Africa realise its health, education, food security and water resources development programme. The World Bank has set out to mobilise 25 billion dollars in the coming 10 years for the massive development programme in Africa.

4.3 Human resources development

The shortage of adequate human resources with skills and experience in the scientific, technical, economic, financial and managerial functions required for proper conservation, development and management of water resources is serious. At all levels, the lack of human resources has formed a crucial constraint to effective performance of most water agencies. Although many people have been trained in various fields, there are deficiencies in areas like economic and financial analysis of water projects. In fact the deficiencies are quite evident in all areas of water resources development. Furthermore, most trained people have not been retained in their jobs because of poor employment conditions and lack of job satisfaction. Along with finance, the issue of human resources development has been identified among the most serious needs in several African countries.

The level of undergraduate courses in the African countries is most important to respond to the many specialised human resources requirements. Unfortunately, this is threatened by the worsening economic situation of most countries who are compelled to cut their recurrent and capital spending. Especially affected are the soft sectors including education, health, water supply and environment. It could be said that the problem even goes deeper as the first and second cycle institutions have equally been affected.

There is no doubt that spending on education was very high in almost every country in Africa during the 1970's and early 1980's. In 1981 and 1982, 20% of the recurrent expenditure in the region was spent on education. This started to fall in 1983 and except for a brief recovery in 1985 it declined to 9.9% of the expenditure in 1988. The impact of this is reflected in the falling school enrolment rate in the region. For the first level (primary education) the annual growth rate of enrolment of 7.3% which was recorded in 1970-1980 fell to 2.6% over the period 1980-1987. For the secondary levels the enrolment growth rate over the same period fell from 11.9% to 8.5% and for the tertiary or university level the growth rate fell from 13.1% to 7.7%. This trend is also found for professional and technical training in water resources management and other disciplines.

One of the most urgent training needs for the water sector is in project planning and preparation at the micro-economic level and water resources sector planning at the macro-economic level. UNESCO currently carries out several post-graduate training programmes. These provide an avenue to improve the human resources situation at the regional level. The universities of Dar-es-Salaam and Burkina Faso also provide regional training courses. For technical training, countries like Ethiopia, Nigeria, Tanzania and Zambia have well-established schools. Other countries, like Ghana, are operating ad hoc training programmes attached to hydrological and meteorological services or water supply agencies. An important problem faced by training institutions is the maintenance of a continuous stream of students as limited employment opportunities are available. Nigeria, Ethiopia and Tanzania have overcome this problem through establishing a single national school to train technicians for all water agency needs with a flexibility to respond to their demand.

At the informal level, the mass literacy programmes have shown good results in many countries. Through these, local people continue to be educated in various matters affecting them. These programmes create greater awareness to mobilise and ensure the increased involvement and participation of local groups and individuals.

4.4 Private sector involvement

An efficient allocation of water needs to prevent possible abuses and monopolistic practices. Thus, water policies, institutions, laws and regulations should promote a sustainable and economically efficient and socially equitable use of water. Moreover, as water becomes scarce, proper legal entitlements to water need to be established to facilitate private investment.

The recovery of operation and maintenance costs is both a financial and economic issue since it forms the basis of the efficient provision of the services. In general, public water schemes have a lower productivity and cost recovery than those developed by individual users or user groups. It is therefore unlikely that the cost recovery objective will be reached without a formal and effective participation of users in management of the project. Experiences in southern Africa, for example, have demonstrated the positive influence of this participation. Pilot projects have shown that much can be achieved when management responsibilities are properly shared with, or transferred to farmers. In fact, some of the most successful water projects in Africa are the result of private initiatives (FAO, 1996). The private sector participation in water resources management and development range from the individual family or small NGO to a large-scale corporate investor. A successful and improved performance of water resources management, especially in irrigation schemes, requires the involvement of all the principal water users.

Water users' associations can engage in contracts with private agents who manage the entire scheme or provide most of the essential services. These agents are set free from the stranglehold of normal government procedures, enabling them to apply private sector procedures and provide efficient, cost-effective and timely services. Thus, a service-oriented approach to management, based on sound economics and

adequate profitability, can help ensure the maintenance and efficiency of water development projects that serve the market and assist farmers to adjust to change. Private sector participation is also essential as a source of finance and technical expertise. The needed capital can be generated from domestic savings and with the new more liberal attitude towards the private sector, it is also possible to devise means to use public finances to promote private sector initiatives (FAO, 1996).

Governments have the responsibility to provide the basic infrastructure that will not be built by the private sector, such as roads, dams and dikes. Private initiatives should be allowed to take over the further development, maintenance and operation of these systems. However, the private sector will do so only if it believes that the investments are profitable and secure. The creation of a business-oriented strategy requires not only the necessary political will but also governmental investments in major infrastructure. This can be achieved through introducing sound macro-economic policies to promote the investment in profitable water resources development projects. These policies, however, need to be accompanied by a high quality technical support of privately managed schemes. It is important that governments retain some control, especially with regards to policy issues. They should be able to monitor the performance of the private agents so that they respect their contractual obligations together with public entitlements such as public safety, environmental protection, and land and water rights of others.

4.5 Community participation and gender equity

In Africa, particularly in sub-Saharan countries, there is a decreasing rate in the development of water supply and irrigation projects. There is also a general failure of existing schemes because of lack of proper operation and maintenance. Consequently, low-income communities, particularly those dwelling in urban fringes and rural areas have no access to proper service facilities in particular drinking water and sanitation. They often revert to unhygienic and polluted water sources. This situation worsens every day and it should form a matter of great concern to all to improve conditions in rural and urban fringe areas. Continuous efforts for community involvement and public participation are essential for improving this situation.

The involvement of communities at the planning stage should show adequate respect and account for the value systems of local people, including their beliefs, cultures and outlooks. Respecting these often forms a vital element for the success of water development projects since it is only through consultation with the community concerned that their needs and aspiration can be addressed and realised and earnest involvement of communities can start.

Involvement of the community in water supply projects and the training of grassroots-level technicians have proven successful in many African countries. They have helped to reduce investment costs by about 40 to 50 per cent. In addition, experiences indicate that public participation provides the basis to promote health care and mass education programmes on proper water use, storage and management, personal hygiene and human waste disposal. Internal dynamism has to be brought to the task of rural poverty alleviation and active leadership has to be supported.

In rural parts of Africa, the task of fetching the family's water, gathering firewood, grinding grain and looking after the health and welfare of children and the family are almost always exclusive responsibilities of women. Women assume the above duties due to their role as wives and mothers. In nomadic areas, women are also burdened with the task of dismantling and setting up of temporary huts. Women in rural areas are caught up in the routine of fetching water from distances of 3 to 6 kilometres. A disproportionate part of the day is spent in obtaining water for the family. Regardless of the amount of water needed, these practices have health implications and lead to a decrease in the women's time and energy available for other activities. In some areas 50 per cent of women's time is spent on gathering fuelwood, making the issue a crucial concern to many. The planners and designers of water schemes should take women as the custodians and guardians for the household's food and water into account. It should be realised that identifying and defining the needs of women would promote more effective public participation and community involvement. This in turn would help achieving more success in integrated water resources management.

To address this issue, well-prepared education programmes need to be implemented to increase the gender awareness and sensitivity of people, to eliminate the discriminatory and negative attitudes of men and to redress the concept of inequality of women. It is also necessary to organise training programmes for men and women to enable them to take care of minor maintenance and operation of water systems. The success that results from efficient and reliable projects could be catalytic for development, especially, if significant complementary efforts in other socio-economic sectors take place at the same time.

If gender issues were addressed, the implementation of water projects would become more useful in reducing the hardships of women and increasing the well being of communities' health, education and economy. It will also liberate women from time consuming, long treks to collect water. Closer sources of potable water through involvement of the community and in particular women would mean that children, particularly girls, would be free to attend school. The "saved time" could also be used for such beneficial and income-raising projects as poultry production, soap-making, pottery making, and production of food crops.

4.6 Regional co-operation, transboundary water management and partnerships

Out of the 57 transboundary river, lake or groundwater basins in the region, only a few have some kind of co-operative

arrangements. Most of the existing basin institutions have been constrained by some or all of the following:

- absence of clearly designated and mandated agency to act on behalf of the riparian countries;
- technical and managerial weaknesses at the level of the secretariat of the basin authorities;
- inadequate funding by member States of the basin authorities;
- inability to mobilise external funds for pre-investment studies and for investment;
- politicisation of the selection of key personnel.

The above being the underlying problems of existing institutions, the most serious problem is the total absence of common co-operative mechanisms on which the development of transboundary water resources could be addressed. As most countries of the region are riparian to one or more transboundary river basins and since about 40 per cent of the area in Africa falls within transboundary basins, the problem pervades a large portion of the continent and remains to be a serious impediment to sustainable water resources development.

Primarily the role for water resources development rests with national governments. Experience shows however that in many African countries the financial managerial and technical capability within government agencies are insufficient to support an accelerated development of integrated water resources management on the basis of multi-sectoral activities. In many African countries, water resources development and management activities are implemented in partnership with external support agencies including UN agencies, the donor community and financing bodies like UNDP, WB and the ADB. Of particular importance is the UN System-wide Initiative on Africa, which has a vital component on water resources.

The ubiquitous nature of water, which identifies itself as a common denominator to most social and economic programmes that cut across a whole range of activities, deems it essential for countries to identify specific areas where partnerships are most needed. The type and degree of partnership and assistance required varies from country to country. It is therefore necessary for countries to identify their specific needs. In this regard, the assessment of indigenous capacity before resorting to external support is essential. It is also necessary for countries to carefully study the impact of partnership and weigh the absorption capacity of technical and financial assistance. The need to evaluate the cost effectiveness of partnerships and the possibility of continuing the activity with their own resources after the project phases out, requires careful consideration before the acceptance of assistance is decided.

5. Conclusions and recommendations

In most African countries, there is a gross under-utilisation or inefficient utilisation of water resources. There is a strong need to harness and put the land and water resources potentials to productive use. Sustainable development should proceed on the basis of sound policies and proper planning strategies that take into account the interfaces and interlinkages with the national socio-economic development perspectives. This calls for bringing together the interplay of the nexus issues of population, environment and food security with the cross-cutting elements of water resources, capacity building and gender equity. The exercise should seek to achieve cross-sectoral harmonisation and reconciliation with the national development targets at the macro-economic level. It is with this objective in mind that the following general conclusions and recommendations are drawn.

Africa is a region that exhibits complex patterns and striking paradoxes of climate, physiography, economy, social, cultural and political features. The countries of the region are at different levels of development. Given such circumstances, it would neither be possible nor desirable to recommend a single national water development strategy as a comprehensive model. What is obviously lacking are national efforts to develop new approaches and strategies suited to specific conditions that could guide the future course of action.

Water management activities and responsibilities are often split among sectoral ministries and administrative agencies. This has hindered co-ordination and impeded the attempts to integrate water management activities. The question of maintaining equilibrium on the extent of centralization or decentralization of responsibilities needs to be dealt with at local and national levels. There has been a generally successful trend initiated during the UN Water Conference in 1977 to designate a national focal point to centre the responsibility for water resources management. These efforts should be revived with resources being provided to enable the future development of effective co-ordination and harmonisation of water activities. A useful instrument to assist in the implementation of multisectoral programmes is the river basin unit. Many countries are currently adopting this as a basic planning unit.

The role of increasing water use in Africa is a subject of interest to a majority of countries and relates to all sectors. It offsets increased water demand and affects investments in infrastructure and operations. Excessive water losses are reported in the water distribution systems of many countries in Africa, in particular in irrigation schemes which have a heavy demand for water. Where irrigation is gaining prominence, the overall efficient use of water is key to development. Demand management particularly in North African countries where irrigation is relatively developed, could have profound benefits for exploration and development of new water resources.

Since the Great Drought of the 1980s, Africa has suffered more frequently from drought events. The downward trend in rainfall continued in many places and has led to increasing droughts and accelerated desertification. The concept of "drought proofing", reflecting concern over possible climatic

changes, should become an integral part of planning with increased water conservation measures and crop diversification. A coordinated training programme on drought and its control is recommended. There has been a growing concern in many countries of Africa for the control and mitigation of flood damages and associated disasters. Whereas the causes of flood may be varied, there are strong linkages between land and watershed management in upper catchments, land use policies in flood-prone areas and the costs of flood damages and of its prevention. This obviously places the subject within many national water strategies.

The meteorological and hydrological services have run down in the past decade particularly due to a lack of adequate funding. They are in urgent need of rehabilitation and expansion. The UNESCO/WMO National Evaluation of Water Resources Assessment activities and the UNDP/ World Bank Sub-Saharan Africa Hydrological Assessment have identified actions that should be taken in each country. The improvement or, where necessary, the introduction of systematic measurement and monitoring of water quantity and quality, in both surface and groundwater sources is essential to improve water resources management and address increasing water demands and climate change.

Closely linked to the economic difficulties, which several countries in Africa are going through, is a common problem of maintaining water systems in a state matching design criteria and meeting operational and efficiency requirements. This applies to all sectors in particular to drinking water and irrigation infrastructures. Emphasis on rehabilitation of inefficient systems, reduction in wastage, recycling of water, and improved operation and maintenance can be more cost-effective approaches than investing in new services. Increased attention needs to be given and investment funds made available to undertake measures to improving water use efficiency and to reducing wastage and damage to natural resources by rehabilitating infrastructures.

The provision and expansion of domestic and municipal water supplies, together with hygiene education can contribute in an important way to the social well being of a community. The widespread lack of access to services requires efforts in water supply in both rural and urban areas should be undertaken at an accelerated pace. To be fruitful, this should be accompanied and matched by complementary services for effluent treatment and disposal especially in the urban centres in Africa. Particular attention is required for the degradation of water quality from discharge of untreated industrial wastes and the entry of fertilizers and pesticides into surface and groundwater. Urgent action needs to be taken to provide adequate wastewater treatment, disposal and reuse facilities, to complement the expansion of water supply systems.

Water is a commodity to be paid for. The cost of providing water services to various users must be met by the beneficiary communities. In applying the principle of cost recovery or a degree of financial autonomy in a scheme, the reliability of the supply system must be guaranteed and the charges must be adjustable to meet the cost of supply. This implies the development and introduction of practical measures towards scheme autonomy and cost recovery in conjunction with greater efficiency and reliability of water supply to the various users.

Human resources development forms a crucial constraint in the strategies of many countries in the African region. Great needs exist for people with adequate training, skills and experience for the scientific, technical, managerial and administrative functions required for the development, conservation and management of water resources. To address this issue requires training in planning, project identification and preparation, project implementation, project monitoring and evaluation. A cost-effective way to train technicians on a continuous basis may be to set up training schools that can train technicians for the various sub-sectors of water.

During the last decade, a promising trend has been developing in some countries towards a more positive involvement of local communities in the conservation and management of their natural resources and the environment. This mobilisation of popular participation, with able organizers and appropriate information support, may offer a great opportunity for sustainable management of resources. The UN Water Conference (Mar del Plata 1977) represented a unique assembly of knowledge and experience in all water related fields and has provided a framework for action that is still valid. Based on the developments over the years and in line with Agenda 21, there are a number of areas requiring action which should be incorporated in the national water strategies of individual countries.

5.1 International support

As a result of the debt burden and economic difficulties of the African countries, investment funds for water projects have diminished. Operation and maintenance funds have either been curtailed or removed under the Structural Adjustment Programme. The flow of external investment funds has been slowing down since 1983 partly as a result of the difficulties of meeting debt service obligations. The international community has been following this closely and supported activities geared to the use and development of water resources in Africa and more so to its implication on the nexus issues of population, environment and food security.

A very vital area in Africa where assistance is most needed is the domain of agriculture. The International Action Programme on Water and Sustainable Agricultural Development (IAP-WASD), which proposes collaborative arrangements like that for drinking water, has been formulated by FAO and other UN organisations. The initiative is to respond during the 1990 and beyond to the growing concern about the poor performance of the agriculture sector during the last 20 years which did not measure up to expectations in the developing countries. The establishment of a collaborative mechanism to maintain close linkages by means of strengthening the capacity for the management of water

resources through the national co-ordinating bodies (National Water Resources Centres) and the corresponding regional and global arrangements and programmes is essential.

5.2 Access to reliable data

Effective water resources assessment and management are not possible without adequate information, including hydrologic information, water-use and quality data, demographic data, forestry and land management. Furthermore, an increased capacity is needed to assess and synthesize information into suitable knowledge that allows informed decision-making. To realize this, nationally and internationally agreed and harmonized information systems are needed that provide data required for decision-making. Ideally, the river basin or watershed should constitute the geographical unit for data collection and analysis. Even though some countries have hydrologic data available, usually on the river basin level, almost no country has socio-economic data sorted at a comparable level.

Despite problems in finding resources for data gathering, there have been some encouraging signs. As part of the Southern African Development Community protocol on water resources, for example, an agreement between member States has been signed to create a water sector dealing with integrated water planning and development of shared river basins. A promising follow-up strategy is currently being implemented.

5.3 Policy options

Countries endowed with land and water resources may have the opportunity to increase agricultural production and exports in the world market from either irrigated or rain-fed agriculture. For those countries with relative water scarcity, and high level of evaporation, agricultural production is possibly best directed into high-value, low water-intensive products. For low-income countries with high water stress, water resources will become a major limiting factor for socio-economic development. Unless early measures are taken towards restructuring production and consumption patterns away from the wasteful and low-value water-intensive uses serious constraints will be placed on development by limits in water resources. Achieving sustainable use of water resources for most low-income countries with high water stress will require that per capita water use decrease as population increases.

Some poor countries lack adequate access to what little water they have, and development assistance could help them in using that water wisely. Countries are urged to give high priority to investment for wastewater treatment and reuse, and to formulate and implement pollution monitoring and control policies as preventive and complementary measures to water supply policies. Special attention should be given to control pollution from agricultural chemicals through land management and integrated pest management measures. Countries are urged to give highest priority to the formulation of economic and regulatory measures designed to increase irrigation efficiency and optimize water allocation among various uses.

Low-income countries with high water stress may need to adopt the following strategies:

to develop educational and information infrastructure necessary to improve the skills of the labour force required for the industrial transformation that needs to take place; the case of Mauritius can serve as an example in this regard;

to shift to more high-value, less water-intensive crops, and develop the associated agricultural industries to process more of the products, thus raising the value-added components in their countries.

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Abbreviations and acronyms

ACC	-	Administrative Committee on Co-ordination
ADB	-	African Development Bank
DIESA	-	Department of International Economic and Social Affairs
DTCD	-	Department of Technical Co-operation for Development
ECA	-	Economic Commission for Africa
EIA	-	Environmental Impact Assessment
ESA	-	External Support Agencies
FAO	-	Food and Agricultural Organisation of the United Nations
IAP-WASP	-	International Action Programme on Water and Sustainable Agricultural Development
IDA	-	International Development Association
IDWSSD	-	International Drinking Water Supply and Sanitation Decade
IFAD	-	International Fund for Agricultural Development
IMF	-	International Monitory Fund
MPAP	-	Mar del Plata Action Plan
MW	-	Mega watts
NGO	-	Non-Governmental Organisation
SAP	-	Structural Adjustment Programme
SSA	-	Sub-Saharan Africa
UNCHS	-	United Nations Centre for Human Settlements (Habitat)
UNDP	-	United National Development Programme
UNEP	-	United Nations Environment Programme
UNESCO	-	United Nations Educational Scientific and Cultural Organisation
UNICEF	-	United Nations Children's Fund
UN System	-	United Nations System
WB	-	World Bank
WHO	-	World Health Organisation
WMO	-	World Meteorological Organisation

Article 1.2

Le lac de barrage de Bagré: quelle stratégie adopter pour un développement local durable

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Mots-clés : barrage, Burkina Faso, biodiversité, développement local, ressources naturelles, décentralisation.

Le Nakanbé constitue l'un des principaux fleuves du Burkina Faso. Il s'agit d'un cours d'eau temporaire qui ne coule débite que deux à trois mois dans l'année pendant la saison pluvieuse. C'est sur le cours inférieur de ce fleuve qu'a été construit, en 1992, le plus grand barrage en terre du Burkina Faso. Le barrage de Bagré produit de l'électricité et irrigue en aval d'importantes terres pour la production de riz.

Si les seules activités possibles dans cette zone se limitaient anciennement à la pêche et au maraîchage dans quelques rares zones d'inondation de la rivière, la construction du barrage a créé des opportunités multiples tant pour la biodiversité que pour le développement. En effet, avec une cuvette de 25.500 ha, le lac de Bagré offre d'immenses potentialités halieutiques et fauniques dont la conservation et la valorisation constituent de puissants leviers pour l'aménagement intégré du sous-bassin de Bagré, d'une part, et le développement socio-économique et culturel de la zone d'influence du barrage, d'autre part.

La mise en service du barrage a ainsi créé un pôle de concentration de populations dont l'impact sur la gestion des ressources naturelles constitue de sérieuses entraves pour le développement intégré et durable de la zone. Ainsi, cet article expose diverses options pour une stratégie de développement qui prenne en compte les principaux intervenants du sous-bassin de Bagré (Etat, SONABEL, privés, usagers, collectivités locales, associations d'usagers, etc..) et les différents plans et programmes de développement des ressources, notamment les recommandations du Plan d'Action national en matière de conservation de la diversité biologique.

The reservoir of Bagré dam: what strategy to adopt for sustainable development at local level

Keywords: dam, Burkina Faso, biodiversity, local development, natural resources, decentralisation.

The Nakanbé river is one of the main rivers in Burkina Faso. It is a temporary river which discharges only for two to three months per year during the rainy season. In 1992, the biggest earthen dam of Burkina Faso was built on the lower course of this river. Bagré dam generates electricity and irrigates a large area for rice production downstream.

If the only possible activities in this zone were formerly limited to fishing and market gardening in some few inundation zones of the river, the construction of the dam has created numerous opportunities for biodiversity conservation and for development. Indeed, with an area of 25,500 ha, the reservoir offers great potential for the development for wildlife and fisheries. The conservation and utilisation of this potential offers a wonderful opportunity for the integrated development of the area, on the one hand, and the socio-economic and cultural development of the area influenced by the dam, on the other hand.

The creation of the lake has led to a concentration of populations. Their impact on natural resources poses a serious threat with respect to the integrated and sustainable management of the area. Thus, this paper sets out various options for a development strategy which takes into account the main stakeholders (the State, SONABEL, private sector, local administrations, users, user group associations, etc.) and the different development plans and resource management programmes, including the recommendations of the National Biodiversity Action Plan.

1. Introduction

Le barrage de Bagré (Figure 1) se situe au carrefour d'axes routiers importants qui lui confèrent un rôle stratégique en termes d'échanges. Il a été construit sur le bassin du Nakanbé, l'un des principaux fleuves du pays. Il s'agit d'un cours d'eau temporaire qui ne coule que deux à trois mois par an pendant la saison pluvieuse. Il coule du Nord au Sud du pays sur 516 km environ avant de se jeter au lac d'Akosombo au Ghana. C'est dans le cours inférieur de ce fleuve, dans une zone nouvellement libérée de l'onchocerchose et située à 150 km à vol d'oiseau de la capitale Ouagadougou, qu'a été construit en 1992, le plus grand barrage en terre du Burkina Faso.

La zone d'étude est caractérisée par un climat tropical nord soudanien. La pluviométrie moyenne annuelle est d'environ 950 mm. Les pluies sont en général plus précoces au sud (avril et mai), qu'au nord (mai et juin); la fin des pluies survient le plus souvent en octobre. Les mois les plus pluvieux sont juillet, août et septembre. Les pluies sont le plus souvent des averses, ce qui induit un ruissellement important et une forte érosion des sols.

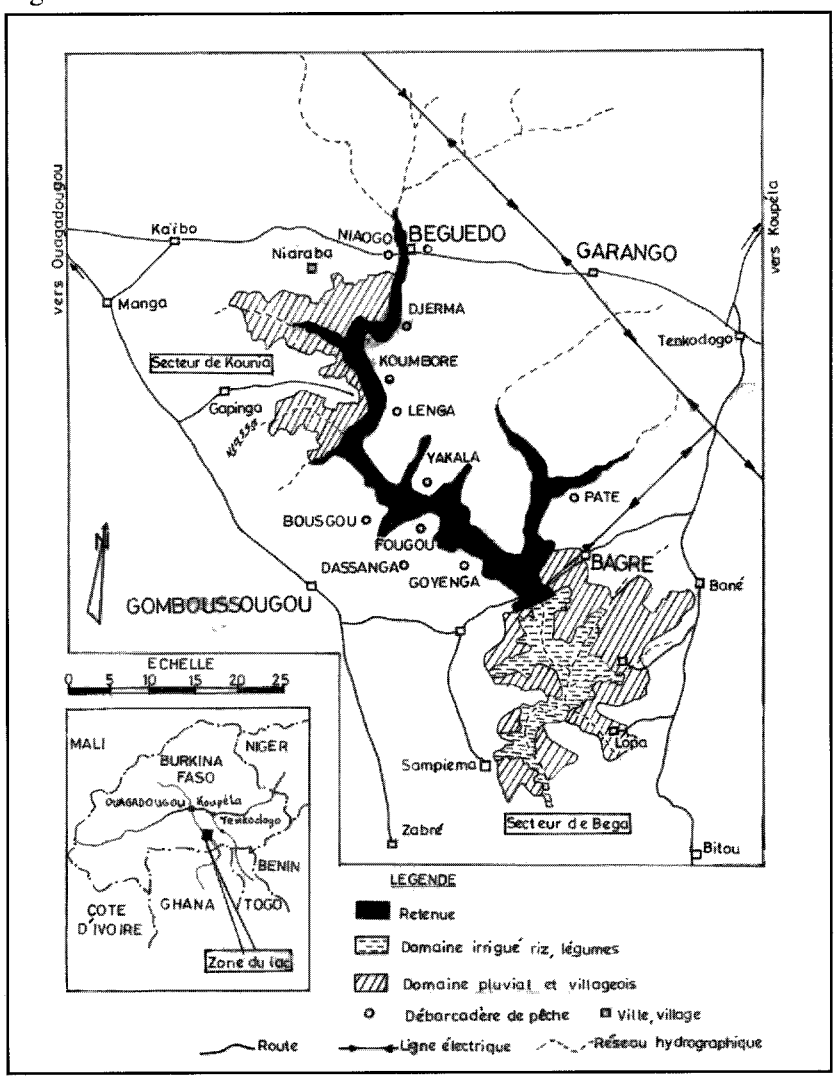
Le but de la présente communication est de donner, à partir de l'expérience en cours sur l'un des plus grands réservoirs du Burkina, des esquisses de schéma et stratégies de développement préservant à la fois la diversité biologique et garantissant le développement local durable.

2. Potentialités naturelles et impacts socio-économiques du lac de barrage de Bagré

Le lac de barrage de Bagré est un barrage à but multiple: construit pour servir principalement à la production hydro-agricole et hydro-électrique, le lac constitue aujourd'hui un important support pour le développement de l'élevage, de la pêche et du tourisme.

Avec une productivité de 44 GWH par an et contribuant pour 25% environ à la production nationale d'électricité, le barrage de Bagré constitue un outil précieux pour le développement économique du Burkina. La production de l'énergie électrique à partir du turbinage des eaux a permis depuis 1993 de desservir les villes avoisinantes et principalement la capitale, Ouagadougou, en électricité, et de réduire les importations

Fig. 1: Plan de situation de la zone du lac



d'hydrocarbure en permettant d'importantes économies de devises (plus de 5 milliards de francs CFA par an).

Le projet Bagré a été créé essentiellement dans le but de développer l'agriculture irriguée (potentiel irrigable de 30.000 ha) dans l'optique de promouvoir l'autosuffisance alimentaire. Il s'agit de produire 200.000 tonnes de céréales par an en période de croisière. Cette production représente 25% des besoins nouveaux du Burkina d'ici l'an 2000.

D'une hauteur de 22 m au dessus des berges du Nakanbé, il doit stocker 1.700 millions de m^3 à la côte 236 dont 1.540 millions constituent la tranche utilisable entre les côtes 236 et 223. L'utilisation des eaux du barrage, établie sur la base d'un apport moyen annuel de 1.270 millions de m^3 d'eau est la suivante: besoins agricoles et domestiques sont estimés à 12% des apports annuels, contre 68% pour le turbinage, 13% pour l'évaporation et 7% pour le déversement.

Sur le plan aquacole, les différentes études réalisées sur le lac révèlent que ses eaux sont troubles et faiblement minéralisées. On y relève cependant la présence d'une forte diversité biologique comprenant:

- du phytoplancton, avec 32 espèces dont 13 *Chlorophycae*, 2 *Euglenophycae*, 6 *Cyanophycae*, 7 *Chrysophycae*, 5 *Rhodophycae*;
- du zooplancton, dont 8 genres de Rotifères, 1 espèce de Cladocère, 1 espèce de *Daphnia pulex* et des Copépodes;
- du benthos dont une grande variété de bivalves, notamment *Caelatura aegyptiara*;
- du poisson appartenant à différentes familles; des crevettes, des grenouilles, des huîtres, etc.

Depuis la mise en eau du barrage en juillet 1992, la composition de la production piscicole a subi une nette transformation: on est en effet passé de 12 familles en octobre 1993 à 17 familles en décembre 1994 et 15 familles en 1998. Les familles non encore inventoriées en 1998 sont les Osteoglossidés et les Anabantidés. Le peuplement a connu depuis lors une évolution amenant une nette dominance des espèces d'eaux dormantes (*Lates*, *Tilapia* etc.) sur les espèces d'eaux courantes (*Synodontis* notamment), ces dernières ayant tendance à coloniser la partie la plus en amont du lac.

Le lac de barrage de Bagré, avec une surface moyenne en eau de 20.000 ha et une productivité comprise entre 60-120kg/ha/an est susceptible de produire 1.600 tonnes de poisson par an et peut accueillir 600 pêcheurs à temps plein (SOCREGE,1998).

Aujourd'hui, près de 2.000 personnes sont occupées par la pêche: 1.200 pêcheurs environ et aides pêcheurs, 400 femmes revendeuses de poisson et 200 commerçants spécialisés. Les revenus sont fonction des saisons de pêche et des catégories socioprofessionnelles des acteurs. Ils varient entre 30.000 et 260.000 F CFA par an (alors que la valeur du SMIG est de 24.944 F). Dans ces conditions, on comprend bien que les pêcheurs se déclarent en général satisfaits de leurs revenus. Ancien refuge de la faune sauvage, la zone du lac a fortement été dégradée par les diverses pressions anthropiques au point de porter un préjudice sévère à la diversité de la faune terrestre. Seuls subsistent aujourd'hui quelques mammifères, oiseaux et reptiles adaptés au nouveau milieu, plus ouvert et plus cultivé: singes, pintades sauvages, pythons, varan du Nil, tortues, hérons cendrés, aigles pêcheurs, crocodiles, hippopotames, etc. L'idée de créer un sanctuaire de faune dans la zone est née du souci de pacifier la cohabitation avec les hippopotames sacrés en leur procurant un milieu de quiétude et d'épanouissement.

Le lac de Bagré, la diversité des paysages et des écosystèmes, les potentialités fauniques (hippopotames, crocodiles, etc.) et l'avifaune que la présence du barrage contribue à enrichir, l'existence d'un biotope favorable à la petite chasse, les valeurs culturelles du pays bissa permettent de distinguer quatre types de produits touristiques dans la région (Yonli, 1997): le tourisme cynégétique, balnéaire artificiel, la pêche sportive et le produit culturel.

Si la zone du projet connaît plusieurs intervenants dans son développement, deux principales structures publiques assurent, de par leur statut juridique, la planification générale des actions. Il s'agit de la Maîtrise d'Ouvrage de Bagré (MOB) et de la Société Nationale burkinabè d'Electricité (SONABEL). Si la promotion des actions de développement rendues possibles par la création du barrage relèvent de la MOB, la gestion de l'eau et des ouvrages du barrage est du ressort de la SONABEL. Ainsi, l'appartenance du lac à deux entités administratives territoriales complique davantage la planification et la gestion d'ensemble des actions de développement déployées par tous les acteurs dans la zone.

3. Problématique particulière de la zone du lac de barrage de Bagré

Le lac de barrage de Bagré se distingue des autres réservoirs d'eau du pays par les caractéristiques essentielles suivantes:

3.1 Forte concentration de populations

La disponibilité permanente de l'eau dans un environnement aride attire des populations d'horizons divers (agriculteurs, éleveurs, pêcheurs, etc..) en quête d'un mieux être. Ainsi, de 1975 (année d'éradication de l'onchocercose) à nos jours, on est passé de 5 habitants environ au km^2 en 1975 à plus de 100 habitants au km^2 dans certaines zones du lac (recensement général de la population de 1985). On estime aujourd'hui à 400.000 le nombre de personnes qui seront directement touchés par la zone du projet

3.2 Risques sanitaires liés à l'eau

L'impact du barrage sur l'environnement social est multiforme. C'est la raison pour laquelle il faut minimiser ses effets négatifs et ceux de ses aménagements sur l'environnement et la santé des populations (infections gastro-intestinales, bilharziose, onchocercose, schistosomiase urinaire, paludisme, etc.).

3.3 Fortes pressions sur les ressources naturelles

La terre: le problème de la disponibilité des terres de culture était déjà apparue avant même la création du barrage. Celle-ci, tout en accentuant cette situation, a occasionné des modifications profondes de l'environnement et engendré de nombreux autres problèmes dans la gestion des ressources naturelles.

L'eau: l'utilisation de l'eau du barrage est libre à tous pour la boisson humaine, l'abreuvement du bétail, la construction, la lessive et la pêche. L'eau ne bénéficie pas d'une gestion indépendante, et elle n'est qu'un élément de l'environnement. Le droit d'usage de l'eau est donc libre à tous les riverains et autres gens de passage. Il n'existe pas encore de réelle prise de conscience du fait que le barrage fait partie du système de production en aval. L'idée qui prévaut généralement est que le barrage est la propriété de l'Etat, donc à tous.

Les ressources forestières et pastorales: l'accès à ces ressources est peu réglementée, ce qui compromet sa gestion durable. Les ressources se caractérisent par leur répartition assez hétérogène dans le temps et dans l'espace liée essentiellement à l'emprise humaine. La pression démographique (humaine et animale) dans la région reste la principale cause de dégradation du couvert végétal.

3.4. Multiplicité des intervenants

Le lac de barrage de Bagré est par excellence l'une des retenues d'eau qui concentre le plus grand nombre d'intervenants (Etat, organisations nationales, partenaires au développement) dans le développement de la zone. Ces structures se caractérisent malheureusement par leur dispersion et l'absence de concertation dans la mise en oeuvre des actions.

En conclusion, du point de vue grandes tendances à dégager, on peut dire que:

- la construction du lac de barrage de Bagré a engendré d'immenses potentialités, tant pour la diversité biologique que pour le développement local;

- la valorisation durable des ressources est compromise par une tendance:
    - à la concentration de populations notamment en aval de la retenue;
    - à la dégradation des ressources naturelles due aux diverses pressions qui y sont exercées;
    - au développement des maladies d'origine hydrique;
    - à l'insuffisance de la concertation dans l'utilisation et la gestion des ressources.

C'est à partir de ce constat que des axes stratégiques pour le développement local durable de la zone ont été dégagés. Cette stratégie se fonde sur l'impérieuse nécessité:

- d'un aménagement intégré et rationnel des ressources naturelles de la zone du lac;
- d'une gestion consensuelle et participative des ressources;
- d'une réadaptation de la réglementation et de la gestion institutionnelle au contexte de développement local durable;
- de la mise en place d'un système de suivi environnemental.

4. Plan stratégique de développement local durable

Le principal défi de la présente stratégie consiste à maîtriser l'organisation de l'espace de la zone d'influence du barrage en vue d'insuffler un développement harmonieux de toutes les activités rendues possibles par la création du lac. Pour atteindre cet objectif global de développement local durable de la zone d'ensemble du lac, il est recommandé:

⇨ Sur le plan de la gestion intégrée des ressources naturelles

La prise en compte de l'unicité du système du sous-bassin de Bagré et du bassin du Nakanbé comme un système unique, l'élaboration d'un schéma d'aménagement et de gestion intégrée des ressources naturelles de la zone du lac, et la mise en place d'un organe de coordination des activités et de gestion de l'espace du lac.

⇨ Sur le plan de la gestion participative

L'élaboration de textes réglementaires définissant les responsabilités et contributions de chacun des usagers, l'élaboration en partenariat avec les populations riveraines des schéma, plans et programmes sectoriels de développement de la zone, et le renforcement des capacités locales en matière de cogestion des ressources naturelles.

⇨ Sur le plan institutionnel

La création d'une agence ou autorité du sous-bassin de Bagré associant l'Etat et les autres acteurs du sous-bassin pour la mise en oeuvre du schéma, et la création d'un cadre de concertation permettant d'associer tous les acteurs aux différentes étapes de prise de décision.

⇨ Sur le plan du suivi-évaluation

La création de mécanismes de suivi interne et externe de la structure en charge de la coordination et de la gestion de l'espace de la zone du lac, la mise en place d'un système de suivi et d'alerte précoce de l'environnement sanitaire de la zone (contrôle des flux migratoires, prévention et gestion des risques sanitaires, etc.), et la mise en place d'un système de suivi écologique du sous bassin de Bagré (veille écologique).

4.1 Les grands axes d'orientation de la stratégie

Organisation et maîtrise de l'espace de la zone du lac

L'objectif de la stratégie étant d'aboutir à une gestion intégré de la zone d'ensemble du projet se fondant sur le

développement local durable, une (ré)organisation de la zone basée sur les vocations nouvelles des terres de la zone apparaît plus que jamais comme une nécessité.

Gestion rationnelle des ressources naturelles

La mise en oeuvre du plan doit être l'occasion pour passer de pratiques proches à l'économie de cueillette à une véritable planification et gestion des ressources naturelles de la zone du projet. Cette gestion sera faite dans un premier temps à l'échelle du sous-bassin de Bagré et dans un second temps à l'échelle du bassin du Nakanbé.

Aussi est-il nécessaire d'élaborer et de mettre en place sur une base consensuelle un **schéma intégré d'aménagement et de valorisation** des ressources naturelles de la zone (eaux, terres, forêts, faune aquatique et terrestre, etc.).

La création d'une **structure de gestion concertée et de contrôle du sous-bassin** de Bagré associant l'Etat, les communautés de bases, les partenaires au développement et les nombreux usagers, notamment à travers leurs organisations respectives, contribuera à une mise en oeuvre efficiente du schéma. L'application du présent schéma requiert cependant son découpage dans le temps en **plans de développement concerté**. Les **programmes de valorisation** des différentes ressources du sous-bassin de Bagré seraient alors les composantes de ces plans.

La création d'une structure de gestion intégrée de l'ensemble du bassin du Nakanbé prévue dans le cadre de la politique nationale en matière d'eau, l'application du Code de l'eau en cours d'élaboration, viendront consolider les actions de développement durable des ressources du lac.

Amélioration du cadre et des conditions de vie des populations

Un des grands défis dans le moyen terme est d'améliorer les conditions de vie des populations riveraines en général et celles des populations déplacées et/ou installées dans le cadre du projet Bagré en particulier. Cette amélioration devrait se traduire par l'accès des populations aux services essentiels que sont l'eau potable, l'habitat, la santé, l'éducation et la formation, l'assainissement du cadre de vie, etc.

Adaptation de la réglementation et de la gestion institutionnelle au contexte du développement local durable

Sur le plan réglementaire et institutionnel, les mesures suivantes sont à prendre en compte:

- la révision du statut de la MOB et l'affirmation de ses prérogatives de leadership, chargé sur l'ensemble de la zone d'influence du barrage, de la promotion, du développement et de la coordination de toutes les actions rendues possibles par la création du lac;
- la finalisation des textes portant création, attribution et fonctionnement du Comité technique de gestion du barrage. Ces textes devraient préciser la place et le rôle des différents acteurs dans la gestion de l'espace du lac et de ses ressources naturelles;
- le renforcement à travers des formations, des capacités d'intervention et de cogestion des ressources naturelles par les communautés de base.

4.2 Suivi et évaluation

Le suivi-évaluation des plans et programmes de développement de la zone d'ensemble du lac revêt trois aspects d'importance capitale: un suivi-évaluation des actions de développement au niveau interne et externe, un suivi-évaluation de l'environnement sanitaire, et enfin un suivi de l'impact environnemental.

5. Conclusions

Cette étude a montré que la construction du lac de Bagré a engendré d'immenses potentialités pour la diversité biologique. Son développement durable dépend de la prise en compte d'un certain nombre de facteurs notamment d'ordre environnemental, humain et institutionnel.

Pour faire en sorte que le projet Bagré puisse être une réussite sans conséquence majeure pour l'environnement, les ressources bio-aquatiques et la santé des populations, un ensemble de mesures ont été proposées. Les recommandations qui sont formulées ont toutes été guidées par la préoccupation constante de contribuer au processus de développement intégré et durable de la zone du projet Bagré.

Globalement, cette étude n'aura réellement atteint ses objectifs et ses résultats ne seront vraiment valorisés que si tous les acteurs du barrage (responsables techniques, politiques, administratifs, coutumiers, etc..) et les communautés de base auront pu être informés et sensibilisés sur l'importance et la nécessité d'une gestion intégrée de la zone du barrage, aussi bien à l'échelle du sous bassin de Bagré que du bassin du Nakanbé. C'est la seule approche qui permette un contrôle d'ensemble de la diversité biologique du barrage liée à l'utilisation des sols jouxtant la retenue, le déversement des déchets et d'eau usée dans certains affluents du Nakanbé, ainsi que l'application des engrais et autres pesticides sur le bassin versant.

Il convient à ce titre de saluer d'une part la stratégie nationale en matière d'environnement et d'eau qui préconise désormais la gestion de l'eau par bassin fluvial et d'autre part l'obligation faite à tout projet de construction de barrage, de réaliser au préalable, une étude d'impact environnemental (cas de Ziga, Samandéni, etc.).

Nous osons croire que les résultats de nos investigations, qui ont déjà été pris en compte dans le cadre de *l'Etude du plan intégré de développement et de gestion de la zone du projet Bagré* en cours d'exécution, contribueront à une gestion durable des diverses ressources générées par le lac au profit des populations riveraines en particulier, et du Burkina Faso, en général.

Remerciements

Au terme de notre étude, nous voudrons adresser toutes nos reconnaissances à tous ceux qui ont contribué de façon directe ou indirecte à sa réalisation. Nos remerciements vont en particulier: à la Direction Générale de la Maîtrise d'Ouvrage de Bagré, à la Société Nationale burkinabè d'Electricité et leur personnel pour avoir tout au long de nos recherches facilité la collecte d'informations utiles pour l'analyse-diagnostique de la zone du lac; à l'UICN pour tous les appuis qui nous ont été apportés notamment notre inscription et prise en charge à la 2ème Conférence Internationale sur les Zones Humides et le Développement (8-14 novembre 1998, Dakar, Sénégal); aux responsables politiques, administratifs et coutumiers de la zone du lac; aux responsables de projets de développement des provinces du Boulgou et du Zoundwéogo; ainsi qu'aux différentes communautés de pêcheurs et aux populations riveraines qui ont consacré leur temps à répondre à nos questionnaires.

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Article 1.3
Wetlands in the Management of the Nile River Basin

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Keywords: River Nile basin, wetlands, integrated management, cooperation.

The wetlands of the Nile basin support millions of people and livestock, provide food and shelter for many wild species and supply many environmental goods and services. The regular supply of water to these wetlands is crucial as they persist on a cycle of flooding or rely on regular inputs for maintenance. Upland wetland areas are increasingly being encroached as agricultural land becomes a limiting resource for the increasing population of the upper riparian countries. Lower level wetlands are affected by many activities upstream that alter stream flows and water quality. These include dam construction, watershed mis management, agricultural run-off and urban pollution.

This paper briefly describes the Nile basin wetlands and examines some of the functions of these wetlands and their needs for water. It is suggested that management of the Nile Basin and its waters should include two main elements namely, catchment management and water resources management. These can be combined in the concept of "integrated catchment and water management" under an agreed programme of Basin Management that takes into account all countries and all stakeholders concerned. It is argued that the wetlands of the Nile Basin must be regarded as legitimate stakeholders because of the goods and services that they supply, because of their value in maintaining biodiversity and because they assist with the proper functioning of the river basin system as a whole.

Zones humides dans la gestion du bassin du Nil

Mots-clés: le bassin du Nil, zones humides, gestion intégrée, coopération.

Les zones humides du bassin du Nil assurent la survie de millions de personnes et de têtes de bétail, fournissent nourriture et abri à beaucoup d'espèces sauvages et dispensent des biens et des services à l'environnement. L'approvisionnement régulier en eau de ces zones humides est crucial car elles existent grâce à un cycle d'inondation ou dépendent des entrées d'eau régulières pour leur fonctionnement. Les zones humides situées dans les régions montagneuses sont de plus en plus altérées parce que les terres agricoles deviennent un facteur limitant pour la population croissante des pays riverains montagneux. Les zones humides de basse altitude sont affectées par de nombreuses activités ayant lieu en amont qui modifient les débits et la qualité de l'eau, telles que la construction de barrages, la gestion inadéquate du bassin versant, le ruissellement des terres agricoles et la pollution urbaine.

Cet article décrit brièvement les zones humides du bassin du Nil et examine certaines des fonctions de ces zones humides et leurs besoins en eau. Il est proposé que la gestion du bassin du Nil et de ses eaux devrait inclure deux éléments principaux notamment, la gestion du bassin versant et la gestion des ressources en eau. Celles-ci peuvent être combinées au sein du concept de "gestion intégrée du bassin versant et des ressources en eau" dans le cadre d'un programme convenu de la gestion du bassin qui tiendrait compte de tous les pays et de toutes les parties prenantes. Il est proposé que les zones humides du bassin du Nil soient considérées comme des parties prenantes légitimes en raison des biens et des services qu'elles fournissent, en raison de leur valeur pour le maintien de la biodiversité et parce qu'elles participent au fonctionnement du bassin fluvial dans son ensemble.

1. Introduction

The River Nile is the longest river in the world with a channel distance of 6,800 km from its farthest source at the headwaters of the Kagera River in Rwanda to its delta on the Mediterranean Sea. The Nile Basin covers more than 3.2 million km^2 in ten countries and has at least 140 million people within its boundaries which range from 3° to 31°N and from 24° to 39°E (See Fig. 1 and Sutcliffe & Parks, 1999). It is one of the few large rivers that flow from south to north passing from wet mountainous areas in Eastern Africa through one of the driest and hottest places in the world - the eastern Sahara Desert. The mean annual flow of the Nile at Wadi Halfa where it enters Lake Nasser is 84 x 10^9 m^3 - which is 6% of the Zaire's flow and less than 4% of that of the Niger River.

Most of the water of the Nile reaching the low levels in Sudan and Egypt originates in the Ethiopian Highlands west of the Gregorian Rift Valley. Only about 15% comes from the White Nile and originates in the Lake Victoria Basin and the streams of the Albertine Rift Valley, eastern Congo and south-western Sudan. The Ethiopian highlands are cool and wet with rainfall exceeding 3,000mm per year in some places and altitudes up to 3,000 m.a.s.l. While there are cold mountains in western Uganda, most of the flow of the White Nile comes from rain and runoff near the waters of Lake Victoria (lake level at 1,135 m.a.s.l) at somewhat lower altitudes. By the time both sources have reached Sudan, they have descended to less than 500 m and entered areas where rainfall is low. A large proportion of the runoff and rainfall that enters the Nile River system leaves it as evapotranspiration - either directly from the water surface or through the vegetation of the associated wetlands of the basin. However these wetlands play important roles in the maintenance of flows of the Nile and in the sustenance of life in this area. This paper briefly describes the Nile basin wetlands and examines some of the functions of these wetlands and their needs for water. Their persistence or survival needs to be ensured through planned integrated river basin management.

2. Nile basin wetlands

Wetlands cover around 6% of the Nile Basin - an extraordinarily large proportion considering that 67% of the basin is arid and that 82% is either low-rainfall grassland or sandy and rocky desert (Revenga , 1998). Wetlands are found from the highest altitudes in both watersheds, through the middle levels of the basin, along the river's course through the desert and in the delta. They include upland wetlands such a valley bottoms, swamps and tarns as well as middle level swamps and lakes which were formed by relatively recent impeded drainage. The edges of Lake Victoria form extensive swamps as do the main rivers that feed the lake from the surrounding watersheds - especially in Kenya and Rwanda. While the tributaries of the Blue Nile and the main channel slope steeply to the lower altitudes and have few middle-level wetlands, the White Nile system includes, for example, most of Uganda, where wetlands occupy around 13% of the land area (Uganda Wetlands Programme, 1998, pers comm.).

At the lower level of the basin are the large wetlands of Sudan, the Sudd being the biggest wetland in Africa. The main Nile channel is lined with riverine wetlands for much of its length until it reaches Lake Nasser with its increasing salinity. The wetlands of the Nile delta are extensive and include lakes, swamps and saline marshes.

The wetlands of the Nile basin support millions of people and a host of species and ecosystems unknown elsewhere. The Nile basin wetlands are the "home" of papyrus (*Cyperus papyrus*) which takes the place of other tall reeds in this system and provides many habitats for animals and plants as well as goods and services for people. But it is the less-obvious goods and services of wetlands to mankind and to the functioning of the Nile River that we wish to refer to in the following three examples from three different altitudes in the Nile basin.

2.1 Upland wetlands in Ethiopia

The upland wetlands of the Nile within Ethiopia are found at the headwaters of its two major sub-catchments, the Blue Nile in the North and the Sobat in the South-west. The Blue Nile's basin has high-ground bogs, valley bottoms and marshy areas which form important components at its headwaters. Lake Tana, a large lake which covers approximately 3,600 km^2, is an important reservoir for the Nile. The area north-east of Lake Tana known as Nabega, has a significant floodplain at high altitude. The Rib and Gumera Rivers, tributaries of Lake Tana, form these floodplains on the Nabega Plains. Freshwater springs are another form of upland wetlands in the Blue Nile Basin. These are found mostly in the upper limits of the Nile and its tributaries where the terrain levels off and at the foot of hills and scarps. These freshwater springs often have their sources in groundwater fed wetlands.

The wetlands of the upper Sobat catchment, which form the headwaters for the Baro River and its tributaries, are mostly upland valley bottoms, riverine wetlands, marshy ground, and spring-fed wetlands. The upper Sobat catchment is an area which receives the highest rainfall within Ethiopia. The high rainfall combined with the lush vegetation and an impermeable basalt bedrock have resulted in valleys with boggy grounds and marshes. Floodplains and swamps are found at a lower altitude where the Sobat spreads out before leaving the borders of Ethiopia.

The vegetation cover around and in the upland wetlands ensures that less soil is eroded from these mountains compared with the northern areas of Ethiopia. Though there are no protected areas in south-western Ethiopia, forests and wetlands have received ample conservation as compared to the areas in the North. One of the main reasons appears to be the low human population and the relatively low

pressure of agricultural activities in the area. At the same time some of the south western areas have managed to retain their forest cover because it is kept specifically to shade the wild and managed coffee plants of this region.

2.2 Middle level wetlands in the Lake Victoria (sub) basin

The major source of the White Nile is the Lake Victoria basin where runoff from Kenya, Tanzania, Rwanda and Burundi adds to local lake rainfall to produce the massive storage of Lake Victoria at the headwaters of the Victoria Nile. Evaporation from the lake almost equals the local rainfall so that the watershed around the lake is responsible for the main flows into the Nile. Many wetlands of the Lake Victoria watershed depend on the runoff of the lake basin and contribute to the regulation and quality of flows into the lake.

An important example of this type of wetland includes the Masirori wetland located in the Mara catchment. The Mara River rises in the Mau Escarpment of south-western Kenya, flows south-eastwards through the famous Maasai Mara National Reserve and enters the Serengeti National Park in Tanzania. It then turns east and heads for Lake Victoria near Musoma Town. For 45km it passes through the Kiribo Valley where impeded flow forms the Masirori wetland which is a swamp and lake complex of around 300 km^2 dominated by papyrus which is typical of the Lake Victoria basin wetlands. The river spreads out up to 14 km wide and meanders through dense vegetation before narrowing in a short channel that reaches the main lake.

2.3 Low low level wetlands in Sudan

The White Nile (Barh el Jebel), the Barh el Ghazal and the Sobat all converge at low altitude in Sudan. All have significant wetlands along their courses with the largest of all formed in a rough triangular shape between Bor and Malakal on the White Nile and the Barh el Ghazal to the West. This is the Sudd, the biggest wetland in Africa which has been estimated to extend over 16,500 km^2 when flooding is at its maximum. This huge area of permanent swamps, riverine wetlands, floodplains and occasional lakes is dominated by papyrus, *Phragmites* and *Typha* with large areas of Water Hyacinth (*Eichhornia crassipes*) and Nile Cabbage (*Pistia stratiotes*) covering otherwise open waters. There are many other wetland plants in this vast complex, including a recently discovered genus of grass-like plants named *Suddia* found among the many pasture species grazed by wild mammals and livestock.

3. Functions, values and requirements of these wetlands

The upland wetlands of the Nile Basin serve as water storage and regulation agents while slowing stream velocities and reducing siltation of their emergent streams. They support many species of wetland plants (including *Cyperus latifolius*, locally know as *cheffe*) as well as providing pasture for livestock and rotating cultivation for vegetables and staples such as maize. Studies continue as to the needs of these wetlands for water to maintain their character and functions. It is clear that if they remain drained or otherwise artificially dried for more than a few years they lose their values for people and may take many decades to rehabilitate.

The middle level wetlands of the Nile Basin are further water stores and stream flow regulators and improve water quality due to their extensive wetland vegetation. The Lake Victoria basin wetlands are the sources of many subsistence and commercial fisheries while providing wetland plants (especially the larger reeds and papyrus) for building materials, fuel and many other plant products including foods and medicines. Wetland-edge agriculture, including paddy rice cultivation, is prevalent in these middle-level wetlands as is brick-making and aquaculture. There are several "papyrus endemics" among the wetland fauna of these swamps, floodplains and riverine systems and a wide variety of wetland-dependent animals and plants including some of the famous cichlid fish, endemic to the Lake Victoria basin.

The low-level wetlands of the Nile Basin are all in relatively dry areas so that their main functions and values relate to the presence of water as a scarce resource. Functions include water storage, stream flow regulation and amelioration of floods and surges in the river flow. These large, flat wetlands in hot, dry areas are usually treeless and subject to high levels of insolation. They have very high levels of plant productivity, equivalent to those of tropical forests. Floods that spread slowly across these vast wetlands bring nutrients as well as water and recharge groundwater for subsequent plant growth. While evapotranspiration is often labelled as a waste of water in such wetlands it is especially through transpiration, the "engine" of plant growth, that natural resources are produced. The primary production supplies immense amounts of food for many other organisms and adds large quantities of organic material to the often poor soils through the breakdown of wetland plants.

The Sudanese wetlands support millions of people and livestock and provide food and shelter for many wild species. Fish are abundant and people use the wetland plants for many of their basic needs, often because there are no alternatives within reach. The regular supply of water to these wetlands is crucial as they persist on a cycle of flooding. Plant growth and decay will be seriously altered through reduced flows due to drought or man's interventions. While we have general ideas about the functions and values of the Nile Basin wetlands and their needs for water, we lack sufficient data to assess the specific economic value or hydrological functions.

4. Threats to Nile basin wetlands

Upland wetland areas are increasingly being encroached as agricultural land becomes a limiting resource for the increasing population of Ethiopia. Land above 2500m a.s.l.,

is poor quality and can only support few crops. Left without alternatives, local people clear highground vegetation for agriculture. This significantly reduces the ability of a wetland to function efficiently. Policies related to national food security are also contributing to wetland destruction because they eliminate traditional uses of natural resources and alter runoff downstream.

Middle level wetlands face multiple threats including water diversion for hydropower generation and irrigation and water supply needs, conversion to agriculture, especially irrigated crops such as paddy rice, pollution and overuse leading to drying and reduction of products.

A plan in Kenya for example has proposed the transfer water from the upper Mara River to the Ewaso Ngiro River in the Rift Valley drainage system. In this way it is possible to take advantage of the greater fall into the Rift Valley to develop a hydropower production system that uses water from both sources. But this is an "out-of-basin transfer" from the Nile basin which may have some deleterious effects. Extraction will reduce the flow of the Mara and, in dry years, may have effects on the Masirori wetland and its dependent goods and services in the Kiribo Valley. It will affect the flow of the Mara river into Lake Victoria and so the outflow of the lake *via* the Victoria Nile.

Lower level wetlands are affected by many activities upstream that alter stream flows and water quality such as diversion, dam constructions, watershed mismanagement, agricultural run-off and urban pollution. The need of low-level wetlands for flooding to provide surface and ground water and nutrients, meeting demands for water supply, irrigation and hydropower often requires much more constant water availability and less changes in stream flows.

In the Sudd for example, according to accepted estimates, 67% of the water that enters the wetland is "lost through evapotranspiration" from the wetland surface. By some water managers this is perceived as a substantial loss of Nile waters for downstream use. Over the last centrury, various schemes have been proposed to bypass the Sudd with a channel to avoid this evaporation and transpiration. In recent years the Jonglei Canal plan was developed to effect this diversion of waters from the Sudd and to "save" Nile waters (Howell & Allan, 1994). Although the plan was not completed the idea of such a canal remains.

The consequences for the Sudd can be assumed to be significant as the mean flows into the wetland will be reduced so much that its extent will inevitably decrease. This will have immediate effects on the people, livestock and wildlife that depend upon this wetland as well as the ground water stocks in the area. Equally important will be the reduced evapotranspiration which is the main mechanism for the great plant productivity of this wetland and the consequent organic material added to the soils of the Sudd and downstream. The cost of these various losses has not been estimated accurately due to a lack of sufficient data. However, it is doubtful whether they will compare with the gains from the water saved. As the water saved has to traverse the hot dry stretches of the river where evaporation is even higher, less water is likely to be available for productive use.

5. Water resources management and the Nile basin wetlands

The many wetlands that are located in the Nile River basin at all levels - from the high altitudes of the mountains to the delta at sea level - produce goods and services for mankind and carry out ecological and hydrological functions for the maintenance of the river, the river basin and its biodiversity. The economic value of these benefits has not been calculated for most of the Nile basin wetlands but it is very likely to be highly significant in the overall valuation of the ecosystem including the value of the Nile waters to people and their aspirations for development and improved livelihoods.

To date the water requirements for the Nile basin wetlands which are fed mainly from the Nile River channel, its tributaries and catchment runoff have not been quantified. The environmental water needs will be a finite but significant amount compared to the presently calculated "available" water from the Nile system. In other words, the entire amount of water in the river system cannot be used exclusively for the direct use of man, cities, houses and farms, but must include a significant and calculable amount "for the environment" and in this case, for the wetlands.

If we accept that these wetlands are an integral part of the river basin, that they provide goods and services to people and to the basin and that they require water from the basin for their survival and functioning, then there is no doubt that we need to include this water need in the apportionment of water use. In the Nile Basin there are ten countries, each with is own requirements for water use, mostly for people and their activities. These needs increase as the Nile passes from high to low rainfall areas and countries. While the upstream countries supply most of the waters of the Nile, they also manage the catchment of the river and are therefore responsible for the amount and quality of flows that leave their territories. Thus there needs to be some system to agree on the amount of water available from one country to the next and this must include both a guaranteed quantity and quality of water for the environment and, in particular, for wetlands.

6. Conclusions – Integrated management

Management of the Nile Basin and its waters should include two main elements that affect the wetlands of the basin:
catchment management to ensure adequate supply and quality of water to the river and wetland systems, and
water resources management that recognises the needs of water-dependent ecosystems of the basin such as wetlands and apportions and adequate amounts for them to function and persist.

These can be combined in the concept of "integrated catchment and water management" under an agreed programme of Basin Management that takes into account all countries and all stakeholders concerned. This is a plea that the wetlands of the Nile Basin are regarded as legitimate stakeholders because of the goods and services that they supply, because of their value in maintaining biodiversity and because they assist with the proper functioning of the river basin system as a whole.

Such an integrated management system would have to involve all riparian countries of the Nile Basin in a way that brings about agreement on water resources apportionment and takes into account the needs of the environment. This, in due course, will be backed up by evaluation of the wetlands from both the human, biodiversity and water resources perspectives so that their role can be fully appreciated in basin management. It is urgent now that insights are gained into the true value of the Nile basin wetlands so that they can be integrated into the catchment and water resources management strategy on the basis of their theoretical, environmental, biodiversity, human and economic values and their appreciated and addressed needs.

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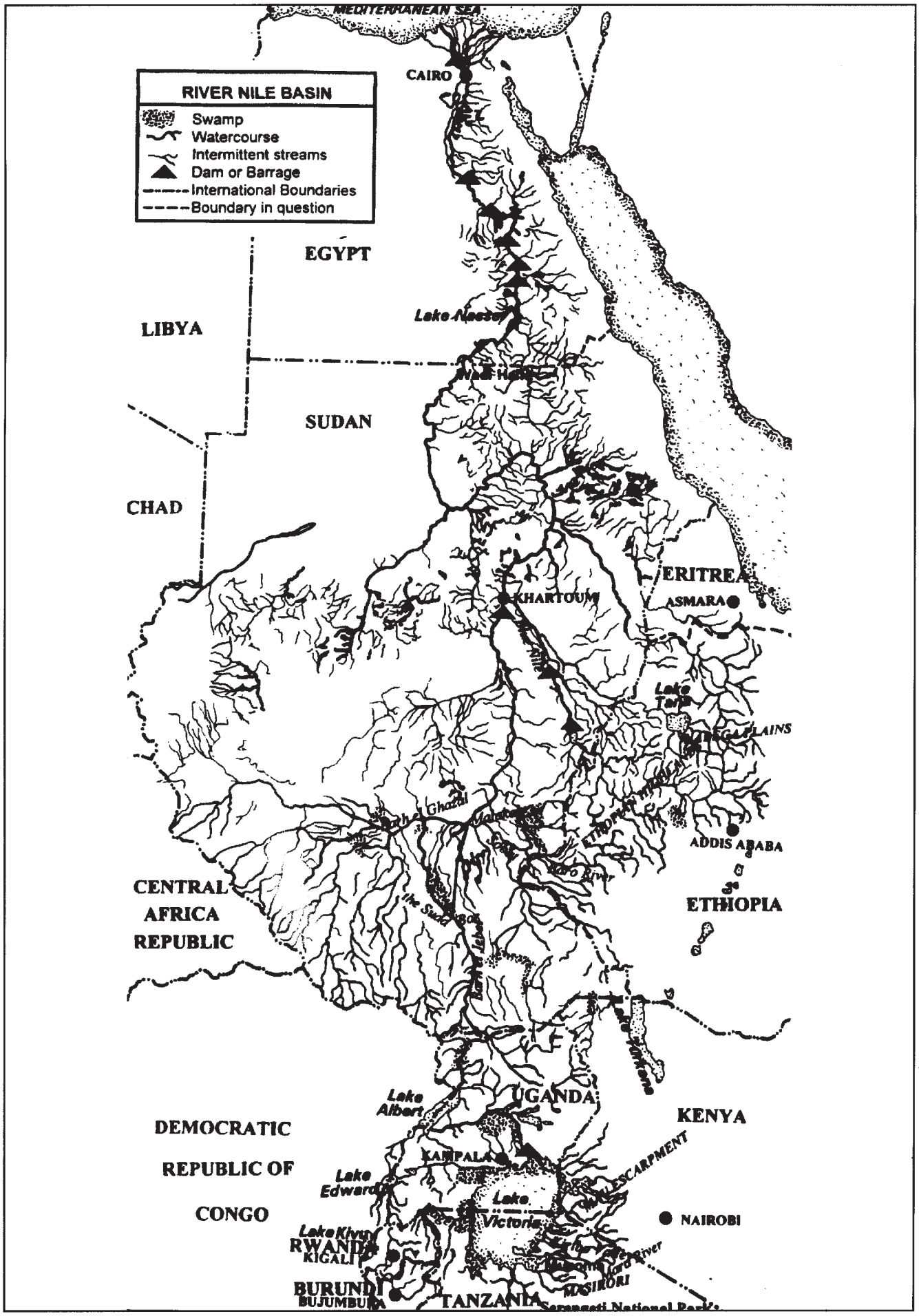
MEDITERRANEAN SEA
CAIRO
RIVER NILE BASIN
Swamp
Watercourse
Intermittent streams
Dam or Barrage
International Boundaries
Boundary in question
EGYPT
LIBYA
SUDAN
CHAD
ERITREA
ASMARA
KHARTOUM
Lake Tana
ADDIS ABABA
ETHIOPIA
CENTRAL AFRICA REPUBLIC
Lake Albert
UGANDA
KENYA
DEMOCRATIC REPUBLIC OF CONGO
KAMPALA
Lake Edward
Lake Victoria
NAIROBI
Lake Kivu
RWANDA
KIGALI
BURUNDI
BUJUMBURA
TANZANIA
MASIKORI

Part II:

Capacity Building for Integrated Wetlands and Water Resources Planning and Management

Article 2.1

Integrated Wetland and Water Resources Management Capacity Building with Special Reference to Africa

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Keywords: Africa, water, wetlands, capacity building, cooperation.

Historically, wetland issues have been the domain of ecologists and conservationists whilst water resources management has resided in the discipline of hydrology and engineering. Yet, the two are inextricably linked. Co-operation between, and integration within the two disciplines is a relatively new concept and scientists and technical experts from each are endeavouring to understand the other's skills.

Africa is probably the premier continent in which wetlands and water together most affect the quality of life of its peoples. Major inter-relationships between wetlands and water resources in the African context, therefore, are reviewed highlighting the values of wetlands as capacitors, buffers and connectors. Particular themes such as 'flooding regimes', 'wetland buffering capacities' and 'wetland evapo-transpiration and the water cycle' are identified for integrated research. However, the research capacity in Africa is very limited. Various reasons are given including *inter alia* the failure of the North to stimulate a critical mass for research in developing countries and the chronic poverty and under-investment by the South in science.

A case for capacity building in both 'pure' and 'applied' sciences is argued. The near absence of basic research negates the scientific empowerment that is essential for sustainability and self-sufficiency. A possible strategy for co-operation in training and research between the North and South, and within the South, is proposed.

Le renforcement des capacités pour la gestion intégrée des zones humides et des ressources en eau, notamment en Afrique

Mots-clés: Afrique, eau, zones humides, capacités, coopération.

Historiquement, les questions relatives aux zones humides étaient traitées par des écologistes et des spécialistes de la conservation alors que celles relatives aux ressources en eau relevaient de l'hydrologie: en réalité, les deux sont inextricablement liés. La coopération entre ces deux disciplines est un concept relativement nouveau, et scientifiques et experts techniques dans chaque domaine essaient de comprendre leurs compétences respectives.

L'Afrique est probablement le continent où les zones humides et l'eau affectent le plus la qualité de vie des populations. Les liens importants existants entre les zones humides et les ressources en eau dans le contexte africain sont resumés pour mettre en valeur le rôle des zones humides comme tampons et couloirs écologiques. Des thèmes particuliers, tels que les "régimes d'inondation", "les capacités tampon" et "l'évapo-transpiration des zones humides et du cycle de l'eau", sont identifiés comme sujets pour la recherche intégrée. Cependant, la capacité de recherche en Afrique est très limitée. Diverses raisons sont données comprenant entre autres, l'échec des pays du Nord à stimuler une masse critique pour la recherche dans les pays en voie de développement, la pauvreté et le manque chronique d'investissement dans le domaine des sciences par les pays du Sud.

Le renforcement des capacités pour les sciences '"fondamentales" et "appliquées" est discutée. La quasi absence de recherche fondamentale empêche la création d'une capacité scientifique susceptible d'aider les populations à acceder au développement durable et à l'autosuffisance. Une stratégie possible de coopération entre le Nord et le Sud, et entre les pays du Sud, pour la formation et la recherche est proposée.

1. Introduction

Historically, "wetlands" have been the prerogative of ecologists and naturalists whilst "water resources" have resided within hydrological and engineering disciplines. Each topic, although inextricably linked, has developed under the intellectual influence of its own discipline. The Convention on Wetlands of 1971 (Ramsar, Iran) (Ramsar Convention Bureau, 1997) initiated a more focused approach to the values of wetlands especially in relation to habitats for birds. From this modest beginning, wetland science evolved into a plethora of studies of one of the major and most important global biomes. It is, perhaps, surprising that hydrology and water resources did not become an integral part of wetland science until relatively recently. Indeed, in the United Kingdom, it was not until the low rainfall periods (droughts) of the 1980s and their impact on wetland ecosystems did the two disciplines truly begin to interact (Denny, 1993a; Acreman and Adams, 1998).

With movement towards "integration", experts have familiarized themselves with each others' views without necessarily appreciating the complexities. This can lead to superficial overviews inappropriate for major decision-making. Integrated wetland and water resource management is truly a multi-facetted, cross-sectoral discipline.

Africa is arguably the premier continent in which wetlands and water together affect human survival and quality of life most. It is, therefore, an appropriate region for cross-fertilization of skills and knowledge and capacity building in this sector. In this paper the major interrelationships between wetlands and water will be considered; the capacity for research on the topic in Africa will then be assessed and finally, possible mechanisms for increasing capacity, where necessary, will be considered. This could involve the development of a training and research network incorporating North-South and South-South partnerships.

2. Background – inter-relationships between wetlands and water resources

Wetlands are capacitors, buffers and connectors. Capacitors because they hold most valuable components of the earth's renewable natural resources which in tropical, developing countries, sustain a high proportion of the human population. Buffers because they act as regulators between systems and connectors because their functioning plays a vital role in the dynamics and feedback mechanisms of local and global natural processes. Water, air, land and biota are integral components of ecological systems. With wetlands, the role of water in the ecosystem is supreme. Therefore, firstly, some primary functions of wetlands and their interrelationships with water resources will be considered.

2.1 Wetlands as capacitors

The sustainable harvesting of wetland natural resources has supported civilizations from time immemorial. The natural flooding of the great river systems provides food security: the Nile delta, for example, sustained the Egyptian civilizations and the Tigris and Euphrates the Marsh Arabs. His Royal Highness The Litunga Yeta IV of Barotseland tells us that today the Barotse Floodplains in Zambia, which are his traditional homelands, support some 675,000 people. The milk and the fish harvests are the major sources of protein, employment and income for the people. The traditions of his society have maintained the productivity of these floodplains for his people and the wildlife over very many generations (*pers. com.*). The African floodplains; the lacustrine wetlands of the African Great Lakes - the Lake Victoria basin alone supports some two million people (LVEMP, 1995); the coastal deltaic regions (the Senegal River is a fine example) and the coastal systems of the estuarine and marine littoral zones all bear witness to the richness of wetlands for human survival and well-being (Howell, *et al.*, 1988; Hollis, *et al.*, 1993; Jeffery *et al.*, 1992). They support an enormous number and diversity of wildlife, including migratory species (Denny, 1991).

The productivity and richness, and the entire living communities of all these areas, depend upon the natural regimes of flood and flood-recession; of water-table maintenance and of surface water recharge. It is not just the quantity of water, the water cycle and water supply which is a life-support system for wetlands but the quality of the water too.

2.2 Wetlands as buffers

The 'buffer' concept has many connotations and different images in the minds of the various practitioners (Haycock *et al*, 1997; Denny, 1993; Davies and Claridge, 1993). Wetland buffers are particularly important in conservation of the landscape. In the upper catchments they are essential for water conservation in watersheds, to allow, for example, time for infiltration, and for maintenance of water quality. They act as 'traps' for surface runoff, reducing soil erosion and help to retain the integrity of the catchment. It is this water which will support ecosystems and human society downstream and its purity will determine subsequent activities.

In the lower catchment and floodplains wetland buffer strips around lakes and along the banks of rivers and tributaries contribute to the natural infiltration, filtration and purification processes too. Run-off water passes through the wetland, either as surface flow or percolation through the root zone, where physico-, physico-chemical and biological processes moderate water quality. It is a dynamic system in which particulates accumulate and soluble nutrients are retained, released or transformed through (micro)biological processes. Like all buffers, it has a finite holding capacity and if overloaded these functions become inconsequential. Changes in conditions will affect their functioning: nutrient and water budgets and the variables that regulate the living process (oxygen supply; toxic compounds; water table variability; plant biomass standing crop *etc.*) all interplay to determine their buffering capacity.

Others look at wetland buffers as sponges. Run-off from catchments collect in depressions and valley bottoms where the water is absorbed and purified by wetlands and energy is dissipated. The wetland takes up the water and releases it in a more controlled manner. The chance of flash flooding down stream is reduced: ground water recharge is encouraged and the maintenance of water flow in the streams and rivers during the dry seasons is sustained. Thus, wetlands are regulators of flow and ameliorate floods (Davies and Claridge, 1993).

2.3 Wetlands as connectors

A third primary function of wetlands is as connectors between habitats, ecosystems and biomes, and as systems of communication for the people who live there. At the habitat level one need only think of the great migration routes of the migratory birds that rely upon wetland systems along their flight paths, essential for the maintenance and completion of their life cycles. These migrations match the seasons, and most particularly, the flood cycles and ecology of their wetland habitats. Likewise, within continents, wetlands are key players in the biogeographical distribution of aquatic species and their biodiversity. They are biogeographic islands in a sea of dry land which act as stepping stones for species migrations and genetic drift, and provide food security for the people (Denny, 1997a).

The buffer zones along and around water bodies not only serve a function of water quality regulation but are vital components of biological diversity conservation. The connectivity within and between ecosystems through wetlands is paramount. The connectivity is multi-directional, forming a distribution network for plants and animals to sustain the ecological stability of the whole catchment. Along rivers buffers allow the movement of organisms both up and down stream in the catchment and the concept of a *River Corridor* is born. They inter-connect otherwise isolated biomes so gene flow and the gene pool may be sustained and genetic diversity, retained. The connectivity extends from the freshwater to the estuarine and marine environments. Here, superimposed on the abiotic geophysical/hydraulic interactions of river flow, tides, currents *etc.* are the biological connections between the three main communities; mangroves, seagrasses and coral reefs. Mangroves in particular have to contend with river floodwaters and their accompanying sediment and nutrient burdens, and freshwater inundations, as well as the marine environment. The interactions of all of these variables are reflected in clearly defined zones along the coastline.

As important as longitudinal connectivity are the lateral connections within and between ecological systems. The wetland ecotone links aquatic and terrestrial habitats through a water depth gradient, often with a fluctuating water level. Floodplains have distinct flooding regimes and seasonal variation in water levels which, during the flood period, allows lateral movement of taxa. Biological diversity has been shown to depend upon these water surges and periodicity of connectivity in riverine systems (Bornette, *et al.*,1998). In coastal floodplains such as those of Sierra Leone, during the flood period freshwater lagoons become re-connected and species migrate to new territories to breed and feed. Change the hydrological regimes and the habitats are destroyed putting their rich flora and fauna, and the visitors they support, at risk.

On the grand scale, there is the connectivity between the life-support systems through wetlands. The water, nitrogen, and carbon cycles of wetlands all interact with the global systems. The carbon cycle is particularly important in the context of global carbon budgets and global warming. A healthy wetland is a net carbon depository, the carbon being held in the plant biomass or organic detritus (eg. peat) or transferred up the food chain. However, anaerobic conditions in waterlogged sediments and the action of methanogens produce methane, a greenhouse gas. Waterlogged soils and flooding regimes are also important in the nitrogen cycle, especially in nitrification, de-nitrification and the evolution of nitrogen gas.

The water cycle through wetlands, arguably, is the most conspicuous link with the life-support systems. Most significant in the warmer regions of the world is the inter-dependence between wetlands, water, evapo-transpiration, humidity and rainfall. Evapo-transpiration water from wetlands and floodplains condenses in the cooler, upper catchment creating morning mists (Denny, 1991). Where days are hot and dry the morning condensation may be sufficient to support permanent vegetation cover without which soil erosion would proliferate. Savenije (1995, 1996a, 1996b) shows a strong association between vegetation and land-use, and the re-cycling of moisture over large continents such as Africa. Evapo-transpiration is dependent upon a number of hydrological variables (Souch, *et al.*,1998) but rarely have the hydrological, ecological and climatological links with wetlands been investigated.

Finally, there is the connectivity of wetlands through groundwater and the water table: another example of inter-dependence. Not only does groundwater recharge depend upon infiltration through wetlands and river basins but they in their turn depend upon the water table. In this respect, the hyporheic zone (the water-infiltrated zone below the river bed connecting the river channel and the groundwater) is very vulnerable (Hill, 1998). If the water table falls permanently and becomes un-connected, the ecosystems will suffer accordingly. Indeed, a major threat to wetland and freshwater systems is the lowering of the water table by abstraction from groundwaters (Denny, 1993a).

3. Integrated wetland and water resources management

In the previous section we highlighted the inter-dependence of wetlands and water resources (both quality and quantity). We selected examples which demonstrate how vital the links are for the sustainability of natural processes, the conservation of global resources and for food security. The wise use of

wetland resources demands a clear understanding of the intricacies of this inter-dependence and the processes therein which sustain wetland functions and values. However, a truly integrated approach which combines the disciplines of wetland (micro)biologists, ecologists, hydrologists, engineers and socio-economists into one entity is in its infancy. Currently, individuals with expertise in one discipline may gain a superficial 'working knowledge' of the other disciplines but a lack of understanding can be counter-productive and lead to errors of judgement: a little knowledge can be dangerous! The immediate challenge is twofold: (I) to develop multi-disciplinary teams of researchers to enhance the knowledge base and (II) to develop appropriate training curricula for integrated wetland and water resource expertise.

With the exceptionally high diversity of wetlands in tropical and sub-tropical zones; the increasing human demand for water together with the real and potential water crises in these areas, and the reliance on wetland products by the (predominantly) rural and riparian communities, what better place than Africa to nurture research in, and develop strategies for, integrated wetlands and water resources management. However, to achieve this objective the capacities for research in Africa need to be examined and, where necessary, appropriate training programmes instigated. Nations require at least a minimum indigenous critical mass in research for equality in international collaboration, for long-term security and for scientific empowerment. Without this, they, and their natural resources are likely to be exploited.

3.1 Research capacity in developing countries

All evidence suggests that research in tropical developing countries is at a very low ebb (Denny, in press; Wishart and Davies, 1998). Take the numbers of publications as an indicator of research activity; Zymelman (1990) shows that science publications from Sub-Saharan Africa account for only 0.4% of global outputs whilst many Sub-Saharan countries produced none at all. Most of that research is carried out by Northern scientists. Wishart and Davies (1998) argue that there is a significant *export* of intellectual knowledge from South to North - for example, the research is largely published in Northern journals not widely available (for financial reasons) to the poorer countries of the world.

Reasons for the lack of research from Southern scientists are complicated. Lack of funding into tertiary education and under funding of local research in developing countries is a primary cause (Zymelman, 1990). Understandably, many countries have targeted universal primary education as a priority. There is criticism of '*Technical Assistance*' schemes by the World Bank and others, to fill the gap in higher education and research. It is claimed that such support can actually increase dependence on the North, decrease local capacity and perpetuate reliance on foreign assistance (Ridker, 1994). Much of the funding either from grants or 'aid' support programmes, may return to the North (Ridker, 1994). These types of schemes may satisfy more the commercial, political or scientific aspirations of the North rather than the needs and aspirations of the South (Adams, 1992; Ridker, 1994). Likewise, research and technical development (R&TD) projects by the European Community's Lomé Convention has had limited success (Retout, 1998). Sometimes, the efforts of Northern experts may even be counter-productive as they may have little appreciation of the indigenous knowledge, and be unwilling to assimilate the totality of local cultures, traditional, social and aesthetic values with their acknowledged expertise (Denny, 1997b). This conference highlighted some of the early conflicts between donor agencies and local communities in the development of water management options for the conservation of the Hadejia-Nguru wetlands in Nigeria, (Ezealor, *pers. comm.*).

The low research outputs from the South cannot only be blamed on the North. In the South, political insecurity, poverty and a poor quality of life is not a conducive work environment. Scientific research is expensive (Vierssen, 1990) and may have a very low priority. Thus, the research ambience can be depressive with obsolete equipment, poor libraries and inadequate salaries reducing morale and motivation. Collaboration between individuals and institutions at the local, national and regional levels is largely lacking (Workshop 3; this conference). Instead, individuals and institutions may accept offers of aid or 'co-operation' to support their scientific infrastructure even though it may be Northern driven and lead to exploitation. As a consequence, they become scientifically passive rather than pro-active, selecting projects that are most beneficial financially to their institutions than the more scientifically challenging ones. Their science, and the self-criticism essential for science writing, is weakened (Payne, 1997) and the quality which comes with competitiveness is reduced (Groen *et al*, 1990).

3.2 The type of research needed

With the limited resources available for research, developing countries find themselves in a cleft stick: applied research to address the immediate, pressing problems of their country or basic research to strengthen their in-house expertise?

Some people argue that basic research is an extravagant luxury which should be left to the industrialized nations whilst Southern scientists attend to solving their immediate environmental problems. Advocates seem to forget that 'applied' and 'basic' research is not mutually exclusive but synergistic. At the XXVII Congress of the *Societas Internationalis Limnologie* in Dublin, August 1998, Denny (in press) argued:

> *One needs to understand processes; investigate the whys? and hows? and the functioning of systems in order to provide base-line information upon which decisions can be made. ..... Over-emphasis on applied science and the neglect of basic research is to address the symptom rather than establish the cause; to be re-active rather than pro-active: to lose the specialist*

knowledge base and expertise which had been built up over a life-time of curiosity.

Without research the South remains subservient to the North: the near-absence of basic research in developing countries negates the research culture and the scientific empowerment which is essential for sustainability and self-sufficiency.

From the above it should be clear that there is an urgent need to strengthen the capacity both for pro-active, integrated research and for the applied and technical sciences. Pro-active to understand natural processes and *prevent* further degradation of wetlands and applied studies for problem-solving after damage has been done. Integrated research implying the simultaneous training of (water) engineers and social and natural scientists to address environmental issues in close collaboration with each other. There is no quick and easy solution, but the following approaches might be considered when addressing this issue.

4. Research training and capacity building: possible approaches

4.1 Technological transfers

The simplest and probably quickest solution is to transfer ready-to-use technologies and management strategies from the industrialized world to Africa. This might well contribute in the short-term to better welfare and healthier wetlands in Africa and might even be sustainable for the Northern consultants who have to return time and again. This model will, however, not contribute to the strengthening of research capacity in Africa itself. It will make Africa even more dependent.

4.2 Research capacity building

Building and strengthening research capacity implies strengthening of the infrastructure and capacity of a whole research system at all levels (Wils, 1995). Individual researchers and research teams must be able to define their own research priorities and to complete an entire research cycle. Crucial is a comfortable balance between basic and applied, problem-orientated research. Institutes must be able to define research programmes and should take care of efficient management of resources. And finally, governments should be responsible for setting national research priorities. Research needs to be properly funded and should be possible as a full-time academic and professional career. In the poorest of countries this is only achievable through long-term commitments by the North to the South.

Research capacity building involves the development of knowledge and skills for which investments in training will be more successful than simply transferring knowledge. Although more time might be needed to see results, its major benefit will be sustainability in the long-term. Training of junior researchers and engineers to all academic levels (BSc, MSc, PhD) and the concomitant training of laboratory and support staff seems to be the most efficient mechanism to strengthen research capacity. The junior scientists will take over key positions in research, education, international consultations and management in due time. But to make this possible, the more senior, present-day researchers and lecturers could combine their efforts for active collaboration. Thus, collaborative research programmes within clearly identified themes such as 'evapo-transpiration and the water cycle', 'flooding regimes', 'catchment integrity', 'wetland buffering capacities', 'ecosystem carrying capacities' might be established.

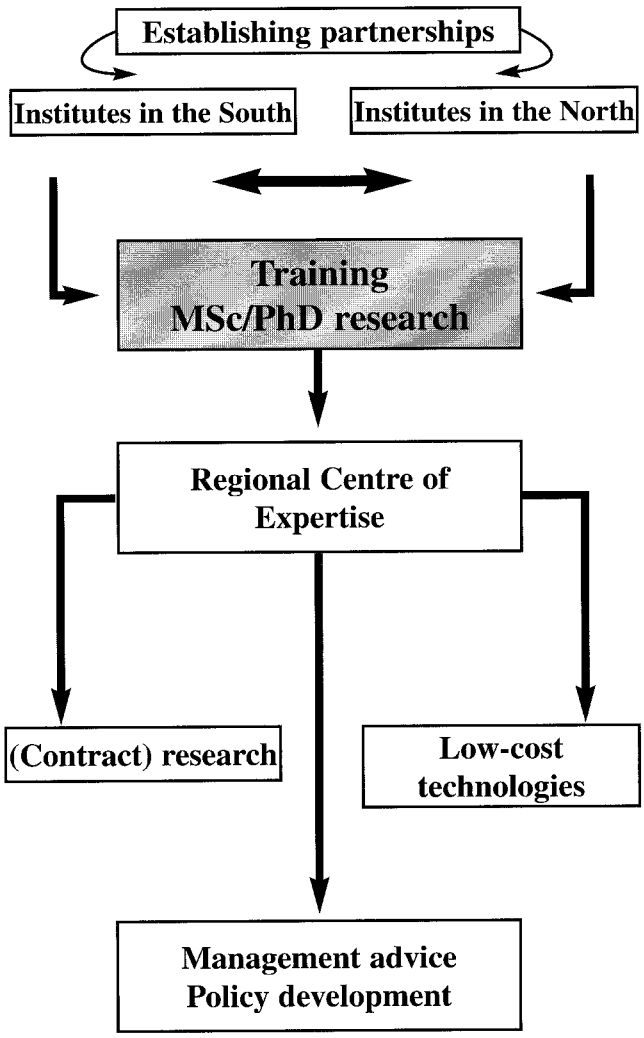

Fig. 1. Aquatic Resources Management and Development Accord (ARMADA): balancing environment and development by linking research, education and infrastructure

4.3 Co-operation mechanisms for training

If it is accepted that academic training indeed is an essential requirement for scientific and technical empowerment and sustainable management of African wetlands, the question remains how to organise this training effectively. Various models exist, with their pros and cons. Here, we would like to present a model which we think will contribute to Africas capacity to manage its wetlands and aquatic resources. A

model which not only relies on the exchange of knowledge between North and South, but also takes into account South-South co-operation. Indeed, this conference puts as a priority, co-operation within regions and river basins in the South with N-S partnerships especially at the academic and research levels.

Central in this approach is the establishment of a network in aquatic resources management, the Aquatic Resources Management and Development Accord (ARMADA), with institutes from both industrialized and developing countries as members (Fig. 1). Together they can form an organization that coordinates its activities in a (virtual) Research or Graduate School. A comparable scheme has already been established by the Water Resources fraternity through the *AWaternet*.

Presently, in the industrialized countries, a number of well-established institutes is specialized in postgraduate training of professionals from developing countries into research and management of aquatic systems. However, there is rarely co-ordination nor co-operation, between these institutes and it seems that a co-ordinated effort in training and post-training follow-up will greatly increase the impact of these activities in the developing world. The objective is to strengthen co-operation between these institutes. For example, streamlining of course activities, thereby appreciating each institute's own specialist expertise, might result in a modular structure of courses, providing participants with the opportunity to join modules from other institutes. In this way tailor-made packages can be developed which better suit individual needs. Participants will then be stimulated to carry out the research for their MSc thesis at one of the participating institutes in an African country; research which is of relevance to the environmental situation in the host country. Thus, the relations with these institutes will be strengthened and South-South co-operation will be encouraged.

PhD research and training can be organised along similar lines. Preparation and research proposal writing can be done at one of the Northern institutes with convenient access to a network of specialists. The research will be carried out in Africa, in close co-operation with, and under joint supervision with, one of the African partners. Finally, writing may be completed in the North where library and information accessibility are better. This procedure would be a transition period of, say, 5 years in which degrees may be attached to the Northern institutes. The ultimate goal, however, would the awarding of Joint Degrees or 'Network Accredited Degrees' for North and South participants alike. Initially, the number of participating institutes from developing countries will be limited as one of the objectives is to establish centres of expertise in the South. These centres of expertise would develop their own specialist research expertise and would form a network of local institutes with a regional scope, responsible for training of professionals from a wider area and doing research in their specific expertise.

Clearly, a number of mechanisms have to be developed to make this model work. Most important is that researchers and lecturers from the network start actively collaborating in joint research and in the harmonization of training (cf. Box 1). This can be stimulated by organizing regular (e.g. annular) joint field/laboratory research programmes and workshops at one of the member institutes, either in the North or in the South. Members of the research teams, the PhD fellows and their supervisors all participate in these activities. The workshops will be used to place the individual research projects in a broader socio-economic-environmental context so as to stimulate integrated approaches. They provide opportunities for harmonizing experimental technologies, training procedures and curricula quality control. Moreover, these workshops can also serve as an international forum to discuss development-related issues and to stimulate North-South as well as South-South discussions.

A second prerequisite for success is that integrated training programmes have to be developed that involve simultaneous participation of professionals from various disciplines (e.g. the ecologists and the water resource engineers). It is essential that these groups learn to understand each other's language and get to appreciate each other's interests and problems. Experience at IHE, Delft, with combining water quality managers and water resource managers in one joint programme has taught us that this is not an easy accomplishment. So here is a challenge.

Following this model a contribution will be made towards capacity building in research and education, both at the individual and the institutional level. It is expected that these approaches to expert training will help to satisfy the growing need for tailor-made study programmes which contribute to the local scientific knowledge base upon which managers and policy makers can rely. The ultimate goal, in a developing context, is a situation in which each developing region is able to support its own integrated aquatic resources management sector through its own tertiary education and research.

5. Conclusions

Integrated wetland and water resources research offers new challenges to combine the expertise of water engineers and social and natural scientists. The problems of water scarcity, the high diversity of wetlands and the reliance on wetland products by the local people indicate Africa is well-suited to spearhead the activities. However, the capacity for research in Africa is limited. The North has failed to stimulate a critical mass for research in Africa whilst the South suffers from chronic under-investment.

North-South and South-South partnerships in research and research training are proposed in which an Aquatic Resources Management Network is established. International co-operation will underpin integrated water and wetland research themes; multi-disciplinary curricula will be developed for training and capacity building and knowledge acquisition will be encouraged. Whilst appreciating the necessity for

Box 1: The MSc Programme in Limnology and Wetland Ecosystems

This MSc programme resulted from an agreement between the IHE Delft, the Netherlands, the Institute of Limnology, Mondsee, Austria and the Makerere University, Kampala, Uganda and can be seen as a first step towards the development of a Research School in Aquatic Resources Management. In this programme, professionals with at least a Bachelor's degree from various disciplines participate for six months in an IHE course in Delft, (either Environmental Science and Technology or Water and Environmental Resources Management) and for six months in the course in Limnology offered by the Institute of Limnology at Mondsee and Lunz. After completion of these taught parts, they normally continue with an MSc research project at Makerere University in Kampala.

This programme is designed specifically to give an overall insight into aquatic systems through lectures, laboratory exercises, appropriate technology, group-work, role-play and field studies. Research skills are developed and a critical approach to real, everyday problems is encouraged. This provides the essential knowledge base for scientists, managers, decision-makers, and end-users working towards sustainable development and the wise use of natural resources.

applied (re-active) research to address the immediate environmental problems, a case for basic (pro-active) research is argued strongly as an essential foundation for scientific and technical empowerment and development.

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Article 2.2

Experiences in Integrated Wetland Management Training at the Kenya Wildlife Service Training Institute

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Keywords: Kenya, training, wetland, biodiversity, management.

This paper focuses on recent experiences in wetland management in-service training for the Kenya Wildlife Service (KWS) and its partner organisations. The KWS Training Institute (KWSTI) is the in-house training facility of the Kenya Wildlife Service Training Programme. It has incorporated wetland management training courses in its curricula.

Biodiversity management training uses a two-column model of conservation management: information collection (upward) and implementation of management (downwards). These columns involve all management levels, from the local to the national level and from field staff to the top of the KWS. These levels are reflected in the courses: field level courses provide techniques to collect information for management interventions; middle level courses help to formulate interventions for implementation; and senior level courses train to integrate and co-ordinate biodiversity management in regions and to develop and implement (wetland) policies.

Analysis shows that the KWS (a large and geographically widely distributed organisation) should pay more attention to annual performance appraisal. Regular appraisal is essential to assess the training required, the capacity required and for the selection of staff for specific courses. This paper examines the roles of direct supervisors, training co-ordinators and KWSTI in such appraisal.

Expériences dans la formation à la gestion intégrée des zones humides au Kenya Wildlife Service Training Institute (KWSTI)

Mots-clés: Kenya, formation, zones humides, biodiversité, gestion.

Cet article relate des expériences récentes de formation à la gestion des zones humides pour le Kenya Wildlife Service (KWS) et ses organisations partenaires. Le Kenya Wildlife Service Training Institute - l'institut de formation interne du KWS - a incorporé des cours sur la gestion des zones humides dans son programme de formation.

La formation à la gestion de la biodiversité utilise un modèle de gestion de conservation sur deux colonnes: la collection de l'information (vers le haut) et la mise en place de gestion (vers le bas). Ces colonnes impliquent tous les niveaux de gestion, du niveau local au niveau national et du personnel de terrain jusqu'au cadre du KWS. Ces niveaux sont reflétés dans les cours: les cours au niveau du terrain enseignent des techniques pour rassembler de l'information pour des interventions de gestion; les cours au niveau moyen aident à formuler des interventions pour la mise en oeuvre; et les cours au niveau supérieur tendent à l'intégration et à la coordination de la gestion de la biodiversité dans les régions et au développement et à la mise en place de politiques pour les zones humides.

L'analyse prouve que le KWS (une grande organisation largement répartie géographiquement) devrait prêter plus d'attention à l'évaluation de la performance annuelle. L'évaluation régulière est essentielle pour évaluer les formations requises, les capacités exigées et pour la sélection du personnel pour des cours spécifiques. Cet article étudie les rôles des supérieurs directs, des coordonnateurs de formation et de l'institut de formation du KWS dans une telle évaluation.

1. Introduction

This paper will focus on our recent experiences with wetland management in-service training for the Kenya Wildlife Service (KWS) and its partner organisations. We will briefly discuss the essential issues and nature of the problems in wetland management training in Kenya, KWS activities and achievements, and finally the lessons that we have learnt.

Under Kenyan Law, KWS is charged with the conservation of Kenya's biodiversity. Its mandate is spelled out in its Mission Statement and Main Goals.

Kenya Wildlife Service mission:

> "On behalf of the Government of Kenya, Kenya Wildlife Service holds in trust for present and future generations locally, nationally and globally the biological diversity represented by its extraordinary variety of animals, plants and ecosystems ranging from coral reefs to alpine moors and from deserts to forests. Special emphasis is placed on conservation of large animals found in few other places on earth."

To fulfil its mission of biodiversity conservation, KWS strives to achieve three main goals:

- To maintain and develop a viable conservation area system, ensuring that a representative and sustainable sample of biodiversity is protected.
- To build partnerships to conserve biodiversity and to ensure benefits for custodians.
- To take the lead in developing sustainable eco-tourism by maximising the economic benefit to the nation and minimising negative environmental effects.

The key issue for the Kenya Wildlife Service is that most biodiversity in Kenya may be found outside KWS' mandate areas, which are the protected National Parks and Reserves.

Although Kenya became a Party to the Convention on Wetlands (1971, Ramsar, Iran) on 5 October 1990, and the KWS's mission statement explicitly mentions examples of wetlands, wetland management is still a relative new area in Kenya and KWS. Therefore, the Service, its partner organisations and their staff, lack the knowledge, skills and motivation for effective co-operation.

A National Wetland Policy, although in an advanced stage of development, is still lacking in Kenya. The absence of such a policy is one of the major obstacles for the improvement of wetland management in Kenya. A second major hindrance is the large number of governmental agencies that are involved in wetland management in a rather uncoordinated manner.

With most of the wetlands outside the KWS mandate area, Government agencies from all sectors and from local to national levels exert management authority over wetlands. Over 70 agencies have claimed official responsibility for wetland management, even though most of these agencies lack adequate understanding of biodiversity conservation and sustainable multiple-use principles.

The KWS is on a relatively unequal footing with its partners. In comparison, the KWS is well-organised and well-funded, and has a history of internationally acclaimed success in anti-poaching. KWS risks to be the dominant – not merely the leading - partner in its partnerships. A dominant position may lead to inertia, and even resistance, in its partner organisations.

We see training in wetland management as a process and a tool to:

- develop knowledge, skills and motivation within KWS, its partners and the Kenya Government at large, to come to a National Wetland Policy, adequate wetland management, and;
- to bring partners to an equal level to ensure active and effective co-operation and co-ordination.

Therefore, the KWS Training Institute's device is: *"Growing together from our combined experiences"*.

2. Assessment of priorities

Too often, training needs are not addressed because training is either irrelevant or inappropriate to the professional's actual responsibilities and tasks. Assessments of capacities and identification of training needs are seldom carried out. Training needs can only be identified when problems in performance and their nature and causes are carefully investigated. Only then can (cost)effective, relevant and appropriate training be developed.

In November and December 1995, KWS used a Training Needs Investigation and Assessment (TNI & A) to evaluate the design of training courses in practical (wetland) conservation management on the realistic basis of existing performance experiences of KWS employees. Two TNI & A Teams visited 14 conservation areas and KWS stations throughout Kenya. During the 3 to 6-day visits, the TNI & A Teams investigated all or most positions at each site (usually 5-12 per site). In total, over 330 employees in 53 different positions were interviewed or analysed on the nature and underlying causes of their job performance problems. The 53 jobs investigated comprise about 75% of the existing positions with KWS, and virtually 100% of wetland management related jobs. The number of positions included in this review is 10-15% of the total establishment of KWS.

In 1996 a similar exercise among actual and potential KWS partners provided information on training demands from outside the KWS. The TNI & A exercise revealed that:

- (Para)military, legal and bush-craft knowledge and skills are comparatively of high standard and cause relatively few performance problems;
- biodiversity management knowledge and skills are of lower standard and often absent, particularly in the lower echelons (rangers, assistant wardens);
- lower echelons rarely receive in-service training; past training, workshops, conferences, etcetera focused on the higher echelons and the national headquarters;
- there is a general lack in *practical and supporting* knowledge and skills. Examples are vehicle, boat, and outboard engine maintenance and repair, marine search and rescue techniques, first aid, visitor reception, customer care, languages, and basic office management;
- there is a general lack of awareness of wetland values and functions, and wetland biodiversity and ecology, particularly of non-game wildlife;
- there is a significant discrepancy between the official job descriptions as known at the national headquarters and the tasks and duties actually performed; employees are often not trained in, or hired for, more than half of their actual performed tasks.

Because the lower echelons in KWS are the primary interface with visitors and biodiversity in the field, we decided to concentrate our training programme on rangers and assistant wardens for the first 3-4 years. We envisaged that attention to the lower echelons would boost morale of KWS staff and increase performance. The training focused on practical skill-oriented short courses, rather than more academic knowledge-oriented long courses.

However, the process of priority setting ran into a major constraint. During 1996 and 1997, KWS underwent a large-scale reorganisation. The Service regionalised, devolving management authority from the national headquarters to middle management at the 8 Biodiversity Regions. In the process of change, many of the jobs investigated in 1995 and 1996 disappeared or changed considerably in character and scope. New jobs were created, particularly at the middle and higher management levels. To address these changes, a rapid training needs assessment was carried out in early 1998, when the organisational change was being consolidated.

3. Emphasis on capacity building, planning and monitoring

The Service has given a high priority to capacity building within and 'around' KWS with the acquisition of the KWS Training Institute in 1993. In 1998 the PAWS Programme, funded by the World Bank, trained middle and higher management staff. More than 8 Regional Management Teams of 10 persons each were trained for 5 weeks in all aspects of organisational management including personnel management, administration, planning, finances, procurement and store keeping, and legal procedures.

Within the KWS Training Institute, the KWS-Netherlands Wetland Conservation and Training Programme (KWS-NWCTP) focused on wetland training. The biodiversity courses carried out by the Programme are strictly focused on two-way biodiversity management. First, there is a bottom-up track where field staff collects information on the current condition of, and threats to, biodiversity. That information is used by middle and higher management for analysis, integration, co-ordination and formulation of management plans and measures. The second track is top-down, where middle and higher management define management measures and interventions for field staff to implement. The cycle continues with field staff collecting biodiversity information to assess and direct the impact of management interventions (monitoring).

Therefore, in addition to general organisational management capacity, the required biodiversity management capacity to be built comprises:

- Biological and ecological field techniques for lower echelons to collect information on the current condition of biodiversity in the field and to assess the impact of management interventions (monitoring);
- Management and policy formulation skills for middle and higher management levels (planning).

In an early stage KWS-NWCTP acknowledged that limiting capacity building strictly to the Service might ultimately lead to a capacity gap between KWS and its partners. Such a gap, in turn, could cause diminished commitment and motivation to co-operate with KWS outside the parks, where most of the biodiversity currently may be found.

During courses, outside the usually stressed work environment, KWS-NWCTP also builds local networks and 'synchronises agendas' by bringing together KWS trainees and partner trainees from the same areas. Moreover, a mixed target group exposes problems, strengths, weaknesses, opportunities and constraints from the viewpoint of different organisations. In this way, the Service would move forward at the same speed as its partners.

In its long-term planning, the KWS Training Institute wishes to develop longer and more knowledge-oriented Certificate and Diploma courses. The Institute further wishes to specialise - among other areas such as community wildlife management - in wetland management training for the Eastern Africa region to avoid regional competition and overlap with other (wildlife) management colleges in (Eastern) Africa.

4. Linkages

KWS-NWCTP attempts in its courses to create linkages, both between KWS and its partners and between the miscellaneous subjects of the course to highlight the integrated character of biodiversity management.

Moreover, many of our training courses are 'roving' courses. They are not executed centrally at our Training Institute in Naivasha, but rather in the duty areas of the trainees. Roving

courses create an excellent opportunity to use real-life cases from the trainee's work environment. Many training courses have yielded the (beginning of a) solution to a problem.

Roving courses also teach trainees new knowledge and skills in the area where they experience job performance problems and where they will apply newly acquired skills after the course. Further, roving courses have often resulted in the first information for a particular area, e.g. on the number of waterbirds.

5. Main initial assumptions

The KWS-NWCTP worked from several assumptions and within some constraints. First, we assumed that only improving knowledge and skills would not suffice. KWS and partner employees would need increased motivation as well, not only to do their jobs better, but also to induce co-operation and changes. Without motivation, newly acquired knowledge and skills would remain ineffective and sterile.

Second, we also assumed that skill-oriented training courses require a large proportion of the course to be devoted to practical fieldwork, preferably in the trainee's duty area. Therefore, our short courses have 40-60% practicals in their programme.

Third, we assumed that training a small number (often just 1 or 2 persons) in a particular job or job type at one KWS branch office or field station would have some trickle-through effect. However, it may be more realistic to assume that a larger number of employees at a particular station needs training to reach a 'critical mass' before individual and group performance improves.

Fourth, we assumed that there will be sufficient funding for new and improved facilities in KWS and partner organisations. However, current funding levels may jeopardise application of newly acquired insights and skills.

The in-service character of our training courses puts a constraint on the duration of individual courses. When attending a course, trainees do not perform their daily tasks. In particular in KWS offices where there is only one employee, courses should be 1 or 2 weeks and address very specific skills. Middle and higher managers cannot leave their duties for more than 4 to 6 weeks, which limits the opportunities to attend (foreign) M.Sc. and PhD training.

On the other hand, short and specific training courses create a greater flexibility to fine-tune training with changes in job content and career development paths. In the future we will explore the possibilities to create 'dossier' diplomas: the trainee would exchange a coherent set of course certificates from short courses, attended over a period of 2 or 3 years, for a higher level Certificate or Diploma.

6. Implementation

Initially, our focus was on increasing the KWS Training Institute's capacity to execute training courses, including for instance physical facilities, transportation capacity and teaching equipment. Staff received training in developing and delivering courses (Training of Trainers, Curriculum Development Workshops etc), and in advanced aspects of wetland management (e.g. integrated coastal area management, integrated environmental management).

From January 1997 to October 1998, KWS executed 26 wetland course and workshop titles, covering 42 courses and workshops; 656 trainees attended and/or completed the courses successfully. The majority of these courses were attended by KWS and partner trainees, which stimulated co-operation and integration between agencies after the course. About 40% of the trainees came from partner organisations (see Table 1). Many training courses related to practical aspects of biodiversity management: Boat and Engine Handling, Maintenance and Repair, Open Water Diving, First Aid, Marine Search and Rescue Techniques, Languages, etc. Other courses for middle and higher management levels included e.g. Integrated Coastal Area Management, Integrated Environmental Management, and Wetland Inventory.

7. Lessons learned

A rapid training impact survey at the Coastal Region of Kenya, where most wetland training has been conducted, revealed interesting results. First, enthusiasm, motivation, commitment and initiative increased considerably, especially in the lower echelons. Rangers and Assistant Wardens also reported increased confidence and comfort in their skills. This is an essential, yet usually overlooked or undervalued effect of training; attention from national headquarters and higher echelons to problems in people's job performance creates commitment. This aspect may even be more important to improve performance than increasing knowledge and improving skills.

Second, supervisors acknowledged improvements in specific tasks and reported more independence and initiative from employees.

Third, with management authority devolved to the KWS Biodiversity Regions, many Regions have incorporated their staff's newly acquired knowledge and skills into the Annual Work Plans, for instance:

- Bi-annual waterbird counts at important wetlands in a Region;
- Regional wetland inventories (running up to the National Wetland Inventory planned for 1999 and beyond);
- Co-ordinated actions with partners.

Fourth, training should be more integrated in the general process of management and administration. KWS is a large and geographically widely distributed organisation with some 3,000 employees. In the process of formulating training, more and earlier attention should have been paid to annual job performance appraisal and the selection of candidates for specific training courses.

performance appraisal and the selection of candidates for specific training courses.

Ideally, the analysis of these appraisals should reveal patterns of deficiencies in knowledge, skills and motivation in specific positions. These patterns should determine the required training ("why training in what?") and capacity ("how many of which job holders?'). In this way, a specific number of particular training courses could be developed for the following year. Selection of employees for specific training courses should be based on problems discovered during their job performance appraisals.

The current situation within KWS is very different. Despite the initial training needs assessments, training courses are still predominantly subject-driven: what managers and supervisors perceive as being good for sub-ordinates rather than on the actual problems perceived by job holders. The offer of training courses is often out of tune with the demand for training courses. The roles of supervisors, the KWS training manager and the KWS Training Institute in the definition and execution of training courses should be more clearly defined.

Fifth, the importance of the training course certificates is still low. Within KWS the certificates are more or less established in the process of career development and promotions. However, outside the Service this is not the case, as the certificates are not yet officially recognised by the Kenyan Committee for Examinations Standards. This means that the training course certificates are not 'portable' and impart little advantage to graduates when they seek employment or further education (e.g. subject exemptions at Universities) outside KWS. This, in turn, diminishes the value of the certificates and at times the motivation to attend training courses.

Table 1: Wetland Courses January 1997 - October 1998

	Course Title	Dates	Trainees
1	Basic Marine Biology	7-11 April 1997	11
2	Boat & Engine Handling, Maintenance & Repair, Mombasa	17-21 March 1997	11
3	Boat & Engine Handling, Maintenance & Repair, Malindi	28 April-2 May 1997	17
4	Swimming & Skin Diving	18-19 September 1997	15
5	PADI Open Water Diving	11-17 September 1997	10
6	PADI Advanced Open Water Diving	15-19 September 1997	16
7	PADI Advanced Open Water Diving		16
8	PADI Medic 1st Aid	16-19 October 1998	13
9	PADI Medic 1st Aid	22-23 October 1998	10
10	PADI Rescue Diver	16-19 October 1998	13
11	St. John's Ambulance 1st Aid	24-27 March 1997	13
12	Diving Equipment Maintenance & Repair	31 May-4 June 1997	11
13	Marine 1st Aid & SAR	4-8 August 1997	11
14	Marine 1st Aid & SAR	18-22 August 1997	12
15	German for Beginners	17 February-14 March 1997	12
16	French for Beginners	1-25 April 1997	12
17	Mooring Workshop	23-24 February 1998	50
18	Mooring Planning	22-30 May 1997	15
19	Mooring Installation & Maintenance	25 February-8 March 1998	14
20	Mooring Users	25 February-8 March 1998	25
21	Integrated Coastal Area Management	16-20 June 1997	16
22	Integrated Coastal Area Management	22-26 September 1997	16
23	Integrated Coastal Area Management	21-27 October 1997	12
24	Integrated Coastal Area Management	23-27 March 1998	13
25	Mangrove Ecology & Conservation	5-11 September 1997	16
26	Management Plan Development Workshops, Coast		23
27	Waterbird Identification & Counting Techniques, Malindi	20-24 January 1997	17
28	Waterbird Identification & Counting Techniques, Mombasa	12-16 May 1997	19
29	Waterbird Identification & Counting Techniques, Kisite	29 September-3 October 1997	14
30	Waterbird Identification & Counting Techniques, Amboseli	17-21 November 1997	20
31	Waterbird Identification & Counting Techniques, Turkana	1-5 December 1997	21
32	Waterbird Identification & Counting Techniques, Tsavo West	23-27 February 1998	19
33	Waterbird Identification & Counting Techniques, Kisumu	16-20 March 1998	25
34	Waterbird Identification & Counting Techniques, Bogoria	30 March-3 April 1998	17
35	Wetland Inventory, Naivasha	11-22 August 1997	16
36	Wetland Inventory, Malindi	20 April-1 May 1998	5
37	Wetland Inventory, Naivasha	11-22 May 1998	16
38	Habitat Evaluation Procedures & Suitability Index (HEP/HIS)	October 1997	21
39	Biodiversity Indicators	May 1998	19
40	Photography & Film Processing	June 1997	3
41	Library KWSTI & Mombasa	8 October-2 December 1997	5
42	Integrated Environmental Management	April 1997	16
			TOTAL 656

Part III:

Integrating Catchment, Land and Water Use Management

Article 3.1

Guidelines for the Sustainable Management of Sahelian Floodplains

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Keywords: Sahel, floodplain, guidelines, sustainability, management.

Floodplain resources in the Sahel are under increasing pressure due to droughts, increasing human population, livestock pressures and rising poverty. These pressures have led to an overexploitation of resources and a general water development strategy that is characterised by large river engineering schemes. The failure of many of these schemes to realise their planned potential combined with their major environmental and socio-economic problems have increasingly highlighted the need for alternative pathways for the development and sustainable management of Sahelian floodplain resources. One of the important obstacles for progress in this direction is the lack of skills, experience and expertise in the region. To overcome this barrier, IUCN – The World Conservation Union established the Sahelian Wetlands Expert Group. This group developed guidelines for the sustainable management of Sahelian floodplain resources. The guidelines define the steps required to develop sound floodplain management plans and to implement these in an effective way. The guidelines will be submitted to various fora for endorsement and implementation.

Lignes directrices pour la gestion durable des plaines d'inondations sahéliennes

Mots-clés: Sahel, plaine d'inondation, lignes directrices, durabilité, gestion.

Les ressources des plaines d'inondations sahéliennes sont soumises à une pression croissante du fait de sécheresses, de l'augmentation de la population humaine, des pressions de l'elevage et de la pauvreté croissante. Ces pressions ont entrainé une surexploitation des ressources et une stratégie générale de développement des ressources en eau caractérisées par de grands projets d'ingénierie fluviale. Leur échec à réaliser leur potentiel prévu, combiné aux problèmes environnementaux et socio-économiques majeurs qu'ils ont engendré, ont demontré le besoin de trouver des voies alternatives de développement pour la gestion durable des ressources des plaines d'inondation sahéliennes. Un des obstacles importants au progrès est le manque de qualifications, d'expérience et d'expertise dans la région. Pour surmonter cet obstacle, l'UICN - Union mondiale pour la nature a établi le Groupe d'Experts sur les Plaines d'Inondation Sahéliennes. Ce groupe a développé des lignes directrices pour la gestion durable des ressources des plaines d'inondations sahéliennes. Les lignes directrices définissent les étapes requises pour développer des plans cohérents pour la gestion des plaines d'inondation et pour les mettre en oeuvre de manière efficace. Les lignes directrices seront soumises à l'appréciation de divers fora pour approbation et mise en oeuvre.

1. Introduction

The Sahelian zone of West Africa is characterised by a low annual rainfall, of less than 1000 mm on average, which is highly seasonal. During the wet season, large areas adjacent to the major rivers in the region, including the Senegal, Niger, Yobe and Logone are inundated due to natural flooding. This produces wetland ecosystems of exceptional productivity, particularly in comparison with the surrounding arid and semi-arid rangelands. For centuries, these floodplains have played a central role in the economy of the region providing fertile land for recession agriculture and grazing for migrant herds. Many floodplains also perform important hydrological functions such as groundwater recharge and yield valuable supplies of fish, timber, medicines and other products and provide essential habitats for wildlife, especially migratory birds.

In recent years, drought, the increasing populations of people and livestock and the rising poverty have put pressure on the floodplains and have led to over exploitation of their resources. In the face of such pressure, water management has been seen as the key to development through the implementation of major river engineering schemes, such as dams, for hydro electric power generation and for providing water for irrigated cereal cultivation. Few of these schemes have however realised their full potential and many are facing serious environmental, technical, administrative, socio-economic, political and health problems. The experience has highlighted the need for improved and integrated management of the natural resources combining the best of intensive and extensive floodplain farming systems using both customary and modern techniques.

To address this problem and to provide guidance on the sustainable management of Sahelian floodplain resources, IUCN – The World Conservation Union has been working with experts from the region to develop an expert network on Sahelian floodplain management. The guidance given by this network is reported in this paper. The objectives are:

1. to provide the context of the development of the guidelines for guidelines for the sustainable management of Sahelian floodplains;
2. to present the guidelines concerning planning and implementation of sustainable floodplain management;
3. to describe the enabling environment that is required for the implementation of the guidelines.

2. The Sahelian Wetlands Expert Group (SAWEG)

One of the great barriers to development in the region is the lack of skills and experience. Nevertheless, there are some talented specialists, with expertise ranging from aquatic plant conservation to water engineering. Their limitation is frequently the lack of experience in working together as teams to solve interdisciplinary problems, such as floodplain management. To build the capacity of institutions in the region to plan and manage floodplain resources in a more integrated and sustainable manner, IUCN established the SAhelian Wetlands Expert Group (SAWEG). SAWEG currently includes around 100 members who meet three criteria:

1. To have a background in one of the following disciplines: hydrology, water engineering, biology, physics, soil science, rural or urban planning, human and animal health, ecology, sociology, law, environmental economics or agro-forestry;

2. To be native to or working in Sahelian countries of Nigeria, Mauritania, Senegal, Mali, Niger, Chad, Burkina Faso, Gambia and Cameroon;

3. To represent a key organisation, including e.g. universities, research institutions (both national such as INERA in Burkina Faso and international such as ORSTOM from France), government departments, non-government organisations (from local to international, including the International Irrigation Management Institute (IIMI) and river basin development authorities such as OMVS, Niger Basin Authority, OMVG and the Lake Chad Basin Commission.

Members of SAWEG have worked together since 1993 to produce guidelines for the management of Sahelian floodplains. These indicate how sustainable and equitable utilisation of floodplain resources can be achieved. It is not intended that these guidelines provide an unambiguous recipe for successful management. Rather the aim is to provide a framework with sound underlying principles within which the issues of individual river basins and their floodplains can be set.

3. The guidelines

3.1 Policy context

Global Policy on Integrated Water Resources Management

Chapter 18 of Agenda 21 develops the concept of Integrated Water Resources Management (IWRM) which treats "water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilisation" (UN, 1992). As such the concept builds upon the Dublin principles and the outcome of the Mar del Plata Conference.

Central to IWRM is the maintenance of well functioning environmental, irrigation and drainage, water supply and sanitation and fisheries systems. As freshwater systems within a catchment are connected, the integrated management of these must be undertaken at a catchment scale. Implementation of IWRM in the Sahel therefore requires integration of the management of floodplain resources with water and land uses within the entire catchment. We call this Integrated Floodplain and Water Resources Management.

National wetland (or floodplain) policies

Most states in Sahelian West Africa are signatories to the Convention on Wetlands (1971, Ramsar, Iran). This requires them to draw up management plans to improve the conservation and wise use of wetlands. To assist in this process, which forms an essential step towards sustainable development, the Convention recommends that Parties adopt National Wetland Policies. These policies are recommended to be based on the concept of Wise Use for which additional guidance is provided in several documents (Davis, 1994).

It is noteworthy that many of the Sahelian countries are currently implementing a process of decentralisation and democratisation, involving the transfer of power from central government to elected representatives of local communities. This has a number of implications with respect to natural resources management. First, national policies will increasingly be implemented by communities at the local level. Second, it is even more important to ensure that national policies are consistent with local legislation, traditional rights and local policies. Third, national policies must be built on traditional and local ecological knowledge as these will be mobilised during implementation of national policies at the local level. Though the decentralisation is likely to increase local representation in decision making and thus possibly the sustainability of implemented changes, it can also increase the difficulty of co-ordination at the catchment level, which is vital to sustainable floodplain management. Furthermore, decentralisation can draw considerable financial and human resources from central government, which might impact negatively on the quality of decisions taken. The opportunities and constraints of the decentralisation process show that guidance is needed for the sustainable development of Sahelian floodplains.

Policy implications for Development Assistance Agencies

Many of the Development Assistance Agencies that are responsible for development projects in Sahelian West Africa are from member countries of the Organisation for Economic Co-operation and Development (OECD). All OECD members have joined the the Convention on Wetlands (1971, Ramsar, Iran) and consequently their Development Assistance Agencies are required to undertake action to support the implementation of the Convention's guidelines on wise use. In addition, the Convention on Wetlands has called on Multilateral Development Banks and Development Agencies to give even greater priority to the formulation and adoption of coherent wetland development policies, procedures and practices directed at sustainable utilisation, wise management, and conservation of wetlands (Ramsar, 1993). It also called for developed countries to assist developing countries in fulfilling their obligations under the Convention. In addition, there has been increasing emphasis by Development Assistance Agencies on working directly with national and international non-governmental organisations to achieve sustainable development.

The Convention on Wetlands recommendations have important consequences for the internal administrative procedures of development agencies as these require them to adopt coherent policies for floodplain development and practices that foster the sustainable use of their resources. Many development agencies have adopted "best practice" guidelines for environmental surveys and impact assessment of development projects (OECD, 1992). OECD has further published its own "Guidelines for Aid Agencies for Improved Conservation and Sustainable Use of Tropical and Sub-Tropical Wetlands" (OECD, 1996) in an attempt to minimise the impacts of development projects upon tropical freshwater and coastal wetlands. These guidelines also apply to Sahelian floodplains and, therefore, development agencies must discourage support of any activities that are likely to damage floodplain functions and services, if provisions for adequate compensation measures are not available.

3.2 Planning

The traditional approach to development has been to assess needs and find solutions in isolation within a single sector. The integrated planning of floodplain development provides a contrasting approach as it offers a structured way of solving problems and achieving objectives for a wide range of activities. It involves viewing the floodplain and its catchment as a single system, which has economic, social and environmental components that interact. The planning process requires a number of elements including: bringing together economic, social and environmental information to provide a holistic view; analysis to define critical levels of use and resources abstraction; definition of development options; assessment of their compatibility and economic, social and environmental impacts; and ultimately the choice of best options that meet sustainable and integrated development criteria. Clearly, planning requires a multi-disciplinary team including experts on hydrology, economics, legislation, health, sociology, soil science, planning techniques and other relevant disciplines. Within the planning process several steps are required for sound floodplain management plans. These steps include: information and data collection, information and data analysis, definition of the development options, assessing the impacts of options for development, and making well informed decisions.

Data

Information is fundamental to all understanding and hence to sound decision-making and management. The first step in any assessment of the current status or the future needs is to collate relevant available information and to establish procedures for collection of necessary information that does not yet exist. Important outputs of information gathering are synthesized information, databases, a record centre or a monitoring programme. Key recommendations developed within the guidelines include the development of activities to set up a data collection and data management strategy, to collect information and identify traditional floodplain uses involving local communities, to publish summary information

and circulate copies widely and establish a records centre to make information freely available.

Analysis

Once information has been collected, it needs to be analysed to produce results suitable for management. For example, health records from clinics need to be analysed to determine trends in diseases and mapped to relate hot spots to potential causes. The objective of this phase is to analyse and synthesise relevant information and data to produce products that support the decision making process. Critical inputs to the analysis phase are information and data sets of key-indicators. The output of this phase is readily accessible synthesised information in formats that allow direct application in the planning process. Key recommendations provided by the guidelines on this include: the quantification of the carrying capacity and production, hydrological and other functions of the floodplain, the assessment of the health, socio-economic and legislative situation, the identification of thresholds for change and the impacts of future changes (e.g. climate) with an indication of uncertainty and the establishment of research and monitoring programmes to address unanswered questions.

Master Plan

When collected data has been analysed and an integrated picture has been produced of the economic, social and environmental components of the system, a vision for the floodplain and its development can be defined. This master plan needs to include specific objectives for development and options to meet the objectives. The master plan thus contains a common vision and specific objectives for catchment and floodplain management developed in collaboration with all key stakeholders. The central part of the plan should be formed by the sustainable development of the floodplain. A further key element should include criteria for wetland conservation and a definition of degraded sites that need to be rehabilitated. Important in the development of the master plan is to consider the "do nothing" option.

Options assessment

Once options for development have been defined, their compatibility and economic, social, health and environmental impacts need to be established before a choice can be made between alternatives. A multi-criteria analysis of options is needed to establish the compatibility of proposed activities. It is important to undertake environmental impact assessments on all options and to consider all impacts at the river basin, regional and international scale. Impact assessment should be an integral part of the process and conducted with the first examination of any project. A key element should be to ensure that traditional rights, such as access to natural resources, are maintained. Overall, options that are environmentally and economically sustainable should be promoted, alternatives or redesign options that have no negative impact on the ecosystem should be developed and the precautionary principle should be adopted.

Environment and social impact assessment (EIA) provide a framework for assessing the implications of development options. EIAs are required on projects that exploit hydrological resources, extract non-renewable resources or might cause a substantial change in renewable resource use or farming or fishing. The EIA process involves:

- screening - to determine whether or not a thorough EIA is required;
- scooping - to identify the most significant environmental issues;
- assessment - which should involve local communities likely to be affected;
- external review - to obtain an impartial judgement of the assessment if the project is implemented;
- monitoring - to be undertaken by the relevant authority.

Making decisions

When a number of options for development of the floodplain or the river basin have been identified, decisions have to be made as to which option or options to implement. Key recommendations of the guidelines include the need to take a long term view, involve all stakeholders, consider who benefits and who loses from an option, and to mitigate conflicts. It is suggested that multi-criteria analysis, including economic valuation, provides a suitable tool for decision making. In general multiple use should be selected in favour of single sector projects and projects that permit sustainable use of floodplains should be chosen.

3.3 Implementation

Following the definition of a shared vision and range of development options, floodplain action plans that meet multiple objectives need to be implemented. The main objectives are:

1. to develop a vision shared by all stakeholders on the implementation of the defined management plans;
2. to guide investments and maintenance of investments in the floodplain system;
3. to develop and implement an effective monitoring and evaluation system that supports the implementation and improvement of management practices.

The guidelines recommend the development of effective management of programmes and projects, the initiation and maintenance of effective co-operation between institutions, and the development of the effective use of instruments for implementation. Throughout the process it is essential to ensure that gender issues are addressed. The implementation of Integrated Floodplain and Water Resources Management requires that the main objectives are fulfilled partly in parallel. This means that an effective integrated management of programmes and projects needs to be established, effective co-operation between institutions should be developed and effective use should be made of instruments for implementation.

Effective management of programmes and projects requires the definition and maintenance of a clear implementation strategy linked to the development of an adaptive and flexible management style. Essential for this is to establish an effective monitoring and evaluation framework that helps to track the progress of implementation of projects and programmes. The feedback from this evaluation forms a core element for adaptive management. To be effective, a catchment system analysis needs to be carried out that will enable the definition of indicators of environmental change in the project or programme area. The use of these indicators will assist in the evaluation of results and the adjustments in management. For these adjustments it is important to make use of emerging opportunities where win-win situations can be achieved, for example through incentives that support environmentally friendly investments. In many cases the establishment of such a strategy and management style will require 'on the job' training to build local capacities and extensive consultation with and co-ordination between the many institutions involved.

Currently, much of the ideas on integrated planning, decision making and management lack implementation because many institutions do not enhance collaboration. However, without effective co-operation between institutions integration cannot be achieved. To build institutional linkages effective co-ordinating mechanisms need to be implemented such as the set-up of a co-ordinating committee. Further co-operation needs to be developed particularly between water management sectors, other natural resources sectors, administrative units and the local community and non-governmental organisations. In this process the clear definition of responsibilities and capacities and the development and maintenance of exchange mechanisms of data and human resources between involved institutions is important.

For effective co-operation, a shared vision needs to be developed, maintained and updated on a regular basis with all stakeholders. Of particular importance is the organisation and empowerment of user groups in such a way that they have better access to government institutions and are also accessible for those institutions, for example through Participatory Action Research. The collaboration with local communities and user groups is crucial for the effective implementation of sustainable floodplain resources management. This can be achieved through enhancing existing, or developing new effective self regulation systems and traditional mechanisms and institutions for managing common property resources. Finally, effective mechanisms and capacities for conflict resolution, negotiation and participatory planning and implementation should be developed within government institutions and NGOs.

For implementation to be successful, effective use should be made of tools, measures and instruments available for floodplain management. Although many of these exist, their use is often not well developed in floodplain areas. Broadly two categories of tools can be distinguished. The first set includes tools that can be used to monitor programme and project implementation and to assess the achieved results in the light of the defined strategy. Often capacities need to be developed or strengthened for using existing techniques of monitoring, evaluation of planning, decision making and management. The need for this is both present in terms of technical system monitoring on the ground and in terms, of ecosystem functioning analysis or river quantity and quality monitoring schemes, and in project and programme system analysis.

The second set of tools includes those that relate to effective legislation and enforcement that can be used for sustainable floodplain management. At the start of programmes and projects it is important to develop a comprehensive understanding of the type of legislation and enforcement that form either an incentive or dis-incentive for sustainable planning and management. Based on this it is important to develop a clear set of management instruments such as charges for the resources used, subsidies (e.g. grants for compensation for wildlife damage, subsidies for rehabilitation of degraded areas), and tradable permits (e.g. for pollution or water resource use). It is equally important to consider the removal of inappropriate incentives such as the lack of waste water charges and subsidies for water intensive crops. For the application of all incentive measures it should be clearly defined when and where the instruments will be used, who can make use of them and what their effect will be. Finally it is important to develop a communication strategy that targets water end-users and other resource users, managers and decisions makers and informs all stakeholders about the progress and challenges of the implementation of the defined strategy.

4. Strengthening the enabling environment

4.1 Awareness building, institution strengthening and training

A wide variety of groups including local communities, decision makers and managers need to be sensitised to the ecological, cultural, social and economic values of well-managed floodplains. In addition, institutions need to be strengthened to contribute effectively to planning, decision making and project development. Many technical specialist need more training in integrated water resources management, wetland functions analysis and legal and incentive system analysis and use.

Awareness building is required at all levels from school children to politicians. A crucial first step is the development and implementation of a clear communications strategy for projects, programmes and for general campaigns. This requires the clear definition of the various target audiences and the principle objectives of the strategies. Decisions on the development and use of communications materials should be based on target group analysis and the objectives of the campaign. In many cases, a local and low cost dissemination mechanism can be considered the most appropriate technique.

Strengthening institutional capacity in integrated floodplain (planning) and management is needed both within governments and NGOs. This requires the establishment of mechanisms for co-operation related to integrated planning and management. Within the Sahelian region, NGOs in particular are in need of an increased capacity to contribute to decision making and project development in an effective way. The development of collaborative management agreements between governments and local communities and the establishment of stakeholder groups can facilitate the development of these capacities and permit local groups to provide an input into policy development, planning and implementation. At both governmental and NGO levels it is vital to ensure that adequate human and financial resources are available to strengthen institutions in wetland conservation and sustainable management.

Training and educating for effective floodplain planning and management are highly in need in the Sahelian region. In response to this required training, the specifics of training needs within different government institutions and NGOs need to be identified. Based on this, effective courses can be developed based on co-operation between regional education and training institutions and co-operation with experienced overseas agencies. Generally, training will need to include staff education in technical aspects of management such as survey, analysis and management of functions and values of floodplains. Also required are the development of negotiation skills and the transfer of appropriate technology to local water managers and regional planners. For these it is important that local training initiatives are developed.

4.2 Financing of wetland development

Only a small proportion of development aid required to meet the needs for sustainable management of floodplains has been made available in recent years. Many aid agencies and recipient governments do not acknowledge the wise use of floodplains as an attractive or simple target for investment. Therefore, only limited financial resources are available within these institutions to meet the objectives of the environmental agenda. The future outlook provides a continued bleak picture as public resources in developing countries continue to be inadequate for financing biodiversity conservation. Likewise, resources available for public investment in water and agricultural sectors in Sahelian countries are extremely limited and unlikely to benefit from any increase in domestic budget allocations. This is due to the fact that most Sahelian countries have a limited tax and capital base, an under-developed taxation system and a generally large foreign debt.

The limited financial resources currently available and the likely future shortages point to the need for innovative internal mechanisms to generate funding and encourage investments. Public sector institutions that have been involved in Sahelian floodplain development have only recently realised that sustainable floodplain management could be an area for which private capital can be sought. This requires however that governments adopt new mechanisms and measures to stimulate the generation of revenues that both draw from and maintain the large economic value of floodplain goods and services.

One of the options to ensure that financial resources are available for sustainable floodplain management is for donors and recipient governments to allow funds originally earmarked for servicing the external national debt to be redirected towards sustainable floodplain management programmes. These programmes may be funded under a joint foreign and domestic public financing mechanism, such as National Environmental Funds specifically set up for environmental conservation.

In the Sahel it is likely, however, that private sector funding will greatly outweigh public investment in floodplain management. It is essential that governments ensure that private sector investments are targeted towards sustainable development and form a constant feature in integrated river basin management. As most private sector involvement in development is still much geared towards short-term profit, effective legislation and incentive measures need to be developed and perverse subsidies removed to ensure a sustainable development enabling market infrastructure to be created. Private sector training forms an important element of such an infrastructure and should be seen as a key-priority.

Given the limited financial resources available for floodplain management, managers need to investigate a number of different financing options for implementing management plans. As with all plans, a thorough financing strategy is a fundamental component to any policy, programme or project for sustainable management of floodplains. A financing strategy focused on achieving economic sustainability is key to ensure that the management plan can be implemented and its objectives achieved.

For the development of a financial strategy, floodplain managers should start with identifying the goods and services the floodplain provides together with an analysis of the corresponding recipients and potential investors. A third element forms the identification of means to have recipients pay for these goods or services in a way that parts of these payments are used for conservation activities. In this way managers can develop a strong stakeholder support group that endorses the plans to manage the floodplain in an ecologically and economically sustainable way. A final element forms the further development and implementation of incentive measures that ensure the sustainable resource use to be established and maintained. A measure that is often used to regulate water use is water pricing. Experiences with water taxes indicate that this is often a most effective mechanism to regulate water use. However, in many developing countries parts of the society cannot afford water against the given costs. Therefore a progressive water tax system is recommended that reduces excessive use but is at the same time also socially acceptable.

Developing a financial strategy requires more than simply identifying investors. A single floodplain may have a number of investors including local community groups, private sector enterprises, national government, and international institutions. Some of these may have conflicting goals and objectives that cannot simply be integrated in a single plan. The development of a financial strategy can help the floodplain manager to identify both areas of conflict and complementary investments. In this way a coherent package can be developed that is both attractive for private investors and does not compromise on the sustainability of the planned development. It is essential to look at the time line of the various investors to ensure that financial resources are available on a continued bases. The financial strategy should be developed in the planning phase of a development process and needs to be re-assessed periodically taking the investors timelines into account.

Developing a diverse selection of investors and income sources for floodplain management projects has a number of benefits. A variety of investors and floodplain users will help to establish a diversity in revenues that contribute to a larger economic sustainability of the projects likely inducing increased security to the overall scheme. Opening the process to a variety of investors will enable a number of different stakeholders to participate in the management process and thus develop buy-in for the projects. This opening of the process will also serve to increase transparency in the management and thus help to establish the trust needed for implementing such management schemes.

5. Application of guidelines

The guidelines for the sustainable management of Sahelian floodplains have been developed to benefit a wide range of interested parties including senior managers, aid agencies, decision makers, academics, politicians, and NGO and local community representatives. Dissemination of the guidelines will be carried out through a series of workshops, project development missions and meetings with a wide range of institutions within the Sahelian region. In this way the guidelines are designed to act as a document that facilitates the bringing together of institutions of all sectors, including water supply and sanitation, irrigation and drainage, hydropower, and wildlife conservation, to establish a convincing process of sustainable development. One of the key steps to achieve this is the endorsement of the guidelines by relevant key organisations at regional and global level including regional governments, investment organisations and river basin organisations, aid agencies, the Convention on Wetlands (1971, Ramsar, Iran), the Convention on Biodiversity, the Global Water Partnership, the World Water Council and the World Commission on Dams.

Finally, it is important to note, as stated before, that the presented guidelines are not intended to be a final document but rather an attempt to bring together current best practice and finest expertise available on Sahelian floodplain management. The guidelines are viewed by the authors as an evolving, living document which can help facilitate the development of a common vision of Sahelian floodplains amongst all stakeholders.

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Article 3.2

Wetland Conservation and Rehabilitation as Components of Integrated Catchment Management in the Mgeni Catchment, KwaZulu-Natal, South Africa

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The Mgeni Catchment in KwaZulu-Natal, South Africa, is the most socially and economically important catchment in the region. Water demand in the catchment is fast approaching the limits of water availability and water quality is deteriorating. The need to manage the water resources in the Mgeni Catchment holistically has led to the formation of the Mgeni Catchment Management Plan (MCMP), the objective of which is to ensure that water resources in the catchment are managed in a sustainable way. Furthermore, South Africa has recently adopted a new National Water Act, which will focus on the integrated management of water resources on a catchment basis. Wetlands have been recognised as integral components of the catchment system. Their important roles as water purifiers and flow regulators make them significant in the management of both water quality and quantity. The importance of the wetlands in the Mgeni catchment has been recognised, and in support of the new water law and the MCMP, plans are being developed to integrate wetland and water resources management. To this end, a collaborative effort has been initiated which involves water management institutions, conservation organisations, wetland experts and landowners and aims at the rehabilitation and conservation of priority wetlands in the Mgeni Catchment.

In this paper, we define a hierarchical system for integrated catchment and wetland management in South Africa and describe a case-study in which we offer a framework for the integration of small-scale local projects involving wetlands, with broader scale catchment management initiatives.

Conservation et réhabilitation des zones humides comme composantes de la gestion intégrée des bassins versants dans le cas du bassin versant de Mgeni, Kwazulu-Natal, Afrique du Sud

Mots-clés: bassin versant, gestion, hiérarchie, structure, réhabilitation.

Le bassin versant de Mgeni à KwaZulu-Natal, Afrique du Sud, est le bassin versant de cette région le plus important au plan social et économique. La demande en eau dans le bassin versant approche rapidement les limites de sa disponibilité et sa qualité se détériore. La nécessité de gérer les ressources en eau de manière intégrée dans le bassin versant de Mgeni a mené à la production du plan de gestion du bassin versant de Mgeni (MCMP), dont l'objectif est d'assurer une gestion durable des ressources en eau du bassin versant. En outre, l'Afrique du Sud a récemment adopté une nouvelle loi de l'eau, qui met l'accent sur la gestion intégrée des ressources en eau sur la base du bassin versant.

Les zones humides ont été reconnues comme composantes intégrantes du bassin versant. Leurs rôles importants comme épurateurs de l'eau et régulateurs des débits les rendent significatives dans la gestion de la qualité et de la quantité de l'eau. L'importance des zones humides dans le bassin versant de Mgeni a été reconnue, et avec l'appui de la nouvelle loi sur l'eau et du MCMP, des plans sont développés pour intégrer la gestion des zones humides et des ressources en eau. A cet effet, un effort de collaboration a été fait pour impliquer des institutions de gestion de l'eau, des organisations de conservation, des experts en zones humides et des propriétaires fonciers et visant à la réhabilitation et la conservation des zones humides prioritaires du bassin versant.

Cet article définit un système hiérarchique pour la gestion intégrée des bassins versants et des zones humides en Afrique du Sud et décrit un cas d'étude dans lequel est proposé une structure pour l'intégration de projets locaux de petite taille impliquant les zones humides au sein d'initiatives à plus grande échelle de gestion des bassins versants.

1. Introduction

The Mgeni Catchment, 4387km^2 in area, is one of South Africa's most developed catchments (Figure 1). The catchment produces approximately 20% of South Africa's gross national product, is home to some 3.5 million people, approximately 45% of the population of the province of KwaZulu-Natal. The need to supply water to a burgeoning population and increasing urbanisation and industrialisation in the catchment has resulted in the construction of five large dams with a combined capacity of 745.9 million m^3. This combined volume represents 135% of the mean annual runoff of the catchment (Kienzle *et al.*, 1997). The water resources in the Mgeni system are currently supplemented by Inter Basin Transfers from the Mooi River, with further transfers planned from the Mkhomazi River.

Umgeni Water, the organisation responsible for bulk water supply in the region, has recognised that water demand in the catchment is fast approaching the limits of water availability, and water quality is deteriorating (Kienzle *et al.*, 1997). The need to manage the water resources in the Mgeni Catchment holistically has led to the formation of a Mgeni Catchment Management Plan (MCMP), the objective of which is to ensure that water resources in the catchment are managed in a sustainable way.

This perspective has, in part, been driven by the movement towards a new National Water Act in South Africa. This Act, which became operational on October 1st 1998, will have a profound effect on the way in which water resources are managed in the country. In particular, the new National Water Act and the documents preceding it have highlighted the need for an integrated approach to the management of water resources at a catchment (watershed) scale. These documents and the discussions around them have recognised that integrated management of natural resources, including water, requires the meaningful participation of stakeholders in the catchment. It is stated in the new National Water Act that "Integrated catchment management fosters co-operative and consensual techniques to manage water, land and other interdependent attributes of every catchment" (DWAF, 1998). This is an extremely difficult goal to achieve. The issues involved are often intimately linked to stakeholder culture and value systems, forming a mosaic of social interactions, operating at different scales within a hierarchy of decision-making levels. With the new management approach embodied in the concept of Integrated Catchment Management (ICM) brought about by the new South African Water Law, management decisions must now involve larger areas of interest, multiple ***spatial*** and ***temporal*** scales across many different organisational hierarchies, and involve diverse groups of stakeholders.

In the MCMP, wetlands have been recognised as integral components of the catchment system. Their important roles as water purifiers and flow regulators make them significant in the management of both water quality and quantity. The importance of the wetlands in the Mgeni catchment has been recognised, and in support of the new water law and the MCMP, plans are being developed to integrate wetland and water resources management. To this end, a collaborative effort, known as the Wetlands Information Network (WIN), involving water management institutions, conservation organisations, wetland experts and landowners aimed at the rehabilitation and conservation of key wetlands in the upper regions of the Mgeni Catchment has been initiated under the auspices of a Midlands Wetlands Working Group (MWWG).

The objectives of this paper are to define a hierarchical system for integrated catchment and wetland management in South Africa and to describe a case-study in which a specific framework for the rehabilitation, conservation and management of wetlands as a component of ICM was developed.

2. A hierarchical and systems approach to integrated catchment management

According to the South African Department of Water Affairs and Forestry (DWAF, 1996), the ICM approach allows clear segmentation of river systems into functional management units (catchments and sub-catchments) which can then be linked together to provide an overall management plan for a river basin. Functional management units should encompass linkages between components and will usually consist of a whole catchment or a similar geographical unit, such as a sub-catchment (DWAF, 1996).

General systems theory holds the view that living and nonliving systems share many general characteristics. Furthermore, social, biological and physical systems are complex systems that may be nested much like respiratory or circulatory systems are nested within the whole human organism (Allan, 1996).

The view of systems made up of sub-components interacting in some way implies both the notions of environments within and outside of the system, and boundaries between them. The internal environment contains, by definition, the parts or components that constitute the system. Boundaries between internal and external systems should not be viewed as fixed, impermeable barriers. For example, the hydrological system and related ecosystems, including wetlands, may change gradually, forming continua on the earth's surface which can traverse administrative and political boundaries. Such systems do not have permanent or absolute boundaries.

A systems approach to integrated management implies that permeability for materials and energy of the system boundaries forms an important characteristic of the system. Therefore, the manager, planner, and/or decision-maker needs to consider the effect of decisions across both natural and jurisdictional boundaries. This requires management to address multiple spatial and temporal scales and fully consider the implications and effects of decisions at these various scales. This will determine the type of information and

analyses needed to make informed choices. A temporal component is often required to bring meaning to the system under scrutiny. The systems considered need to be defined over time and space. For example, the impact of a policy or legislation needs to be viewed in systems terms that define both spatial and temporal scales. The whole concept of sustainability has an implicit temporal aspect.

Many scientists consider an ecosystem based approach to natural resources management to require a hierarchical perspective (Allen and Starr, 1986; Kay, 1993). To address complex issues related to natural resources managment, no single set of hierarchical criteria (aquatic/physical systems, national/international boundaries, land management/ organisational boundaries) will be fully adequate. The use of separate criteria to scale and analyse every issue will render the goal of integrated management virtually unattainable. An ICM approach, however, aims at *integrated*, rather than *isolated* management, of each specific component within the catchment. To achieve this, analysis and management need to be conducted at multiple scales, and integrated to adequately address the many issues arising from this approach. To address this issue, three important properties of hierarchies derived from systems theory and applicable to ICM, are important (Allen, 1987):

i) levels of organisation are populated by entities whose attendant processes behave with characteristic cyclicity,

ii) big is not more, it is different, i.e. the sum of lower level behaviour does not equal upper level behaviour, and

iii) complexity results from interactions between components at several levels of organisation.

Using space and time as the basic reference elements, hierarchical levels may be scaled by either structural elements or physical processes. The use of a hierarchical structure for catchment system will offer the following benefits (Godfrey, 1977):

i) classification at higher levels narrows the sets of variables needed at lower levels,

ii) provision is made for integration of data from diverse sources and of different spatial and temporal scales (levels of resolution), and

iii) the scientist or manager is allowed to select the level(s) most appropriate to their objectives.

In effect, entities at lower levels of the hierarchy are constrained by the behaviour of the upper levels. For example, the top level of an administrative hierarchy may be the national law. A provincial or state authority may apply its own laws, however, they are still governed by the laws of the higher authority. Similarly, a city or town may have its own laws which are governed by both higher authorities. A change in the broader scale (higher level) system can affect all the lower level systems. The reverse, however, is far less likely.

3. Towards a hierarchical system for integrated catchment and wetlands management in South Africa

3.1 Background to management of catchment systems

Both the ecological and hydrological systems are most often described as "complex systems with some degree of organisation" (Harris, 1996; Schulze, 1995). Dent (1996) recognised two major types of complexity in water resources simulation modelling, *viz.*, the "detail complexity" of many variables and the "dynamic complexity" when the dynamics of cause and effect are not immediately obvious. It is self-evident that both types of complexities are equally applicable to ICM.

When catchment management actions are being considered, multiple scales should be addressed. As consideration of all the physical, biological and socio-economic processes and components is impossible, some practical bounds are needed in terms of scales of analysis and of the range of components and processes. According to DWAF (1996), one of the steps towards implementing ICM, is to focus planning and management actions and activities at a sensible regional and local scale so that both are strongly related to natural systems, and accommodate local and regional community needs and desires as well as the national water management objectives. But what are sensible scales?

To understand a system's response to change requires that the system must be considered at several scales in time and space. For example, is the goal of the exercise to maintain the integrity of a landscape, a unique wetland, a particular species, or all of these? ICM considers all of these, and builds upon ecosystem management as the most effective approach to achieve this. Therefore, management plans must be made at the level most applicable to the component under consideration and related to broader or finer scale causes and effects.

A lack of a broader perspective on the part of both managers and practitioners at fine scales, is probably the most common scale-related problem in natural resource management (Haufler *et al.*, 1997). Regardless of the particular issue or question, there is always a need for a broader scale perspective to deal with cumulative impacts and a context and a framework for actions (Reid and Ziemer, 1996; Haufler *et al.*, 1997). Comprehensive terrestrial and aquatic hierarchies have in recent years been developed to facilitate an ecosystem approach to management (Bailey, 1983).

In this study a hierarchical framework relevant to southern African catchments and their components, including wetlands is proposed.

3.2 Wetlands as catchment components

The occurrence and maintenance of wetlands, and many of the wetland functions valued by society (e.g. water quality enhancement) reflect large-scale and long-term characteristics of catchments, landscapes, and regions (Bedford and Preston 1988). Societal values provided by particular wetlands result not only from the intrinsic nature of the wetland (e.g. its size and slope) but also from its relation to other wetlands, ecosystems and land-use types (Bedford and Preston, 1988). Wetlands occur as patches in a landscape matrix, with exchanges of material, information and energy in both directions between wetland and matrix. It can be assumed that the functioning of a wetland will be influenced by the nature of the surrounding matrix, including influences by anthropogenic modifications. Thus, the value of a wetland for performing a particular function may be reduced by activities beyond its boundaries. For example, Richter and Azous (1995) found amphibian species richness in individuals wetlands in the Puget Sound Basin to be negatively affected by the level of urbanisation of the surrounding catchment, which was shown to alter the timing of runoff into the wetland.

In South Africa, evaporation is usually well in excess of precipitation and a significant proportion of the water supply to most wetlands is from the surrounding catchment. Aside from possible impacts on inflow of water and other materials to the wetland, an increase of natural habitat destruction in the surrounding matrix also generally diminishes the habitat function of the wetlands by increasing isolation among wetlands and reducing the quality of habitat complexes for species requiring wetland and adjacent habitats. Wattled Crane, for example, which nest and feed in wetlands, also feed extensively in adjacent non-wetland grasslands (McCann, 1998). A transformation of these grasslands will reduce their value as breeding sites even if the wetland itself is not altered.

In South Africa, protocols to assist in describing the context of wetlands in the landscape are lacking. For example, WETLAND-USE, a wetland management decision support system for the KwaZulu-Natal Midlands (Kotze *et al.*, 1994) employs a simple rule: the higher the existing loss of wetland area in the landscape the greater will be the assumed cumulative impact if further loss is incurred. The rule does not, however, consider different spatial and temporal scales and patterns and processes of wetland loss. However, these have important implications for the level of cumulative impact. For example, within a catchment, riparian wetlands are all linked by the drainage network and together can be described as one functional unit that includes significant altitudinal differences. Impacts on upstream wetlands have the potential to result in impacts on downstream wetlands. Nature conservation departments, which are increasingly looking at broad-scale processes rather than at single species, are increasingly recognising the importance of considering management options at the catchment scale. Clearly, there is a need to examine more fully how landscape-level considerations for wetland protection and functioning can be incorporated into decision-making in South Africa, particularly in the light of the ICM focus of the new National Water Act.

3.3 A framework for comprehensive hierarchical classification for management of South African catchments

Within a catchment there are role-players who act at smaller spatial and temporal scales, such as individual landowners, and there are others who define policy, create management plans, *inter alia,* at larger spatial and temporal scales. These groups act at different ends of an ICM hierarchy. The top of such a hierarchy involves broad scale and regional natural resources planning to provide overall direction for the management process. Strategic planning defines broad scale regional goals and basin-wide resource utilisation and conservation plans to direct the next lower level in the hierarchy. At this level, catchment management plans are translated into specific sub-catchments plans and strategies. The lowest level of the hierarchy is based on operational decisions relating to, *inter alia,* specific river reaches, reservoirs, wetlands or specific lands.

Figure 2 presents a systematic conceptual view of a comprehensive hierarchical classification system applicable to South African catchments in the context of ICM, that is focused on wetland systems. The diagram provides a tool for placing catchments, wetlands, rivers, their habitats and other components in a wider biophysical and administrative context. The hierarchy is based on relative, not absolute scales.

The diagram in Figure 2 is not intended to completely mirror existing catchment systems, but rather provides a framework into which existing systems can be fitted. Moving around the circle will traverse various horizontal sub-systems. This provides some idea of the components which are applicable at the same spatial and, often, temporal scale. Moving through the circle from the circumference to the centre traverses the vertical sub-systems. Lines between sub-systems and components are not solid so as to represent the permeability of the boundaries selected. To analyse South African systems with respect to integrated wetlands and water resources management, this framework could be used to track the components and layers of a catchment and levels of responsibility of the authorities represented in the socio-economic component. The many objectives of ICM, are influenced by choices taken at a number of levels of decision-making. Hierarchical decision making is an iterative process acting at multiple vertical and horizontal levels of decision making in order to flow from broad scale management goals for very large regions, down to the finer details required for specific operational schemes or for individual tracts of land. Each inter-related level requires more precision of detail as the spatial and temporal scales become smaller.

DWAF and WRC (1998) describe a management structure for South African catchments. This structure consists of a

Catchment Management Agency (CMA) which will be responsible for the implementation of ICM initiatives at a basin scale. The CMA will report to the national authority in charge of catchment management, the Department of Water Affairs and Forestry (DWAF). Reporting to the CMA will be a series of Catchment Management Advisory Committees (CMC) which will most likely, operate at a local or sub-catchment scale. This structure is included in Figure 2 as an example of socio-economic sub-systems and includes the CMA, CMC and stakeholders at the scales at which they operate. The lower levels of the hierarchy inherit, or are governed by, the properties of the upper levels.

South Africa, in common with a number of other Contracting Parties to the Convention on Wetlands (1971, Ramsar, Iran) has a variety of governmental and non-governmental agencies involved in wetlands conservation. A National Wetlands Conservation Programme and a national Ramsar committee has been formed to help South Africa meet its obligations under the Convention on. The committee originally served as a working group of a Sub-Committee for Nature Conservation of the Statutory Committee for Environmental Management as established by the Environment Conservation Act (No 73 of 1989). Subsequently the committee was absorbed into the Sub-committee on Biodiversity and ad-hoc working groups are to be established to advise on specific issues (DEAT, 1997).

With reference to Figure 2, it can be seen that a CMA is governed by national legislation, the CMC is governed by rules developed by the CMA, as well as those inherited from the national body, and so on, down to the lowest level of the hierarchy, i.e. vertical integration. Similarly, the structure described by the national Wetlands Conservation Programme may also be included in such a framework. By moving through the system horizontally, the role of each of the components can be seen relative to the issues relevant at the same scale at which they operate. For example, if a catchment management aim is to rehabilitate a specific small wetland, it may be the role of local landowners to do this at the spatial and temporal scales of the system at which they are active. However, they need to be guided by regional initiatives, such as the MWWG, who in turn will interact with similar organisations in different vertical sub-systems working at similar scales, such as the CMC.

In South Africa the vertical integration of organisations and initiatives dealing with wetland conservation at different spatial scales has generally been poor. There has largely been a failure to explicitly address the linkages across organisational scales owing to a lack of manpower and resources focussed on this issue and a conspicuous lack of policy across the various spatial scales. Despite the fact that wetlands were recognised as being important in the 1980s, no national policy has been developed since. At provincial level, KwaZulu-Natal did not endorse comprehensive policy proposals for wetlands that were developed on the basis of inputs from stakeholders (Begg, 1990). At a more localised level, policies relating to wetlands have been similarly lacking.

In the past few years greater resources have been devoted to facilitate vertical integration. The MWWG is one of five working groups operating in different parts of the country. These working groups are being supported by a national, corporate-sponsored NGO initiative, the Rennies Wetlands Project. During 1998, the Department of Environmental Affairs and Tourism and the Rennies Wetlands Project facilitated a forum, termed the Palustrine Wetland Conservation Group. Its aim is to network more localised initiatives, such as the working groups, and allow areas of common interest to be addressed in a synergistic way. One of the key issues being addressed by this forum is the development of protocols that can be used in all provinces to promote wetland custodianship.

4. Towards a framework application in the Mgeni catchment: a case study

According to the MCMP, the Mgeni catchment has been sub-divided into 12 sub-catchments, termed "management units" for the implementation of ICM at the level of the total catchment (Figure 1). This study will focus on the Midmar management unit in which most of the Mgeni Catchment wetlands are found. The largest concentration of wetlands is located in a small doleritic area known as the Mgeni Sponge (Figure 4). The best known of these is the Mgeni Vlei which is approximately 300 ha in extent and situated near the source of the Mgeni River. Several other relatively large wetlands are found in the area, but the Mgeni Vlei is the only one of these which is undeveloped and under conservation management (Begg, 1989).
Begg (1990) highlighted the view that although the Mgeni Vlei has important conservation qualities of its own, the function and value of the system cannot be seen in isolation of the other wetlands in the area of the Mgeni "sponge". These and the other wetlands in the Midmar management unit are considered to have an important role in the control of water quantity and quality to the Mgeni System, and the Midmar Dam in particular. Furthermore, Mgeni Vlei is one of South Africa's most important Wattled Crane breeding areas.

4.1 Gathering wetland information

The best currently available information on the historical distribution and extent of wetlands in the study area was identified as a detailed soil map at a scale of 1: 50 000 (Scotney, 1970). The boundaries of all those areas shown on this map with soils known to characterise wetland areas (i.e. soil types with a gleyed horizon close to the soil surface) were digitised and incorporated into a Geographical Information System (GIS). The system is maintained by Umgeni Water, as part of their Catchment Management Information System.

In order to gather information on the nature and status of the delineated wetlands, a data sheet was compiled with input from stakeholders. The stakeholder organisations were for instance involved in specifying what information should be

collected, based on their organisation's information needs. Descriptors on the data sheet include:

i) current land cover within and surrounding the wetland;

ii) extent of degradation through factors such as artificial drainage, damming and alien plant infestation;

iii) extent of temporary, seasonal and permanent wetness zones, identified using soil morphological indicators, notably matrix chroma and presence and depth of mottling (Kotze *et al.*, 1996); and

iv) landform setting and terrain type.

Data relevant to these descriptors were gathered during information gathering ventures that included field training and a research project investigating Cranes at a national level under the auspices of the South African Crane Foundation (SACF). Of the 169 wetlands identified in the catchment, 60 were described in the field. The remaining wetlands were described using interpretation of 1:30 000 airphotos flown in 1996. Some of the descriptors could not be derived from airphoto interpretation. Furthermore, the level of alien plant invasion could not be assessed and it was impossible to distinguish between planted pastures and certain crops. Consequently, these were grouped together as cultivated lands. All data were incorporated into a GIS and made available for spatial assessment (Figure 3).

4.2 Analysis of data gathered

The results of the wetlands survey provide information on wetlands of the Midmar Management Unit classified according to remaining natural vegetation (Figure 4).

Wetlands were found to cover 6227 ha (5.7%) of the catchment. Although approximately half of the wetlands are less than 10 ha, collectively these smaller wetlands make up only 0.7% of the total wetland area. Almost all of the wetlands were associated with the river network and could be described as riparian systems. In terms of natural cover type, all were found to be palustrine, emergent, with natural tree and shrub wetlands being largely absent.

As an aid to securing representative wetlands of the range of wetland types found across the catchment, the catchment was analysed according to upper (>1700m), middle (1100-1700m) and lower altitudinal (<1100m) zones. The results indicate that 66% of the wetland area has been lost to man-induced causes, with historical loss across the catchment increasing from intermediate levels at the upper altitudinal zone (47% of the original wetland area lost) to high levels in the mid altitude zone (67% loss) and still higher levels in the lower altitude zone (73% loss). Alien plant infestation within wetlands was found to be the greatest in the lower altitudinal zone and decreasing with altitude.

The factors contributing most to loss of wetlands include drainage and cultivation (mainly for pastures) and permanent flooding due to small dam construction. Wetlands of the study area generally have fertile soils and favourable positions for irrigation, making them popular areas for cultivation. They also provide suitable sites for farm dams as they are characterised by a geologically impermeable foundation or obstruction and a gentle gradient (Nänni, 1970)

4.3 Prioritisation of wetlands for management intervention

Wetland prioritisation is usually used in the context of establishing the priority of wetlands in terms of their requirements for management intervention. In South Africa, no national protocols exist for prioritising wetlands. In the absence of any national guidelines, the following criteria were used for prioritising wetlands in the Midmar catchment:

i) the magnitude of the benefits that the wetland currently provides in terms of erosion control, water quality enhancement and biodiversity support;

ii) the magnitude of the threat of development or degradation, together with the magnitude of the benefits that would be lost as a result of development or degradation; and

iii) the magnitude of the additional benefits that the wetland could potentially yield as a result of rehabilitation.

The only wetlands to be secured in a formally conserved area are confined to the high altitude zone, comprising the Mgeni Vlei and its four small adjacent wetlands. It is in this zone where the smallest loss of wetlands has been incurred. Thus, it is important that wetlands at mid- and, particularly, lower altitudes, where considerably higher levels of wetland loss occured, are classified as Natural Heritage Sites or Sites of Conservation Significance. Prospective wetlands to be secured within these zones were identified using the criteria given above. From the prospective sites, those having the most receptive landowners will be identified as the final sites to be secured.

The importance and value of the wetlands in the Midmar Management Unit has been highlighted in the MCMP (NSI, 1996). However, to date no overarching implementation plan for the Midmar Management Unit or for the wetlands in the unit has been developed. The lack of a CMA for the Mgeni catchment as a whole, or a CMC for the Midmar management unit is a major reason for this situation. The implementation of the new National Water Act should result in some progress in this regard.

The MWWG, under the umbrella of the SA Palustrine Working Group, have undertaken a public awareness campaign as well as, in collaboration with the landowners, the rehabilitation of some of the priority wetlands in the area. These initiatives are two amongst several projects focused

on achieving the overall vision of community based ICM, promoting equitable, efficient and sustainable use of natural resources. What remains now is to:

i) consolidate the existing data on wetlands,

ii) collect information on the remaining wetlands in the catchment (i.e. update and expand the wetland data base),

iii) make the data readily available to all potential users through a well-designed data management system which has good linkages with the DEAT national wetlands database,

iv) use the data for natural resource planning and promoting community based initiatives. Thereby improving the management of wetlands and the overall catchment, guided by the catchment policy and management strategy,

iv) develop policy and management strategies for the wetlands in the Midmar Management Unit in conjunction with the new catchment management authorities and higher level initiatives.

5. Conclusions

Local and regional wetlands management initiatives need to be guided by national and international policies and conventions. By placing such initiatives within a hierarchical system applicable to ICM, horizontal and vertical integration required for successful management of wetlands and catchments may be achieved. Horizontal and vertical linkages need to be addressed specifically as these are unlikely to be established by default.

A high degree of awareness of the various initiatives by the stakeholders in the catchment has ensured good collaboration between Umgeni Water, DWAF, the SACF, local conservation organisations and the MWWG. In fact, the existing organisations have already established a degree of vertical and horizontal integration in the development of wetlands management plans as a component of a ICM. Nevertheless, a more formalised and systematic initiative is required to enhance the effectiveness of both horizontal and vertical linkages. The new National Water Act will force these initiatives into a more formal structure and the framework described here may provide a useful tool to guide the process.

Acronyms

CMA	Catchment Management Agency
CMC	Catchment Management Committee
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
ICM	Integrated Catchment Management
MCMP	Mgeni Catchment Management Plan
MWWG	Midlands Wetlands Working Group
WIN	Wetland Information Network

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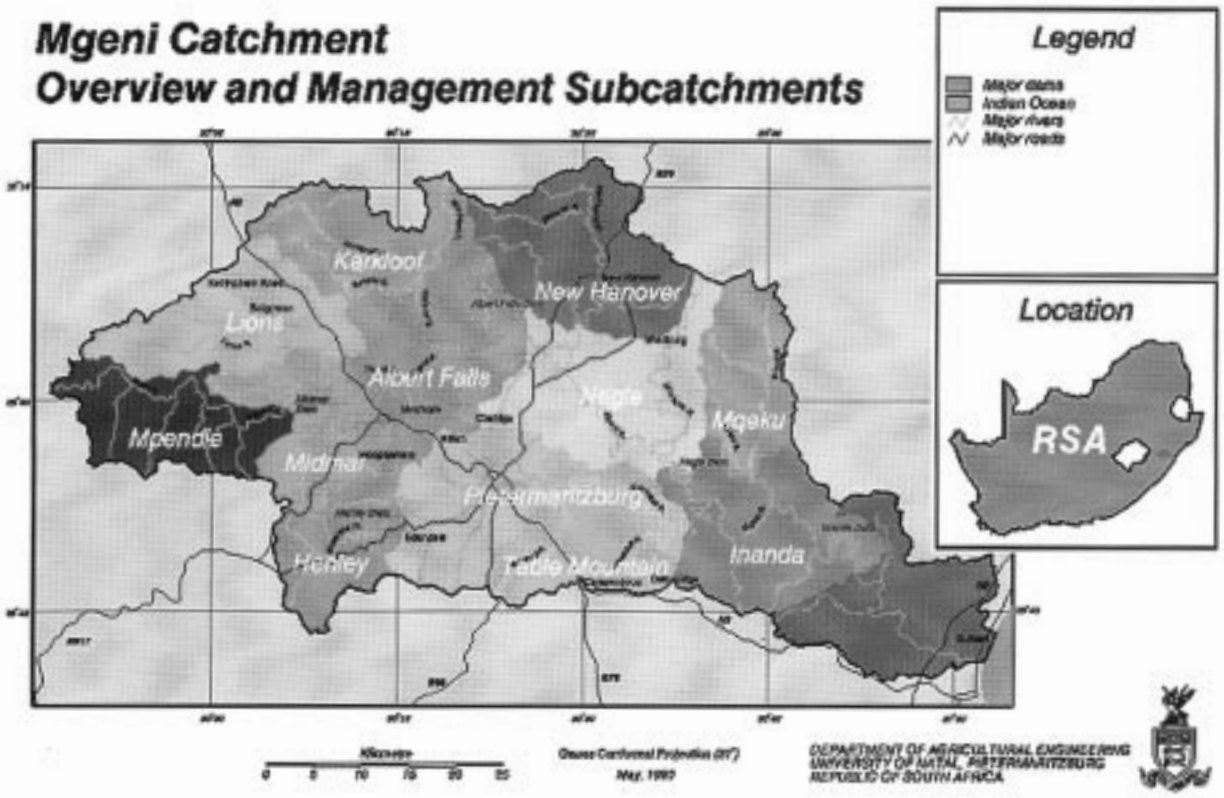

Figure 1. The Mgeni Catchment.

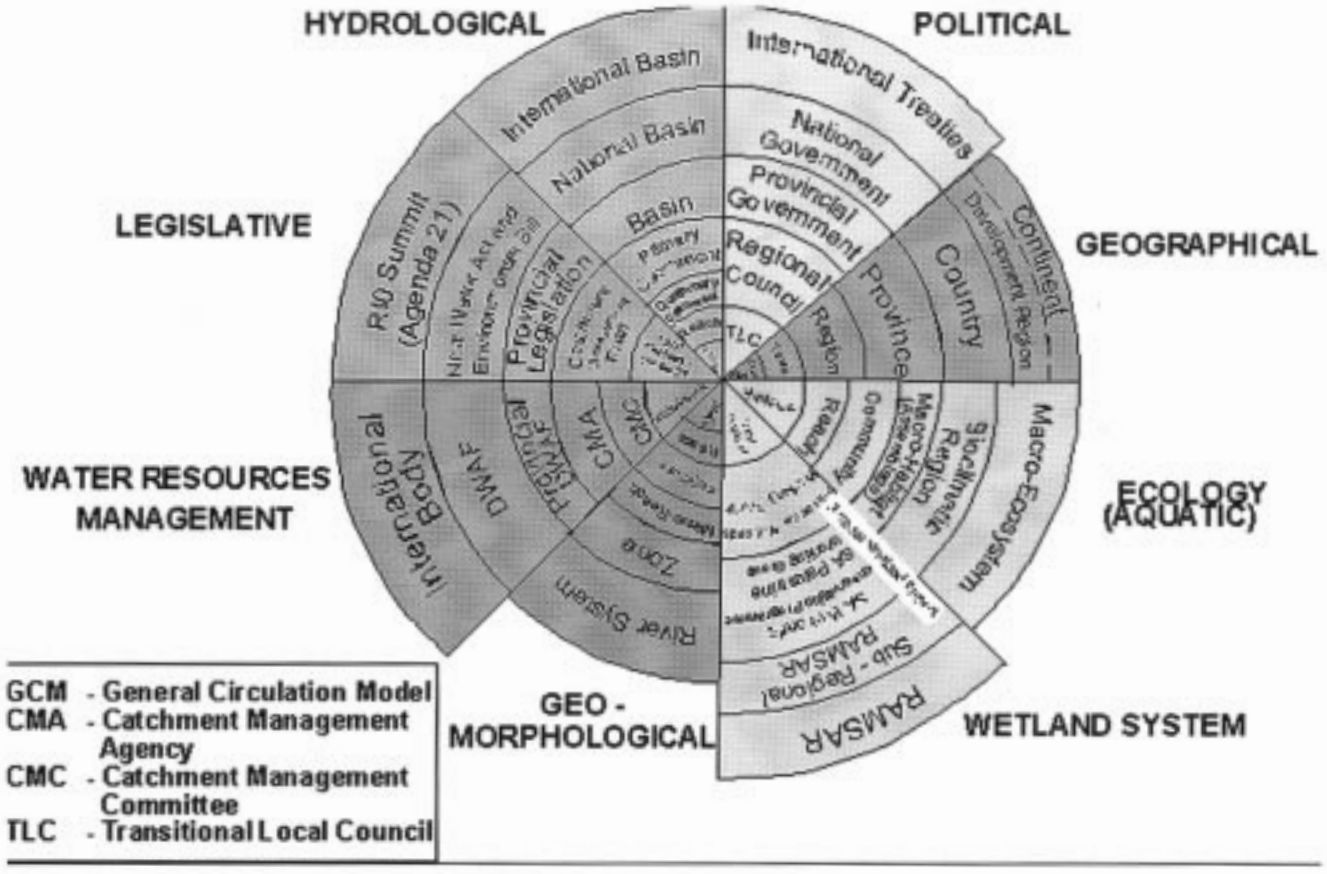

Figure 2. A framework for the development of hier rachical systems to aid in ICM and wetlands management in South Africa.

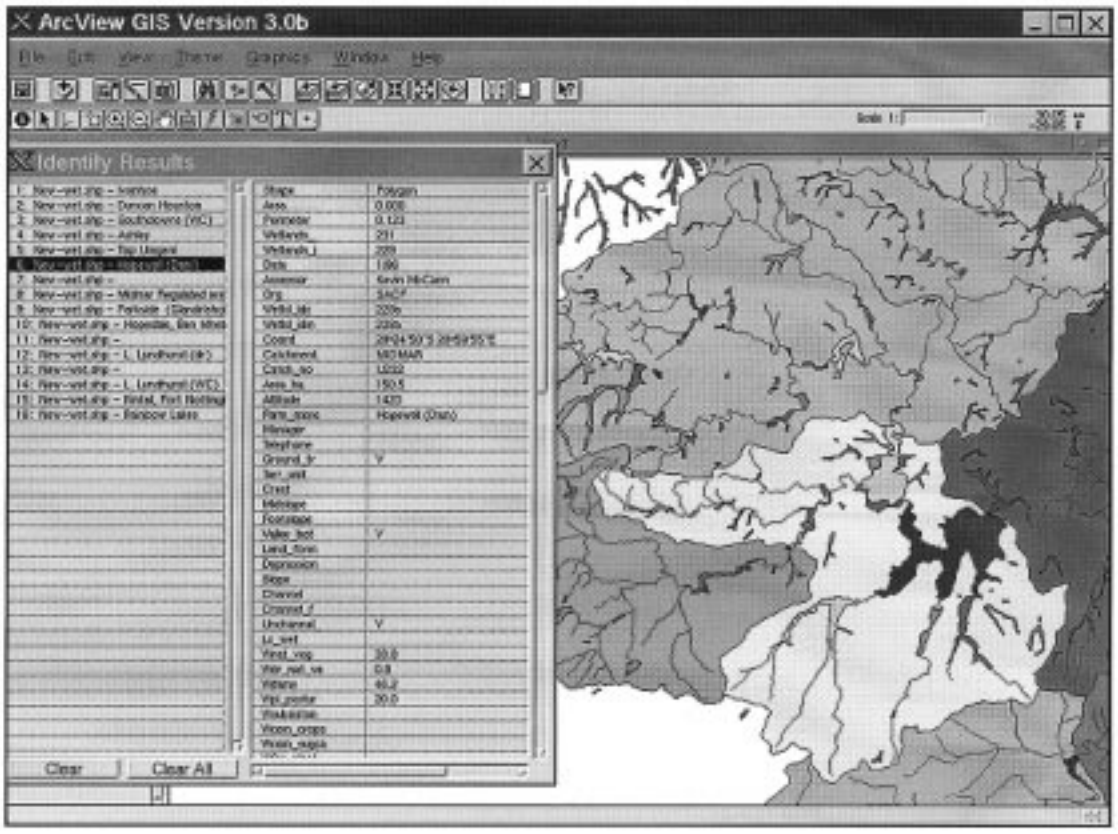

Figure 3. "Screendump" showing GIS query of the Mgeni wetlands database.

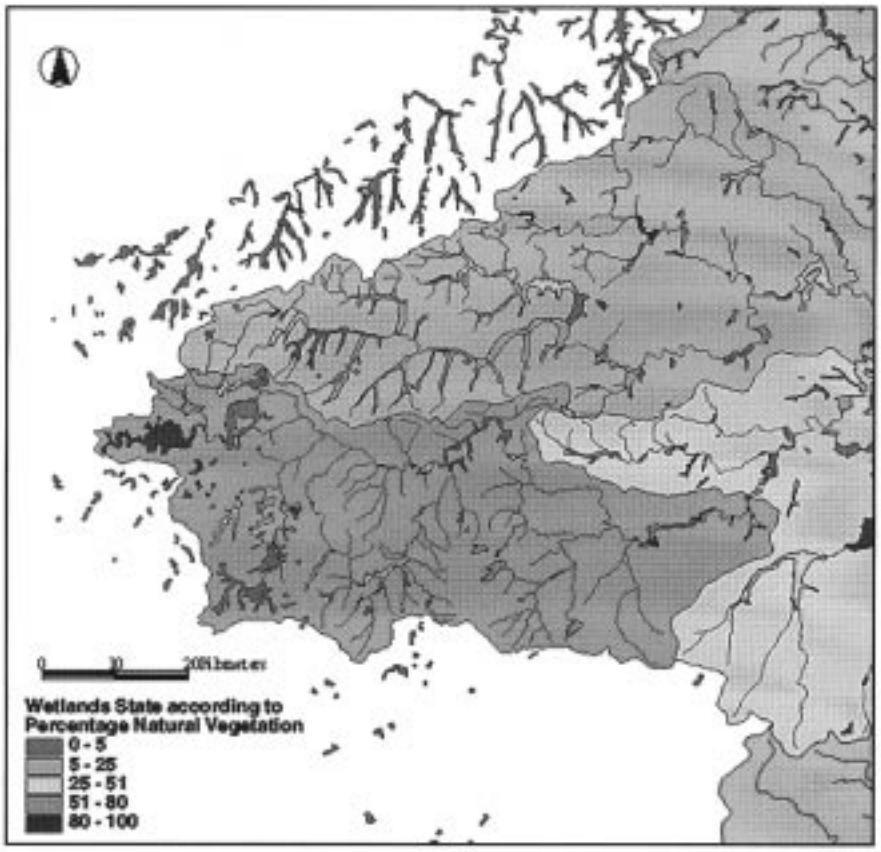

Figure 4. Map showing the status of the wetlands of the Midmar Management Unit based on remaining natural vegetation.

Article 3.3

Restauration d'une zone humide Ramsar : Espoirs et difficultés de la remise en eau du Ndiael et des Trois-Marigots, delta du fleuve Sénégal

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Mots-clés: delta, zones humides, re-inondation, restauration.

Au début des années 1950, le Ndiael et les Trois-Marigots constituaient un des plus importants complexes humides du delta du fleuve Sénégal. Les aménagements et les infrastructures routières ont conduit le Ndiael, site Ramsar, à l'assèchement, et les Trois-Marigots à des entrées d'eau irrégulières. L'aboutissement des aménagements, et plus particulièrement la construction et le fonctionnement du barrage de Diama, permettent d'envisager une remise en eau. Un premier essai par un canal reliant les Trois–Marigots au sud du Ndiael a eu un effet limité. Une seconde étape, réalisée en 1998, s'est attachée à assurer le remplissage de la réserve d'eau de Saint-Louis dans des délais très courts, afin d'acheminer autant d'eau que possible dans les Trois-Marigots puis le Ndiael. Cette option ne suffira pas à assurer la remise en eau de la totalité du Ndiael. Simultanément, compte tenu de l'immense espoir que suscite la remise en eau tant chez les populations locales que dans les milieux de la Protection de la Nature, une coordination du projet Ndiael a été mise en place par la Direction des Eaux et Forêts du Sénégal, afin d'organiser la gestion du site et veiller à ce que l'objectif principal reste la remise en eau à des fins écologiques.

Restoration of a Ramsar wetland: hopes and difficulties with the reflooding of the Ndiael and Trois-Marigots, Senegal river delta

Keywords: delta, wetland, reflooding, restoration.

In the early of the 1950s, the Ndiael and Trois-Marigots wetlands constituted one of the most important wetlands in the Senegal delta. Conversion of the wetland and road constructions resulted in a drying out of the Ndiael - a Ramsar site, and in the irregular flooding of the Trois-Marigots. Different development schemes, especially the construction of the Diama dam, will allow implementation of a reflooding plan for the area under consideration. An earlier project consisting in a canal joining the Trois-Marigots to the south of the Ndiael had only limited effects. A second project, completed in 1998, was aimed at a rapid refilling of the Saint-Louis reservoir to allocate as much water as possible to the Trois-Marigots, then to the Ndiael. This option will not be sufficient to completely refill the Ndiael with water. At the same time, because of the immense hope that the re-flooding represents for local populations and environmental conservation organisations, coordination for the Ndiael project was established by the Water and Forestry Department. This project coordination unit will organise the management of the site and ensure that the re-flooding for ecological purposes remains the main objective of the project.

1. Introduction

En zone sahélienne, chaque zone humide présente des fonctions essentielles pour la conservation de la vie sauvage ou pour la vie et le développement des populations humaines. Dans le delta du Sénégal, avant la construction du barrage de Diama, les zones humides présentaient une fonction déterminée, pour la préservation de la faune ou pour la satisfaction des besoins humains. Cette situation engendrait des conflits entre conservateurs de la nature, soucieux du bon fonctionnement des Parcs Nationaux, dont notamment celui du Djoudj, et les structures de développement (communautés rurales...) qui voyaient dans les Parcs des refuges pour des oiseaux pouvant causer de sérieux problèmes à leurs cultures, mais y voyaient également de vastes zones pouvant faire l'objet d'une certaine forme d'exploitation, notamment par l'élevage. Le manque de ressources en eau laissait la situation sans solution. La mise en eau du barrage de Diama crée une situation sans précédent dans laquelle la ressource en eau n'est plus le facteur limitant. Il est donc possible d'envisager la remise en eau de territoires asséchés. Le Ndiael fait partie de ces sites. Depuis son assèchement dans les années 1960, différents projets de remise en eau n'ont pu être menés à leur terme en raison du manque d'eau et de moyens financiers (UICN, 1987). La fermeture du barrage a permis de commencer un programme à long terme de restauration de l'écosystème aquatique du site. Ce programme est mené conjointement par la Direction des Eaux et Forêts du Sénégal et par Oiseaux Migrateurs du Paléarctique Occidental. (OMPO).

2. Description de la zone d'étude

2.1 Le delta du fleuve Sénégal

Le delta du fleuve Sénégal (15°44' - 16°38'N, 15°35' - 16°30' W, fig. 1), plaine alluvionnaire s'étendant sur 320,000 ha de l'océan Atlantique à Rosso (165 km en amont de l'estuaire), comportait dans les années 1950 une immense zone inondable de 74,000 à 110,000 ha au Sénégal et 80,000 ha presque totalement inondables en Mauritanie. À cet ensemble s'ajoutaient les lacs de Guier au Sénégal (170,000 ha) et de R'kiz en Mauritanie (115,000 ha).

L'aménagement du delta est lié au souhait des autorités de maîtriser totalement l'eau pour permettre l'irrigation nécessaire aux surfaces aménagées pour l'agriculture en toutes saisons. Cet aménagement, commencé dès le XIXème siècle, fut poursuivi au début du XXème siècle à Richard Toll par des barrages au niveau de la Taoué, rivière reliant le fleuve au lac de Guier. Depuis 1965, il n'y a plus d'inondation non contrôlée sur une grande partie de la rive gauche du fleuve, ce qui bouleverse les paysages et les équilibres écologique. En particulier, la cuvette du Ndiael (Fig. 2) est mise hors d'atteinte des crues et subit dès ce moment un assèchement inexorable (Triplet et Yésou, 1997).

2.2 Le site

Description générale

Le Ndiael est une réserve de faune de 46,550 ha depuis 1965. Il s'étend sur 15 km dans le grand axe nord-sud et sur 9 km sur son petit axe et se localise à 60 km environ au nord-est de Saint-Louis (Fig. 1). Il fait partie des marges du delta du fleuve Sénégal, c'est à dire des régions qui furent longtemps inondées par la crue du fleuve. Selon Mietton et Humbert (1992, 1994), le Ndiael est une dépression complexe dont le creusement jusqu'à une cote très basse (-1,15 m IGN d'altitude absolue) est liée à une dynamique d'écoulement mais aussi de déflation éolienne et qui peut être définie comme une cuvette de décantation ou localement, une sebkha. Outre le statut de réserve de faune, le Ndiael a été désigné comme zone d'importance internationale pour l'avifaune à la Convention sur les Zones humides (Ramsar, 1971, Iran). Il faut noter que cette désignation est intervenue alors que le Ndiael souffrait déjà d'un manque d'eau chronique. Cette situation allait conduire, en 1987, la Conférence des Parties Contractantes à la Convention de Ramsar à inscrire le Ndiael parmi les 29 sites Ramsar les plus menacés au monde (Registre de Montreux).

Schématiquement, le Ndiael peut être divisé en deux parties :

La partie sud est le prolongement des Trois-Marigots. Zone accidentée, entrecoupée de nombreux marigots qui reçoivent et concentrent les eaux de pluie, elle est assez verdoyante, et les troupeaux y trouvent leur alimentation. Les Tamaris constituent l'essentiel de la végétation arbustive. Peu de typhas se développent ici en raison de l'assèchement total et annuel des marigots.

La seconde partie, située au nord, est constituée par la cuvette asséchée, sursalée et totalement désertique. Ce mini-désert de 10,000 ha, situé à 3 km environ de Ross-Béthio, présente dans sa partie nord une dépression inondée en permanence par les eaux de drainage du casier rizicole de Kassak. La cote minimale est de -1,15 m IGN au centre de la cuvette.

Les Trois Marigots (le Khant, le Nguisset, le Ndiasseou) se présentent sous forme de trois marais allongés dans des dépressions sensiblement parallèles et séparées par des cordons dunaires. Ces marais ont une longueur voisine de 15 km pour le plus petit et de 20 km pour les deux plus grands. Leur largeur est comprise entre 600 et 800 m. Ils constituent une zone de chasse partagée entre deux amodiataires.

Alimentation naturelle en eau

Jusque dans les années 1950, la cuvette du Ndiael n'était jamais asséchée. La surface en eau variait selon la saison de 10'000 à 30'000 ha (Mietton et Humbert, 1992) et le site était considéré comme marais salant. Il y a quelques dizaines d'années, le Ndiael possédait trois sources d'alimentation en eau:

1. Le marigot de Bonbol coupé par la route nationale Saint-Louis à Rosso depuis le début des années 1960. Ce marigot est l'aboutissement du marigot de Télel, bras du Lampsar également appelé Kassak à cet endroit, distant du Ndiael de 3,5 km.
2. Le trop plein des Trois-Marigots: le Ndiael était alimenté par le marigot de Mengueye, prolongement du Troisième Marigot, (ou Marigot de Diasséou) qui entrait dans le Ndiael par le Nord ouest. L'eau qui arrive dans les Trois-Marigots provient du Marigot du Djeuss (ou du Lampsar) qui est raccordé au fleuve au niveau de Dakar-Bango. Elle circule ensuite dans le marigot des fours à chaux, passe le pont du Diaoudoun, se jette dans le marigot du Ngalam qui dessert les premier et deuxième marigot. Le deuxième marigot alimente à son tour le troisième, qui rejoint ensuite le Ndiael.
3. Le Nieti Yone : ce marigot mesure 28 km de long. Un doute subsiste quant à sa réelle efficacité en temps que possibilité d'alimenter le Ndiael en eau. En effet, les cartes anciennes de l'IGN ne montrent par une communication avec la cuvette.

Actuellement, l'alimentation en eau résulte de deux apports :

1. L'accumulation d'eau de pluie dans quelques dépressions situées au sud de la cuvette. Ces dépressions de faible profondeur (30 à 40 cm) sont asséchées rapidement.

2. La vidange de 2.250 ha de rizières de Kassack, Grande Digue et Tellel, par un canal creusé dans le lit de l'ancien marigot de Télel, au nord de Ross-Béthio. Ce canal, busé sous la route Saint-Louis à Richard-Toll, se jette dans une cuvette d'une centaine d'hectares dont une partie est ceinte par de la végétation herbacée haute. L'autre partie, s'enfonçant dans la cuvette est très salée et ne permet que le développement de quelques plantes halophyles. De nombreuses espèces d'oiseaux sédentaires ou migratrices y sont régulièrement notées.

La richesse ornithologique

Les oiseaux constituent évidemment le groupe animal le mieux connu dans le Ndiael et, de façon générale, dans l'ensemble du delta du fleuve. Les données publiées sur les recensements réalisés avant l'assèchement du site témoignent de son extraordinaire richesse. Les effectifs moyens, pour la période 1958 à 1965, indiquent le rôle important du site (Tableau I).

Après l'assèchement du site, les effectifs ont fortement chuté. Il a fallu attendre le début des années 1990 pour assister à un retour progressif de différentes espèces, quand la lagune résultant de l'évacuation du trop plein des rizières, au nord de Ross Béthio, est devenue propice aux stationnements. Les premières espèces qui y furent notées sont les ardéidés, les flamants roses et les pélicans. Le site a ensuite été utilisé par les anatidés et par les limicoles. Ainsi, en janvier 1993, sur la zone d'évacuation du trop plein, ont été dénombrés, par une mission ONC/OMPO 70'000 combattants, 10'000 barges à queue noire, 1'000 anatidés (Trolliet *et al.*, 1993). La composition avifaunistique dépend essentiellement de la hauteur de la lame d'eau. Si celle-ci est peu importante, les limicoles prédominent. Dans le cas contraire, le site accueille plus d'anatidés.

Fig. 1 : Le delta du Fleuve Sénégal dans son environnement géographique.

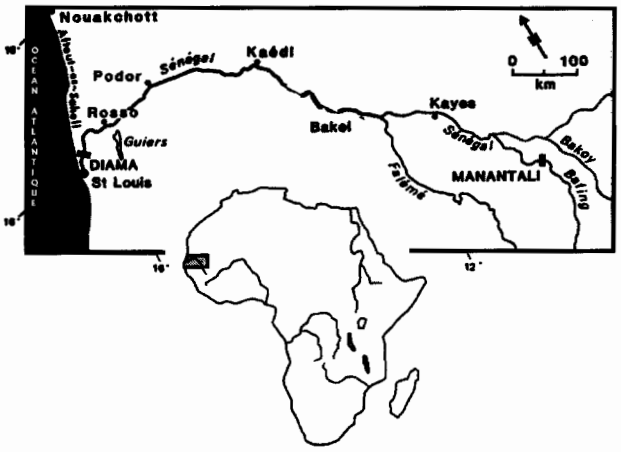

Fig. 2 : La Réserve de Faune du Ndiael (voir texte pour explication sur les limites).

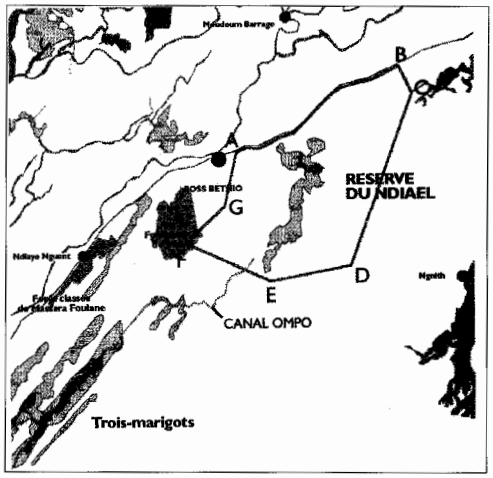

Tableau I : Effectifs moyens de différentes espèces au Ndiael au cours de la période 1958 – 1965

Nom français	Nom latin	Effectifs
Sarcelle d'été	*Anas querquedula*	50 000
Canard pilet	*Anas acuta*	11 000
Canard souchet	*Anas clypeata*	> 1 000
Barge à queue noire	*Limosa limosa*	plusieurs dizaines de milliers
Flamant rose	*Phoenicopterus ruber*	> 5 000
Ibis falcinelle	*Plegadis falcinellus*	> 1 000
Spatule blanche	*Platalea leucorodia*	> 100

Environnement socio-économique

L'élevage transhumant est pratiqué par des éleveurs nomades du Ferlo qui trouvent, des Trois-Marigots au sud du Ndiael des surfaces en eau encore facilement accessibles pour y faire boire le bétail. Cet ensemble reste le seul, côté rive gauche du delta, à pouvoir encore accueillir des troupeaux. Quelques cultures maraîchères sont implantés le long du canal creusé en 1994. La zone nord, au niveau du Nieti Yone, fait l'objet d'une exploitation plus intensive.

3. Vers la restauration du Ndiael et des Trois-Marigots

Le projet vise à restaurer le site en temps que site Ramsar et ambitionne simultanément de redonner à l'homme une place dans ce contexte particulier, dont il s'est lui-même exclu en coupant les alimentations en eau, et donc ses possibilités de vivre sur place.

3.1 Les premières actions

A l'issue d'une longue période d'investigations (acquisitions de connaissances hydrauliques et socio-économiques), la décision de tenter de remettre en eau le Ndiael par les Trois-Marigots a été retenue en première phase. Cette option n'a été rendu possible qu'en raison de la création du barrage de Diama et de l'utilisation de l'ouvrage de Bango comme une voie d'amenée d'eau dans le Djeuss et non plus comme une voie d'évacuation. Les travaux nécessaires ont été réalisés entre décembre 1993 et janvier 1994. Ces travaux ont consisté à faire sauter les bouchons sableux qui obstruaient l'ancien lit du marigot de Mengueye, puis du marigot de Haf, afin de relier le Troisième Marigot aux diverticules et marigots qui forment le sud de la cuvette du Ndiael. Le 17 janvier 1994, l'eau circulait dans le canal creusé dans l'ancien lit des marigots.

A l'heure actuelle, compte-tenu des hivernages très différents qui ont suivi le creusement du canal, il n'est pas possible d'établir un shéma simple de remplissage. Au cours de l'hivernage 1995/1996, la crue peu importante a permis l'acheminement de l'eau jusque dans les marigots situés au nord du canal. L'année suivante est caractérisée par une crue exceptionnelle qui a inondé toute la zone du canal et donc toute la partie située au nord de ce dernier. Cependant, tout comme pour l'année précédente, la limite atteinte par l'eau dans le Ndiael sud n'est pas connue. On peut supposer, vu le bon état de la végétation, qu'une bonne partie des marigots a été inondée. La situation de l'hiver 1996/1997 est caractérisée par une crue très faible qui n'a pas amené d'eau du fleuve jusque dans le canal. De l'eau était présente dans celui-ci entre août et octobre. Le même type de situation a été noté au cours de l'hiver 1997/1998, pendant lequel l'eau n'a atteint le canal que pendant quelques semaines entre octobre et début décembre. Ainsi, le simple creusement d'un canal n'est pas suffisant pour assurer une régularité à la remise en eau. Cependant, ce creusement avait permis de montrer qu'il était possible d'acheminer de l'eau dans le Ndiael par le sud de la cuvette et le système pouvait donc être complété et amélioré.

Sur le plan écologique, ces travaux se sont avérés très favorables au développement de la végétation, notamment des tamaris, ce qui a contribué à fixer le sol. Les plans d'eau, même remplis pour des périodes très courtes, fournissent de l'eau pour les villages voisins et les troupeaux. De nombreuses espèces d'oiseaux utilisent ces zones pour leur alimentation (ardéidés, anatidés...).

En 1997, une rupture accidentelle de la digue de Bifèche avait entraîné un très bon remplissage des Trois-Marigots. Cet événement montrait qu'une large ouverture sur le fleuve et un canal bien dégagé entre le Troisième Marigot et le sud du Ndiael pouvait permettre, au moins en partie, l'inondation de ce dernier. Cet accident prouvait également que beaucoup d'eau pouvait être reçue du fleuve, plutôt que rejetée dans l'océan. Il restait donc à pérenniser le système afin de ne pas dépendre d'accidents comme la rupture d'une digue dont les conséquences peuvent parfois être dramatiques.

Un nouvel ouvrage, construit en juin 1998 sur la digue de Bifèche afin d'augmenter le débit d'entrée dans le Djeuss, est fonctionnel depuis le dernier hivernage. Il a permis de remplir les Trois-Marigots en un temps record et de faire écouler de l'eau vers le Ndiael. Il reste maintenant, et ce n'est pas le plus facile dans ce genre de projet, à faire fonctionner sur du long terme ce mode d'entrée de l'eau dit option sud. En effet, il ne peut être envisagé de ne pas intervenir chaque année, pour vérifier les différents ouvrages de passages de l'eau, enlever les dépôts sableux issus de mouvements de sable, supprimer la végétation dans le canal reliant le Troisième Marigot au sud du Ndiael et vérifier que les populations locales pratiquent bien une exploitation durable des ressources engendrées par l'eau.

3.2 Le plan de gestion

Deux objectifs de gestion non exclusifs répondent donc à une démarche globale de conservation du site privilégiant les principaux éléments du patrimoine avifaunistique, mais visant simultanément à respecter, voire à restaurer, des activités traditionnelles respectueuses du caractère naturel du site.

Objectif lié aux ressources naturelles :

- restaurer les potentialités avifaunistiques du site, susceptibles de rétablir son importance au plan international.

Objectifs liés à l'exploitation du site par l'homme :

- organiser l'utilisation du site par des activités traditionnelles de pêche et d'élevage, dans le respect des équilibres naturels.
- favoriser le reboisement afin de lutter contre la désertification et de fournir à terme du bois de chauffe pour les populations locales.

Cinq groupes d'opérations permettent de parvenir à ce résultat:

1. Achever le projet de remise en eau par les Trois-Marigots.
2. Terminer les études et consultations préalable aux autres possibilités de remise en eau.

3. Organiser l'utilisation du site pour les activités traditionnelles.
4. Procéder à des opérations de reboisement sur des zones déterminées.
5. Améliorer la connaissance générale du site.

Ces groupes d'opérations s'organisent autour de trois thèmes:

1. Les études et les opérations de suivi écologique : code SE (Tableau II).
2. Les opérations de gestion des espèces, des habitats et des paysages : code GH (Tableau III).
3. Les opérations d'entretien, l'organisation annuelle : code OR (Tableau IV).

Trois tableaux permettent de visualiser les différentes opérations codifiées et les dates d'intervention.

Tableau II : les études et les opérations de suivi écologique (SE)

Nature de l'étude	**Code**	**Réalisation**
Suivi des niveaux d'eau	01	Régulier
Suivi de la qualité des eaux	02	Annuel
Suivi de la végétation	03	Annuel
Possibilité de remise en eau par le Lampsar	05	1999 à 2000
Possibilité de remise en eau par le Niéti Yone	06	1999 à 2001
Dénombrements de tous les oiseaux d'eau	07	Octobre à mars
Suivi photographique du site	08	Janvier, juin
Quantification et évolution du peuplement piscicole	09	1999 à 2001

Tableau III : les opérations de gestion des espèces, des habitats et des paysages (GH)

Nature des travaux	**Code**	**Réalisation**
Terminer les ouvrages au niveau de la digue de Bifèche	01	1999
Améliorer la circulation de l'eau au niveau des Trois-Marigots	02	1999
Établir le bornage de la réserve de faune	03	1999
Remettre en état les différents ouvrages	04	2000
Procéder à des opérations de reboisement	05	2000 et plus
Fixer le sable aux abords des voies d'eau	06	2000 et plus
Valoriser les pâturages de décrue	07	2001
Réalisation du canal du Lampsar	08	2002
Réalisation du canal du Nieti Yone	09	2003

Tableau IV: les opérations de gestion et d'entretien, à renouveler annuellement (OR)

Nature des travaux	**Code**
Sensibiliser les populations locales	01
Faire participer les amodiataires des zones de chasse à la protection du site	02
Mettre en place un circuit de découverte	03
Assurer un entretien régulier des ouvrages	04
Assurer l'entretien du canal OMPO	05
Contrôle du bornage	06
Organiser la gestion du site à travers l'application et le suivi du plan de gestion	07

4. Conclusions

Les toutes premières actions menées, le creusement du canal et la mise en place d'une cellule de coordination, ont été lancées sans plan de gestion. Celui-ci, achevé en novembre 1998, définit les actions à mener au cours de la période 1999-2003. Le plan de gestion ne cache pas les difficultés déjà rencontrées et celles qui ont été mises en évidence pour les prochaines années. Ces difficultés tiennent aux quantités d'eau irrégulières autant qu'aux ressources financières. Pour le moment, le projet a démarré humblement, mais avance et continuera d'avancer pour devenir une réalité et trouver la place qu'il mérite dans les perspectives de mise en valeur du fleuve dans le schéma d'après-barrage.

A ce stade, de nombreuses contraintes ont été identifiées et nécessitent une intervention permanente des promoteurs du projet. Il n'existe actuellement pas de calendrier d'ouverture des ouvrages d'amenée d'eau. Ainsi, ils peuvent rester fermés alors que de l'eau disponible est rejetée au fleuve, ou être fermés, alors que de l'eau circule encore et pourrait augmenter l'inondation. Seule la mise en place d'un comité de suivi (effectif depuis octobre 1999) permettra de déterminer ce calendrier et de faire prendre en compte les préoccupations écologiques et pastorales dans un contexte principalement orienté sur la riziculture.

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Article 3.4

Integrated Water Resource Management and its Application to the Waza-Logone Floodplain Restoration Project, Cameroon

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Keywords: Cameroon, floodplain, restoration, ecosystem

This paper examines some of the reasons for the destruction of wetlands worldwide, suggesting that inadequate management approaches are a significant factor in the process. An integrated, ecosystem-based approach is called for that recognises the importance of the natural resources and biodiversity of wetlands, secures the benefits they can provide, and assures their long-term integrity.

A system of Integrated Water Resource Management (IWRM) based on ecosystem management principles has been developed at the Waza-Logone floodplain rehabilitation project in northern Cameroon. It has been successful in achieving its objectives of restoring the ecosystem, conserving biodiversity, and promoting sustainable development. This paper describes a model for the integrated management of wetlands in the practical context of a wetland rehabilitation project, and presents the results and the lessons learned as an aid for IWRM.

Gestion intégrée des ressources en eau et son application au projet de restauration de la plaine d'inondation de Waza-Logone, Cameroun

Mots-clés: Le Cameroun, plaine d'inondation, restauration, écosystème.

Cet article examine certaines des raisons de la destruction mondiale des zones humides, suggérant que les approches de gestion inadéquates sont un facteur significatif dans ce processus. Une approche écosystémique intégrée est nécessaire qui reconnaît l'importance des ressources naturelles et de la biodiversité des zones humides, assure les bénéfices qu'ils peuvent fournir et préserve leur intégrité à long terme.

Un système de gestion intégrée des ressource en eau basé sur des principes de gestion d'écosystèmes a été développé par le projet de réhabilitation de la plaine d'inondation de Waza-Logone dans le nord du Cameroun. Il y est parvenu en atteignant ses objectifs de restaurer cet écosystème, de conserver sa biodiversité et de promouvoir le développement durable. Cet article décrit un modèle pour la gestion intégrée des zones humides, dans le contexte pratique d'un projet de rehabilitation, et présente les resultats et les leçons appris comme une aide pour la gestion des plaines d'inondation.

1. Introduction

Wetlands continue to be degraded and destroyed worldwide, despite their position as one of nature's most productive and useful ecosystems on which millions of people in the developing world depend for their livelihoods. Taking the sub-Saharan zone of West Africa as an example, flow regimes of river systems have been drastically modified in recent years by large-scale dam developments for hydroelectric power, water supply and irrigation. The consequent reduction or elimination of the annual inundations of the floodplains has caused a decrease in traditional fisheries, livestock and agricultural production, salinisation of soils, an increase in conflicts, and marginalisation of the populations whose lives depend on the annual inundation. There has also been a considerable decline in wildlife and biodiversity through the loss of wetland habitat and increased human pressure on the remaining resources.

These major infrastructure developments are often accompanied by a misplaced optimism in their ability to perform, and facilitated by readily available international funding. There is at the same time an inadequate understanding by water planners of the functions of wetlands in the water cycle and of their role as provider and protector of the resource base. There is also little appreciation of the economic benefits that wetlands can provide. Insufficient expertise in water resource management, a lack of dialogue and an unwillingness to change have added to these misapprehensions.

In an attempt to avoid repeating past mistakes and to overcome the problems which have been created, new systems of management have been introduced in the form of river basin authorities. These can provide more integrated strategies and mechanisms, improved coordination of data collection and information management, and increased technical and managerial capability.

The river basin authorities have not however been entirely successful. They tend to be dominated by engineers, hydrologists and economists, who continue to have a sectorial rather than an integrated approach to water resource management. Ecosystem management strategies are not well developed, and there are inadequate planning skills, technical expertise, communication, and institutional coordination.

A fully integrated approach to wetland and water resource management, which addresses many of the shortcomings of the systems of management presently in operation, is required. Such an approach would evaluate the ecosystem through information management, communication, and participation of all stakeholders. A system of resource management would be established which has a long-term strategy to ensure that the benefits to the local population and the conservation of biodiversity are sustainable. Management processes would include training of managerial and technical staff, monitoring and evaluation to ensure that relevant skills and methods are employed and the desired outputs achieved.

A system of Integrated Water Resource Management (IWRM) as developed at the Waza-Logone Project is described and proposed as a model at the project level for wetland management and rehabilitation.

2. Integrated Water Resource Management

Integrated Water Resource Management is a new concept that is linked to principles accepted at the Dublin and Rio conferences of 1992. IWRM takes a fundamental new approach in the assessment, development and management of freshwater resources. Water is a finite and vulnerable resource, which requires a holistic approach for effective management through political commitment and the participation of users at all levels, recognising its economic value in all its competing uses.

IWRM aims to:

- ensure the long-term integrity of the wetland and the hydrological system by maintaining its ecological and hydrological functions;
- benefit human society without eliminating alternative, future management options, through the wise use of resources and sustainable development.

In being 'integrated', IWRM seeks to bring together technical knowledge, information, and expertise across all sectors and between institutions, and to establish partnerships and networks at all and between levels. It is therefore:

(1) Multi-functional, to include all elements of the ecosystem: hydrological, ecological, and socio-economic;

(2) Inter- and multi-sectoral, to include natural systems as well as water supply, hydro-power, and irrigation;

(3) Inter- and multi-disciplinary, to make available the full range of skills and expertise.

The management system implied in IWRM requires not just resources management, but also project management. Without suitable project management processes, implementation is unlikely to be successfully achieved.

3. Implementation of IWRM at the project level

3.1 Project description

The floodplain of the river Logone covers approximately 8000 km^2 of the Sahel region of northern Cameroon and Chad (see Figure I). As a social, economic and nature conservation resource, the floodplain is important both regionally and internationally. The plains inundated during the annual cycle of flooding are highly productive, providing breeding grounds for fish, dry season pastures and fertile land for rice growing. Fish are harvested intensively by the sedentary population and migrant fishermen, and nomadic and transhumant herders benefit from the grazing. These and the other abundant natural

resources of the floodplain in total sustain over 100,000 people.

The floodplain also has a rich biodiversity, supporting large numbers of resident and migrant birds and mammals. It contains the 1700 km² Waza National Park, which is designated a Biosphere Reserve, and the 45 km² Kalamaloué National Park.

The Waza-Logone region within Cameroon has however been suffering from economic decline and environmental degradation for a number of years. The problems are mainly due to the effects of poor rainfall and to the construction in 1979 of a dam and flood embankments for a rice irrigation scheme, which prevented flooding over a large part of the floodplain. The reduction in flooding resulted in a decline in wildlife and biodiversity, a collapse of the fisheries, a drastic reduction in grazing capacity, and a shortage of surface water in the dry season.

The problems of the Waza-Logone region were recognised internationally and identified in a study in 1988, which set out guidelines for a programme of rehabilitation. In 1992 the Waza-Logone Project was established by IUCN-The World Conservation Union with the support of Dutch government aid and WWF. The objectives of the project are to pursue the integrated management of the natural resources of the floodplain, maintain biodiversity, and provide a sustainable livelihood for local people.

The present phase of the project (Phase III) began in 1995. Its specific objectives are to:

- restore the natural resources of the floodplain by hydrological and ecological rehabilitation, and develop and maintain sustainable systems of natural resource management;
- ensure the conservation of biodiversity of all the sub-zones of the region, and safeguard the National Parks of Waza and Kalamaloué as important centres of global biodiversity;
- develop a community-level eco-development strategy leading to socio-economic development benefiting the resident and migrant populations which depend on the region, and at the same time ensuring the capacity of the government and the local populations to maintain sustainable resource management and development in the long term.

3.2 From concept to reality

Two components of the project's strategy are fundamental in attaining these objectives. The first is the large-scale reflooding of the floodplain. Reflooding has already been partly achieved through the implementation of two pilot releases in 1994 and 1997, which have resulted in an additional annual reinundation, under average hydrological conditions, of up to 200 km² (see Figure 2). The second is the application of an appropriate integrated ecosystem management approach. In the case of the Waza-Logone Project, an Integrated Water Resource Management (IWRM) model was developed and applied.
The approach as developed for the Waza-Logone Project can be divided into three distinct stages:

- Ecosystem Evaluation
- Resource Management
- Exit Strategy

The stages run concurrently and contain activities that overlap both in scope and timing. Ecosystem Evaluation will generally start first, but activities of the Exit Strategy will be implemented while the Ecosystem Evaluation is continuing.

The stages are linked by continuous project management processes, which include project planning, communication, monitoring and assessment, and finance. Feedback within these processes and the adjustment of the activities on a regular basis enables the adaptation to changing conditions.

The relative timing of the stages and processes is shown in Figure 3, and the system as a whole in Figure 4.

3.3 Stage 1 - Ecosystem Evaluation

In this stage the ecosystem was defined and evaluated. An understanding of the natural and socio-economic characteristics and processes that make up the ecosystem was obtained, providing the basis for the development and evaluation of management options. In the Waza-Logone Project, ecosystem evaluation was divided into two components: information management; and social and institutional participation.

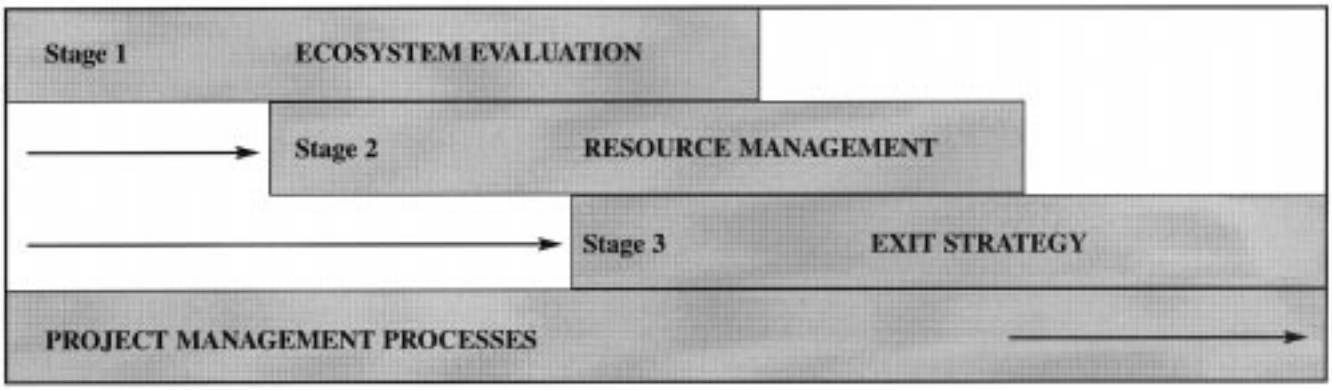

Figure 3 : Implementation of stages and project management processes

Physical data obtained on the ecosystem were mainly ecological (studies on vegetation, fish, large mammals, birds, and soil chemistry) and hydrological (including surface flow, water quality and hydrogeology). The collection, treatment, and interpretation of the data were aided where possible by the use of remote sensing techniques, databases, and Geographic Information Systems.

To ensure the full participation of the people of the floodplain, and permit them to determine their own development paths, the 'Process Approach' was employed. This required the involvement of the target groups in all levels of decision-making and their participation both in funding and the provision of free labour for development projects. These groups were also involved in the development of targets at each stage in the process, which depended on the achievements of the previous stage. Support was provided for a step-by-step transfer of information and capacities to local organisations for the future development and implementation of the programme. This participation also included resolution of conflicts, training, collaborative management, establishing partnerships, institutional development, and capacity building.

Many of these activities can be placed in both the components shown in Figure 5. For example, identification of social issues and collection of socio-economic data, which involve the collection and interpretation of data on stakeholders, demography, fisheries, livestock, markets, health etc. are information management, but are based on participatory processes.
The results of these activities are designed to allow the development and evaluation of management options, forming a basis for resource management.

3.4 Stage 2 - Resource Management

Three components of resource management were identified for the Waza-Logone Project: ecosystem rehabilitation; ecosystem management planning; and implementation of development activities. All three components were developed in parallel, with a large degree of interaction and overlap. The reinundation of the floodplain was the central element of each. The concept is displayed in Figure 6.

Ecosystem rehabilitation required the definition of the strategy for the floodplain reinundation, leading to the development of specific proposals. The implementation of the pilot releases provided important data for the formulation of reflooding proposals and for the development of a hydrodynamic model of the floodplain. The feasibility of the proposals was established, leading to the selection of the preferred options for large-scale reinundation.

Ecosystem management planning began with the development of the management objectives and planning processes. A primary activity was the production of the Waza National Park Management Plan in collaboration with the Cameroon government Ministry of the Environment and Forests. The objectives of the plan were to maintain the biodiversity of the park and the surrounding area, to introduce the concept of co-management, and to provide long-term benefits for the population around the park. A management structure for the park consisting of the administration, committees of local representatives, and a scientific committee was developed on the basis of the plan.

A natural resources management plan to be drawn up for the entire floodplain will attempt to ensure that all the resources of the floodplain may be used in a sustainable manner, and will remain under the control of the stakeholders themselves. The plan will focus on the management of fisheries, livestock rearing, forestry, ecotourism, and natural products such as thatch, gum arabic, and honey. A water management plan for the floodplain is also being established in conjunction with the rice scheme operator SEMRY, who has responsibility for the use of the waters of the Maga reservoir. A water balance model for the reservoir has been prepared, and will be further developed with SEMRY into an operational lake level management model. The water management plan is fundamental in optimising the availability and utilisation of lake water for the major reinundation of the floodplain.

Development activities have in general been stakeholder-led, as a result of the participatory processes. One of the first development activities was a pilot release, which provided improved fishing and dry-season pasturage at an early stage in the project. Wells for domestic water, latrines, and a programme of hygiene instruction were provided to reduce health problems related to water use and water-borne disease. Other important elements were the development of programmes for fishing, grazing, ecotourism, community forestry, rice growing, and the harvesting of natural resources. Financing systems were also established to permit participants to have access to small scale credit when needed.

3.5 Stage 3 - Exit Strategy

Few of a project's achievements can be expected to survive in the long-term without the planning and implementation of a suitable exit strategy. The objective of this strategy is to ensure the transfer of responsibilities of management and financing to local structures and organisations.

Implementation of an exit strategy for the project began early in the ecosystem evaluation stage, with training, establishing of partnerships, capacity building, and institutional development. In the resource management stage, management structures and organisations were set up which can continue in the long-term given appropriate support. The implementation of the exit strategy is on-going through communication and environmental education.

An important element of the exit strategy is the exit phase, which will be the next phase of the project (Phase IV). The

establishment of the structures and committees for the management of the natural resources of the floodplain will be completed. Local support organisations will be encouraged to implement activities on the floodplain, in the park's peripheral zone, and for environmental education. The project, which at present administers all its programmed activities, will become a co-ordination unit, passing many of its responsibilities to the local support organisations. Ultimately the co-ordination unit itself is likely to disappear, and all the administrative, organisational and financial responsibilities of the project will have devolved to the local organisations. Governmental institutions will continue to be closely involved in the strategy at all stages.

3.6 Project management processes

Project planning

Project planning has focused on strategic planning, provision of technical and managerial staff, and financial planning, together with the prioritising and programming of activities. Reviews were undertaken throughout the management process to take account of the changes and requirements of the programme from the earliest activities to the exit stage.

Communication - Participatory Approach

Communication was integrated into the system as a continuous participatory process from the beginning of project activities, targeting audiences at all levels. Through the 'Process Approach', discussions with and the participation of the floodplain population were assured. Dialogue and consultation with central government and the local administration, together with in-house training of government personnel and capacity building, were important aspects of project policy. An environmental education programme was set up to target both the adult and the schools population.

Professional and technical cooperation was obtained with IUCN headquarters, the University of Leiden, and WWF. This collaboration was based on regular dialogue and information exchange, technical support missions and supervision missions. Dialogue and cooperation with the funding organisations (Netherlands government, WWF, European Commission) was also established.

Monitoring and Assessment

Monitoring and assessment were applied throughout the programme. A preliminary Environmental Impact Assessment was carried out for the major reinundation, making use of the results on the floodplain of the first pilot release. An economic evaluation was carried out to assess the expected economic benefits of the reinundation. On the basis of internal and external monitoring and evaluation, project planning and activities were reviewed and if necessary modified.

Financing

Financial planning formed an integral part of the project management process, as a means of ensuring that new financing would be in place to implement programme activities.

Phases II and III (1992 - 2000) assured funding for the setting up of the project, the ecosystem evaluation stage, and many of the activities in the resource management stage. Initial funding specifically for the reinundation programme feasibility stage became available during Phase III, following the presentation of the proposals for the reinundation and a preliminary cost-benefit analysis.

Funding is still being actively sought for Phase IV (Exit Phase) and for the reinundation programme design and implementation of the major infrastructural works.

4. Successes and failures

4.1 Project stages

The establishment of partnerships early in the ecosystem evaluation stage, through consultation processes with the local people, the local administration, central government, and rice scheme operator SEMRY, paved the way for the identification of stakeholders, target groups and the social issues involved.

Data collection and consultation activities provided a sound information base for the project. They permitted the identification and evaluation of alternative resource management options and formed the basis of the development programme and the reinundation programme.

Some weaknesses were identified in the ecosystem evaluation stage. The latest technology was insufficiently used, and better results could have been achieved through earlier and more intensive use of remote sensing and Geographic Information Systems. Data collection and treatment were not always clearly targeted, and thus were not fully integrated into the system.

The development and evaluation of management options in Stage 1 led to a number of development activities being implemented during the resource management stage. The adoption of the Process Approach meant that these were based on the needs of the population. The pilot releases reflooded up to 200 km^2 of the floodplain, providing socio-economic and ecological data that demonstrated the value of the reinundation. The hydrological data yielded were also vital to the formulation of the project's proposals for the large-scale reflooding.

The management plan for Waza National Park and its peripheral zone was successfully developed through the collaboration between the project, the administration, and the local people. Management and scientific committees were set up, and implementation begun.

The problems encountered related mainly to ecosystem management planning, namely land tenure issues, the lack of regional planning policies, the inflexibility of the government structure and systems, and the unwillingness of government personnel to accept change. Other important factors have been the difficulties of integrating gender issues into the framework of the programme, and the weakness of local NGO structures.

The first elements of the exit strategy; training, capacity building and institutional development, were successfully set in motion as part of the ecosystem evaluation stage, and continued through the resource management stage. All actors have been involved in these activities; the local population, administration and central government. The completion of the strategy, the establishment of efficient committees and local support organisations to achieve self-sufficiency is likely to prove difficult. The lack of local technical capability may pose problems in the long-term, with a continuing reliance on external technical experts. Long-term commitment from government may also be difficult to achieve.

4.2 Management processes

Generally the project planning and feedback processes have worked successfully. However, some strategic planning, programming and co-ordination problems have been evident. Technical expertise was not always available when required, reflecting the difficulty in a multi-disciplinary programme of finding staff to cover all eventualities. Prioritising and initiating of activities in time, and targeting of activities to objectives also proved problematic.

The project has been highly successful in establishing good relations, through dialogue and communication, with stakeholders, government, its partners, and with organisations such as the Lake Chad Basin Commission. However, communication on a wider scale has not yet assured that the Waza-Logone regional water needs are an integral part of national and lake Chad water resource planning.

The preliminary Environmental Impact Assessment served a useful purpose in confirming early that the technical proposals for the reinundation were generally beneficial, and provided sufficient time to begin monitoring programmes on water quality and groundwater.

The economic valuation has provided essential information to strengthen the case for reinundation as a means of improving the economic well-being of the floodplain population.

External and internal evaluations also enabled modifications to be made to project policy. However, internal monitoring could have been more effective in modifying priorities and programming.

The process of obtaining new financing for the reinundation programme has taken two to three years longer than expected at the project planning stage, and the implementation of the programme has consequently been delayed by the same period. The time scale has been underestimated because of the complexity of the stage by stage processes needed to arrive at a feasible scheme, and having to find financing progressively for each stage of the programme.

5. Conclusions

An examination of the successes and failures identified for the Waza-Logone Project provides a useful indication of the strengths and weaknesses of the applied IWRM approach. The following conclusions in the form of lessons learned are based on the experiences gained from the Waza-Logone Project.

Lesson 1	A strategic plan has to be developed early in the project to define and integrate the different stages, elements, and activities to arrive at the objectives.
Lesson 2	A database is indispensable for resource management of a project. Information-gathering targets, treatment, and use requirements need to be clearly defined early, and evaluated and updated during the project.
Lesson 3	Development activities must be stakeholder-led and should be implemented from the early stages of the project onward.
Lesson 4	The development of a meaningful management plan in cooperation with the population requires considerable investment in time, human resources and finance.
Lesson 5	An Exit Strategy must be drawn up and its implementation begun early. Adequate allowance should be made for the strategy to develop to fruition.
Lesson 6	Project and financial planning and programming need to be targeted to global objectives, with systematic reviews of needs and direction.
Lesson 7	The information and conclusions drawn from evaluations must be acted upon to ensure project orientation is always appropriate.
Lesson 8	A communications strategy must ensure dialogue at all levels to include stakeholders, government, funding agencies, technical institutions and national and regional planners.

Acknowledgements

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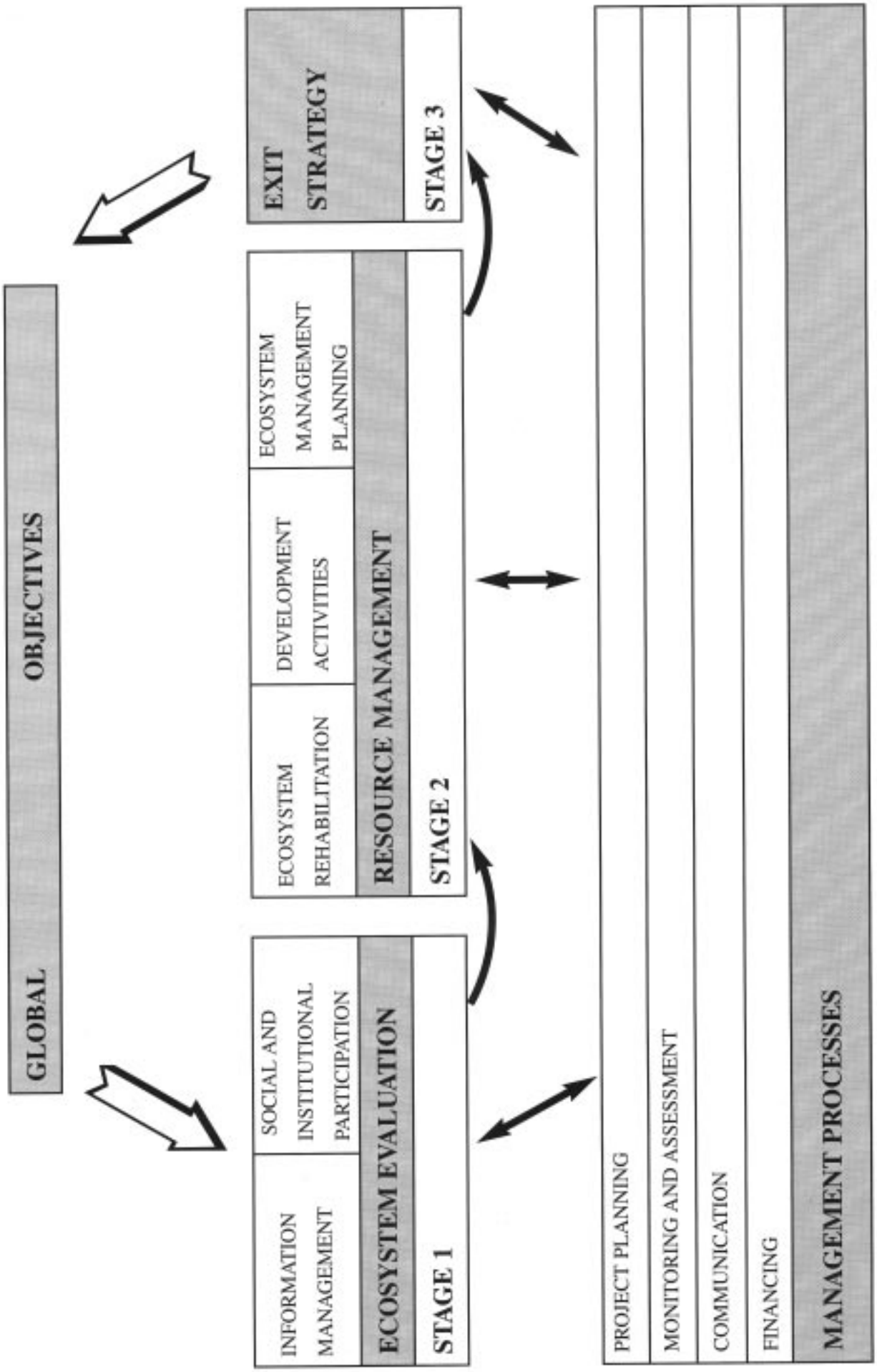

Fig 4: Integrated water resource management

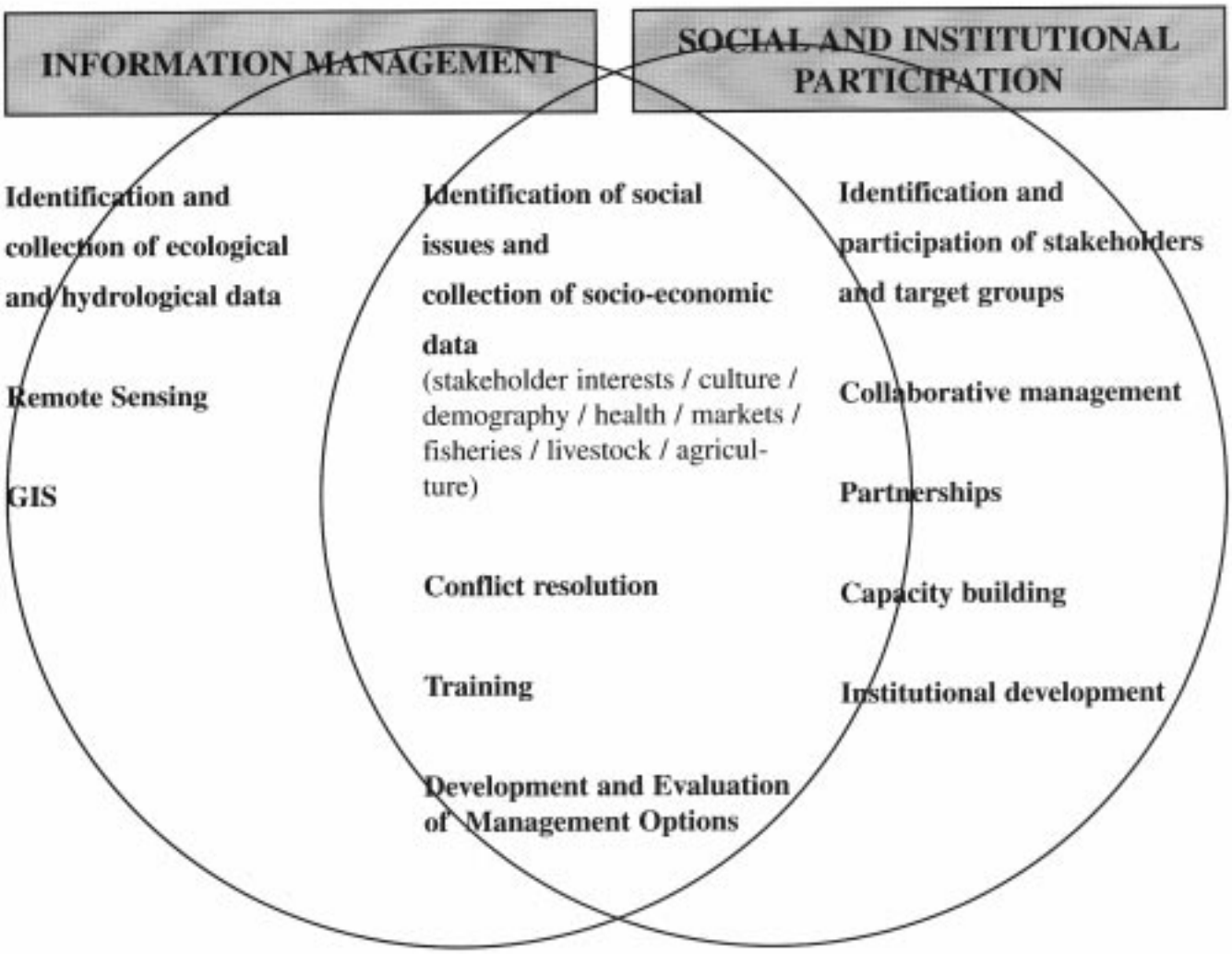

Figure 5: Ecosystem evaluation

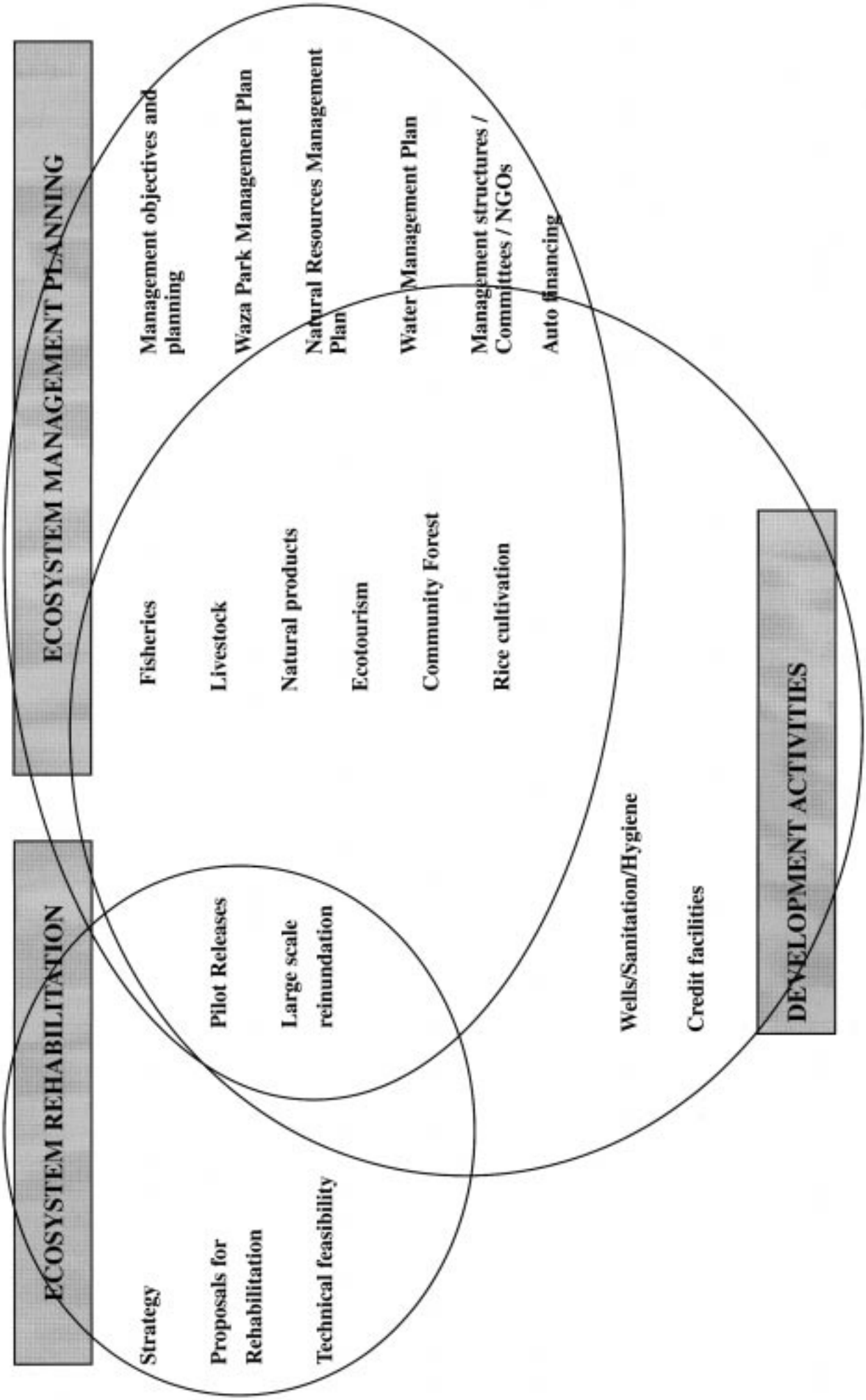

Figure 6: Resource management

Article 3.5

Développement d'un modèle hydraulique pour la gestion du Parc National du Diawling (Mauritanie)

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Mots-clés: barrages, zones humides, gestion, delta du fleuve Sénégal

Les impacts des aménagements hydrauliques récents du fleuve Sénégal sur le bas-delta mauritanien sont très marqués. Le régime hydrologique est artificialisé depuis la mise en service du barrage de Diama et de ses infrastructures annexes (digues et ouvrages hydrauliques). La qualité des eaux et des sols est modifiée. La gestion actuelle du barrage de Diama prend rarement en compte les impacts sur l'environnement, les besoins des sites écologiques humides (Diawling, Chott Boul) situés en aval du barrage et les besoins des populations du bas delta. Dans ce contexte, le Parc National du Diawling est confronté à une gestion complexe des eaux qui déterminera l'évolution des écosystèmes et des systèmes sociaux du bas delta mauritanien.
La restauration de la plaine inondable grâce à la création d'un estuaire à alimentation artificielle demande une circulation des eaux inédite. Une telle gestion n'est pas sans risques:

- Une inondation prolongée peut modifier la qualité des pâturages;
- Des inondations trop brèves peuvent compromettre la productivité halieutique;
- Une inondation de contre-saison trop tardive peut causer une mortalité de la mangrove.

Dans ce nouveau contexte, il est donc nécessaire de disposer d'un modèle hydraulique permettant de comprendre le fonctionnement hydrologique du bas delta mauritanien et de gérer efficacement une circulation des eaux convenant aux différents utilisateurs.

Development of a hydraulic model for the management of Diawling National Park

Keywords: dams, wetlands, management, Senegal river delta.

The impacts of the new hydraulic infrastructures of the Senegal river in the Mauritanian lower delta are severe. The hydrological regime is artificial since the implementation of the Diama dam and its related infrastructures (embankments and sluicegates). Water and soil quality have been affected. The day to day management of the Diama dam and of the sluicegates rarely takes account of the environmental impacts, of the ecological requirements of important wetlands (Diawling, Chatt Boul), and of the population's requirements. In this context, the Diawling National Park is confronted with a complex water management system, whose adequacy will determine the evolution of the ecosystems and the social system of the Mauritanian lower delta. The floodplain restoration effort and the creation of the artificial estuary requires a new water circulation system. Such a management is not without risks :

- a prolonged flooding can modify the quality of pasture;
- flooding for too short a time can affect fish production;
- a late counter-season flooding may cause mortality of mangrove.

In the new situation it is therefore necessary to develop a hydraulic model which will allow to understand the functioning of the Mauritanian delta and efficiently manage the water flows in agreement with the different stakeholders.

1. Introduction

Dans le contexte de péjoration climatique des années 70, le choix a été fait de développer l'agriculture irriguée dans la vallée du fleuve Sénégal pour améliorer la situation alimentaire des pays sahéliens. Les deux grands barrages de Manantali et de Diama ont été construits. Le cours du fleuve ainsi régularisé, le fonctionnement de la plaine inondable - déjà fragilisé par la diminution de la pluviométrie dans les années 1970 (Duvail S., Mietton M., Hamerlynck O., 1998) et par une pression démographique responsable de l'intensification des systèmes d'exploitation - s'est trouvé fortement modifié.

Mais les progrès accomplis dans la réalisation des objectifs de développement ont été plus lents que prévu et les effets négatifs des aménagements réalisés ont été sous-estimés. La perte des fonctions traditionnelles des plaines d'inondation (alimentation des nappes souterraines, agriculture de décrue, pâturage, pêche, production de bois, etc.) et l'augmentation de la prévalence des maladies d'origine hydrique affectant l'homme et le bétail ont entraîné une dégradation des conditions de vie et ont accéléré un exode rural vers les capitales.

Dans un contexte où la majeure partie de l'espace du delta est aujourd'hui reconvertie en espace agricole, l'objectif du projet du Parc National du Diawling est au contraire de restaurer les richesses écologiques du milieu estuarien et de valoriser le bas delta comme espace de pêche, d'élevage et d'écotourisme. (Fig. 1).

Une telle expérience de restauration comporte quelques difficultés techniques : il ne suffit pas de remettre de l'eau dans la plaine. Il faut la gérer pour éviter les risques écologiques et sanitaires et satisfaire, au mieux, les besoins des populations. A cette fin, un outil de connaissance du fonctionnement hydrologique de la plaine et de prévision de différents scénarios de circulation des eaux est développé par les chercheurs des Universités de Nouakchott (GREZOH), de Strasbourg (CEREG) et de Caen, en collaboration avec les gestionnaires du Parc National du Diawling et de l'UICN (Union Mondiale pour la Nature).

2. Description de la zone d'étude

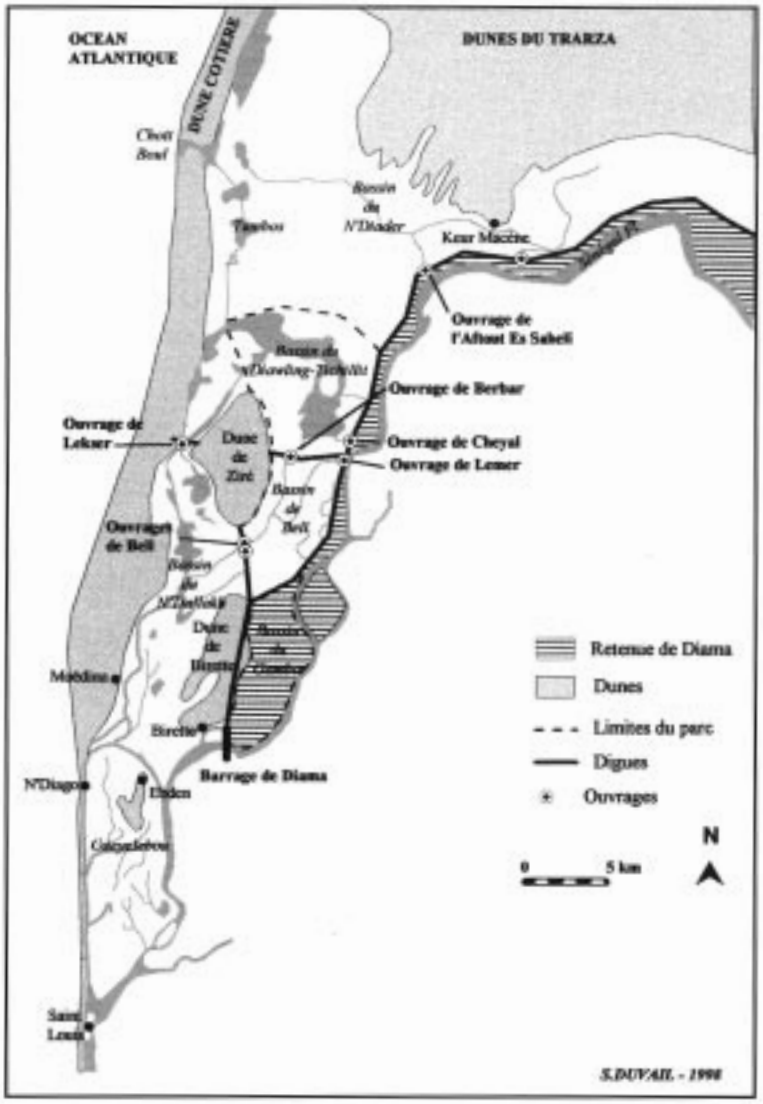


Fig. 1: Plan de situation du Parc National du Diawling.

2.1 Le cadre géomorphologique

La région du bas-delta est entièrement constituée de terrains quaternaires :

- Les plus anciens et les plus internes, sont formés par un ancien cordon de dunes mortes et rubéfiées. La mise en place de ce système dunaire est rapportée à une période aride qui s'est installée vers 20000 BP et qui est connue sous le nom d'Ogolien (De Naurois, 1969). Morphologiquement, cet édifice est fortement érodé et il n'en reste plus, dans la région étudiée que quelques buttes témoins ainsi des colluvions issues de leur démantèlement (dunes de Ziré et de Birette).
- Les dépressions sont occupées par des sebkhas sub-actuelles, parfois délimitées par des terrasses marines fossilifères datées du nouakchottien.
- Les levées deltaïques marquent l'ancien cours du fleuve Sénégal dont l'embouchure occupe aujourd'hui une position plus méridionale.
- L'ancienne ligne de rivage et une dune constituée de sables jaunes post - nouakchottien occupent l'arrière du cordon littoral actuel.

Lors de la dernière transgression marine nouakchottienne (5500 BP), l'estuaire du Sénégal se présentait comme un bras de mer. Par la suite, entre 4000 et 1880 BP, ce golfe a été progressivement comblé par des dépôts fluvio-deltaïques. Il y a 2500 BP, plusieurs bras du fleuve Sénégal se sont frayés un chemin à travers la zone deltaïque et ont gagné la mer par plusieurs embouchures séparées par des flèches sableuses qui ont isolé des lagunes plus ou moins vastes .

Ces anciennes embouchures (Chott Boul, Tweïkitt) ont été progressivement fermées par un cordon littoral. Le cours du fleuve a été dévié vers le sud sous l'action de la dérive littorale et un immense réseau hydrographique s'est constitué dans la région du bas-delta.

2.2 Le contexte climatique

Le bas-delta du fleuve Sénégal est soumis au climat sahélo-saharien, caractérisé par deux saisons très contrastées :

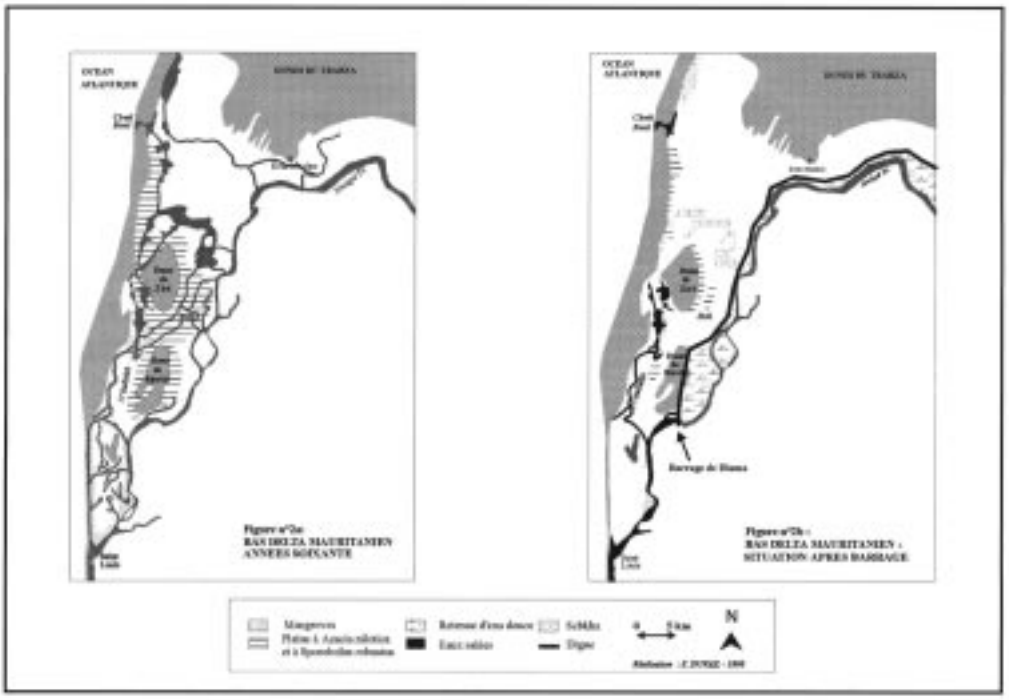
- une courte saison des pluie de deux à trois mois (mi-juillet à mi-octobre) marquée par des précipitations inférieures à 400 mm;
- une très longue saison sèche de 9 à 10 mois (mi-octobre à mi-juillet) sans précipitations.

La température de l'air est élevée, avec un gradient sensible et régulier d'ouest en est, passant de 25°C de moyenne annuelle sur la côte à près de 30°C vers l'intérieur. Les vents viennent préférentiellement du Nord à Nord-Est. Ils soufflent en moyenne 260 jours par an à des vitesses supérieures à 50 km/h. Le régime des vents a donc des effets considérables de dessèchement, et favorise également l'arrachement et le transport des matériaux (Loyer, 1989).

L'évapotranspiration potentielle, calculée par formule de Penman, est de 2400 mm par an en moyenne (Loyer, 1989). Le déficit hydrique est important pendant toute la saison sèche, avec une moyenne évaporatoire de l'ordre de 7 mm par jour mais pouvant atteindre 15 mm.

2.3 Les unités hydrologiques

Fig. 2a et 2b: Bas Delta Mauritanien: Effets du Barrage de Diama



Sept unités hydrologiques (bassins séparés par des seuils naturels ou artificiels) peuvent être délimitées dans le bas - delta :

- ***le Chott Boul,*** une ancienne embouchure du fleuve Sénégal forme une brèche dans la dune côtière qui peut être percée par l'océan atlantique. D'une superficie de 6,000 ha environ, le Chott Boul est atteint par la crue à travers les mares de Tumbos sud et le marigot de Hassi baba, où un seuil d'environ 1 m IGN le sépare du lac de Tichilitt dans le bassin du Diawling.
- ***le bassin de Ndiader*** dont la superficie est estimée à 9,000 ha est alimenté à travers l'ouvrage de l'Aftout Sahli sur la digue rive droite. C'est une superficie entièrement inondable et dont une partie importante est actuellement sous l'eau de façon quasi permanente.
- ***le bassin de Diawling*** couvre une superficie de 1,000 ha, dont 8,000 ha font partie du Parc du Diawling.
- ***le bassin de Bell*** : s'étend sur 4,000 ha environ et fait partie du Parc National du Diawling. Ce bassin était essentiellement alimenté par le Mréau, le marigot de Bell et le Njorakh.
- ***le bassin de Gambar :*** couvre 4,500 ha et représentait une plaine inondable avec plusieurs mares et marigots. Actuellement, le Gambar fait intégralement partie de la retenue de Diama.
- ***le bassin du Ntiallakh*** couvre environ 20,000 hectares. L'inondation de ce bassin se fait principalement par le sud à travers le marigot de Ntiallakh qui est en connexion avec la partie du fleuve située à l'aval de Diama.
- Enfin, ***le bassin de Gueylebou*** couvre une superficie de 4,000 hectares environ. L'alimentation de ce bassin se fait principalement par l'est à travers le marigot de Gueyelebou en communication avec la partie du fleuve à l'aval de Diama.

3. Le projet de restauration de la plaine inondable

3.1 Les modifications du régime hydrologique et ses conséquences

Au début des années 1960 (Fig. 2a), le bas delta mauritanien se présente comme un réseau de cuvettes alternativement inondé par les eaux salées marines à partir du mois de mai et par les eaux douces de la crue à partir du mois d'août (Baillargeat, 1964).

Le cycle hydrologique qui caractérisait alors la zone du bas delta- mauritanien était déterminé par la marée d'une part et les crues venant du Mali d'autre part. Les eaux saumâtres pénétraient le bas delta par l'aval dès le début de l'hivernage. Les vives eaux de fin mai favorisaient la remontée des eaux salées marines dans l'estuaire du Ntiallakh. En août, la crue annuelle repoussait ces eaux salées et envahissait les plaines d'inondation selon deux parcours : l'un du Sud vers le Nord empruntait le marigot du Ntiallakh, l'autre de L'Est vers l'Ouest empruntait des affluents perpendiculaires au fleuve. Des débordements se produisaient alors à partir du Mréau, de Oualalane et de Cheyal amenant ainsi des eaux douces dans les bassins du Diawling, du Tichilitt et du Bell. Elles repoussaient les eaux salées vers l'Ouest, le nord ouest (Chott Boul) et le sud (Ntiallakh). Au maximum de la crue, les eaux du fleuve refoulaient totalement les eaux salées de l'estuaire.

La hauteur d'eau maximale était généralement atteinte à la mi-octobre, la superficie inondée pouvant alors varier de 3,000 ha (1974) à 100,000 ha (observée en 1950 quand l'Aftout es Saheli, dépression côtière au nord du bas delta, a été envahie jusqu'à Nouakchott).

D'août à novembre, la vidange des deux cuvettes se faisait vers le Chott Boul par le marigot de Hassi Baba. En octobre s'amorçait la décrue : les écoulements s'inversaient, les principaux marigots, fonctionnaient alors en chenaux de vidange.

Au fur et à mesure de la décrue, l'eau de mer pénétrait progressivement vers l'amont dans le lit du fleuve et dans les principaux chenaux de marées. L'eau douce stockée dans les dépressions isolées devenait progressivement saumâtre par contact avec les sols salés. L'évaporation entraînait l'assèchement des lacs saisonniers entre janvier et mars et créait des conditions hypersalines dans les chenaux de marée (donnant ainsi naissance à un estuaire dit inversé).

Cette alternance d'eaux douces et d'eau salées favorisait le développement de mangroves à *Avicennia germinans* et à *Rizophora racemosa* dans la zone estuarienne (Adam, 1965). Les pâturages de qualité (*Echinochloa colona),* les herbacées annuelles telles que *Sporobolus robustus* et les peuplements d'*Acacia nilotica* étaient abondants dans les zones inondables. Ce milieu saumâtre était une zone de frayère pour les poissons et les crevettes (Reizer, 1971) et un important lieu de nidification d'oiseaux piscivores tels que cormorans, hérons, aigrettes et spatules (De Naurois, 1969).

La diversité des activités pratiquées alors par les populations locales témoigne bien des fortes potentialités de ce milieu : pêche en cuvette, élevage bovin, tissage de nattes en *Sporobolus robustus*, maraîchage dunaire (Duvail, 1996).

Depuis la réalisation du barrage de Diama et de ses infrastructures annexes, l'alimentation par l'aval est totalement modifiée. En effet, les eaux salées pénètrent actuellement de façon permanente dans le bassin du Ntiallakh. Aussi, le mélange eau douce - eau salée, qui devrait limiter l'augmentation de la salinité du milieu et favoriser sa productivité biologique, dépend aujourd'hui de la gestion du barrage de Diama. De 1986 à 1993, les lâchés d'eau douce sont restés minimes à inexistants, entraînant une importante mortalité au sein des mangroves et des pâturages et anéantissant la production de poissons et de crevettes dans l'ancien estuaire. La zone inondable à l'ouest de la digue rive droite est devenue alors un désert salé. L'absence d'écoulements des eaux douces vers l'aval a pour conséquence de limiter les dilutions des eaux marines pénétrant dans le Ntiallakh et donc de favoriser l'évolution des cuvettes inondables en sebkhas.

Dans les années 1980, la construction du barrage antisel de Diama a modifié le fonctionnement de ce système deltaïque (Fig. 2b). La construction d'une digue en rive droite a coupé la plaine deltaïque de son alimentation par les eaux douces de la crue. Le barrage de Diama est par ailleurs resté quasiment fermé de 1985 à 1994. En l'absence de lâchés d'eau douce, les eaux de l'estuaire du Ntiallakh situé en aval du barrage sont devenues hypersalines et les anciennes cuvettes inondables ont eu tendance à évoluer en sebkhas (Hamerlynck, 1996). La ressource halieutique a fortement diminué tandis que la végétation estuarienne a quasiment disparu (Diawara, 1997).

3.2 L'expérience de la restauration de la plaine inondable menée dans le Parc National de Diawling

Des études hydrologiques, réalisées au cours des années 1970 dans le delta du Sénégal (rive droite du fleuve), avaient souligné que tout aménagement hydrologique sur le fleuve du Sénégal aura des impacts négatifs considérables sur les écosystèmes en aval (Baillargeat, 1964).

Le Parc National de Diawling a été créé en 1991, pour restaurer un ensemble d'écosystèmes estuariens qui faisaient autrefois l'originalité du bas delta du Sénégal (rive droite du fleuve). D'une superficie de 16,000 ha, ce Parc devait être doté, dès sa création, de vannes permettant un apport en eau douce de 45 $m^3.s^{-1}$ dans la plaine d'inondation dont 15 $m^3.s^{-1}$ serviront pour la création d'un estuaire artificiel en aval du Parc. La mise en service de ses ouvrages devait atténuer les conséquences négatives, engendrées par les bouleversements hydrologiques récents, sur la productivité et la biodiversité biologique du milieu (Ould Baba et Hamerlynck, 1997).

La réalisation des ouvrages de réalimentation de la plaine, prévus au travers de la digue rive droite, a subi un grand retard et c'est seulement en 1993 que les écoulements à faible débit ont été rétablis (Fig. 1). La même année, au passage de la crue les eaux douces ont pu remonter par le Ntiallakh. La mise en place, en grande partie, des ouvrages d'alimentation et les importants lâchés effectués à Diama (1994 et 1995) ont contribué à l'inondation de la plaine du Parc National de Diawling par l'aval. Les résultats sont spectaculaires et ont prouvé que les écosystèmes du bas delta avait encore une énorme capacité de régénération. Les pêcheurs ont pu prendre une grande quantité de poissons dans les anciens bras du delta en 1995. Les crevettes roses et les crabes bleus ont fait leur réapparition dans les sebkhas. La régénération de la mangrove est amorcée et les jeunes plants de palétuviers s'implantent dans les zones basses, ménageant de nouveau de bonnes conditions de reproduction pour les poissons. Les pâturages se développent. Certains végétaux en voie de disparition comme *Sporobolus robustus* sont réapparus (De Boissezon *et al.*, 1996).

En 1997, le renforcement des infrastructures hydrauliques dans le Parc a permis une meilleure inondation de la plaine avec des évacuations d'eau douce vers le Ntiallakh. Cependant, ces premiers essais d'écoulement dans le sens amont-aval, ont montré que les canaux autrefois empruntés par les eaux ont été obstrués par les dépôts éoliens. Le curage de certains marigots s'impose donc pour faciliter la circulation des eaux dans la plaine d'inondation.

Le principe actuel de gestion des eaux dans le Parc National de Diawling est basé sur le remplissage, en eau douce, de deux bassins fermés par des digues, à partir de deux ouvrages vannés. Lorsque les deux bassins sont suffisamment pleins, on procède à l'évacuation des eaux vers le bassin du Ntiallakh pour tenter d'assurer un mélange eaux douces - eaux salées caractéristique des estuaires naturels.

Les objectifs de la restauration de la zone humide du Parc National de Diawling sont écologiques mais aussi et surtout socio-économiques. A cet effet, la création du Parc a été conçue dès le départ de telle manière que le développement de sa zone périphérique soit privilégié, afin que les populations soit associées à sa réussite. Le projet mise donc sur la reprise des activités traditionnelles de pêche, d'élevage et d'artisanat et sur le développement de nouvelles activités tel que le tourisme.

3.3 La nécessité de disposer d'un modèle hydraulique

Il ne suffit pas de remettre de l'eau douce dans la plaine pour récréer un système estuarien. Une restauration à l'identique est illusoire: si le projet vise à la restauration des ressources naturelles et par là même des systèmes d'exploitation traditionnels, les circuits empruntés par l'eau dans le nouveau dispositif hydraulique sont nouveaux et l'on peut parler d'un hydro-système artificialisé.

La gestion de l'eau d'une telle zone humide artificialisée est une opération complexe: ainsi, les objectifs de restauration des pâturages et de restauration des ressources halieutiques peuvent être antinomiques: Une ouverture des vannes au début du mois de juillet favorisera une bonne production halieutique mais peut porter préjudice à l'épanouissement des graminées pérennes telle que *Sporobolus robustus* que les femmes utilisent pour le tissage des nattes.

C'est aussi une opération délicate: une quantité trop importante d'eau fait courir le risque d'être confrontés à des modifications inédites de la végétation (développement des cypéracées) et à l'apparition de maladies hydriques.

Une bonne gestion des eaux ne peut donc se faire que si l'on connaît précisément les relations complexes entre l'inondation et les différentes composantes de l'écosystème et si, et seulement si, l'on maîtrise précisément les volumes d'eau à apporter, les durées et les hauteurs de submersion et le degré de salinité des eaux.

C'est dans cette double optique de compréhension du fonctionnement du milieu d'une part et de gestion des eaux de la plaine inondable, d'autre part, que les différents partenaires ont entrepris de mettre au point un modèle hydraulique du bas delta.

4. Développement du modèle hydraulique du bas delta mauritanien

4.1 Objectifs du modèle hydraulique

Gestion: Les objectifs de ce modèle hydraulique sont de comprendre le fonctionnement du système et de mettre à la disposition du Parc National du Diawling un outil de gestion des eaux. En effet, pour satisfaire à leur objectifs de restauration du milieu, les gestionnaires ont besoin de savoir quel volume d'eau doivent t-ils faire transiter par les ouvrages vannés et pendant combien de temps.

Recherche: De plus, un tel milieu deltaïque artificialisé est un bon observatoire des relations entre l'eau, premier maillon des chaînes trophiques et les différents éléments de l'écosystème.

Simulation de différents scénarios: Enfin, disposer d'un modèle hydraulique permet aux chercheurs et aux gestionnaires de pouvoir simuler différents scénarios de circulation des eaux et donc d'envisager d'autres hypothèses de recherche ou de nouvelle options de gestion des eaux. Un tel milieu artificialisé se prête bien à ce type d'expérience car il y a possibilité de faire varier les paramètres d'entrées du modèle, c'est à dire d'essayer plusieurs scénarios de gestion de l'eau.

Autour de cette problématique de compréhension du fonctionnement d'une zone humide s'est constituée une équipe de recherche pluridisciplinaire, le GREZOH, Groupe de recherche sur les zones humides, basé à la faculté des Sciences de Nouakchott. Cette équipe, composée d'hydrologues, de chimistes, de pédologues, de botanistes, de microbiologistes, de sociologues et de géographes d'universités mauritaniennes et françaises s'est donné pour programme de mieux définir les relations entre hydrologie, écosystèmes et systèmes sociaux.

4.2 La structure du modèle et les méthodes utilisées

Calcul des bilans hydrologiques

Le remplissage des casiers de Bell et du casier du Diawling se fait par des vannes de fond rectangulaire de 1, 65 x 1, 90 m noyées à l'amont et à l'aval. Chaque vanne est prévue pour passer un débit de 5 m^3/s sous une différence de charge de 20 cm mais ces abaques sont peu précis. Pour le calcul des débits transités, nous aurions pu utiliser des formules hydrauliques mais celles ci sont imprécises car le coefficient d'ajustement de la formule peut être variable en fonction des conditions d'écoulement. Pour connaître les débits réels transitants par l'ouvrage vanné, nous avons jugé nécessaire de chercher à établir une courbe de tarage des vannes en étalonnant les ouvrages par jaugeage au moulinet. Deux campagnes de jaugeages ont été programmées (1997 et 1998). Au total 60 jaugeages ont été réalisés. A l'un des principaux ouvrages d'entrée, la charge à laquelle est soumise la vanne est connue à tout instant grâce à deux limnigraphes implantés en amont et en aval de l'ouvrage.

Les **précipitations** sont connues grace à cinq pluviomètres installés dans le bas delta. Pour l'**évaporation,** les mesures réalisées sur le lac de Guiers (Cogels *et al.*, 1991) sont

utilisées. En effet Cogels note à propos d'une comparaison des processus d'évaporation entre les lacs Tchad, Bam et Guiers que les processus d'évaporation s'y exercent avec une égale intensité. Néanmoins, par souci de vérifier si il y a bien une corrélation entre les données du lac de Guiers et les données du bas delta, un bac à évaporation (à lecture visuelle) a été installé. Grâce à ce bac, il sera aussi possible d'établir une correspondance avec les données d'une station météorologique qui nous permet de calculer l'Evapo-transpiration Potentielle par une formule de type Penman. Dans un tel système deltaïque, on considère le **ruissellement** comme négligeable. En revanche, le facteur humectation pourra être obtenu par déduction en début de remplissage : "quantité d'eau entrée moins la quantité d'eau en début de remplissage" (De Boissezon, 1994).

Pour estimer l'**infiltration**, nous réalisons dans un premier temps un calcul théorique : en fonction des caractéristiques granulométriques des superficies inondées on applique un coefficient d'infiltration. Pour préciser ce calcul théorique, l'installation d'un réseau de tensiomètres est envisagé.

Il est également prévu d'installer un réseau de pièzomètres dans le Bell pour mieux suivre s'il y a une remontée de la nappe salée par pression hydrostatique sous l'effet de Diama comme on semble l'observer en périphérie de la zone.

Suivi limnimétrique

Nous avons implanté un important réseau **d'échelles limnimétriques** que le suivi des hauteurs dans un tel système deltaïque nécessitait (26 sites d'implantation). Un suivi très régulier de ces échelles a été réalisé aux cours des trois dernières années, en collaboration avec les agents du Parc National du Diawling.

Courbes de cubature

Les données seront spatialisées grâce à une **relation hauteur-surface-volume** calculée à partir des informations morphométriques sur les cuvettes. Pour l'instant nous disposons d'un levé topographique précis (1/20.000ème) mais ancien (1985). La dynamique morphogénique ayant été très agressive ces dernières années, il est probable que l'érosion éolienne ait partiellement remodelé l'ancienne plaine deltaïque. Les lits mineurs des marigots asséchés ont été particulièrement modifiés. Aussi est–il nécessaire d'effectuer des relevés complémentaires pour localiser les nouveaux bouchons sableux.

Validation du modèle quantitatif

La comparaison des surfaces inondées estimées par calcul et des surfaces observées sur des images SPOT du maximum de la crue pourra être un exercice intéressant permettant d'estimer la marge d'erreur de nos calculs. De manière plus précise, les limites d'inondation ont fait l'objet de relevés GPS au sol et de prise de vue aériennes obliques qui pourront être redressées par photogrammétrie.

Suivi de la qualité et de la géochimie des eaux

Parallèlement à ce modèle quantitatif, l'accent est mis également sur un **suivi de la qualité des eaux** des bassins pour au moins deux raisons: dans un tel milieu estuarien, il est en effet important de connaître l'évolution des salinités dans les bassins. Un suivi sur l'année des paramètres physico-chimiques de l'inondation est réalisé (conductivité, pH, température et oxygène dissous) en différents sites du bas delta régulièrement répartis. D'autre part, en rive sénégalaise, la construction d'un "émissaire delta" pour évacuer les eaux de drainage des rizières est programmée. Ces eaux risquent de remonter l'estuaire du Ntiallakh. Il apparaît donc indispensable de connaître un état de référence initial de la qualité des eaux du Ntiallakh avant la mise en service de cet émissaire delta.

Par ailleurs, un **suivi annuel des apports de la matière en suspensions** (MES) en quantités et en qualité est effectué. Les points de prélèvement sont choisis en fonction du nouveau réseau hydrographique après barrage.

- *zone amont*: ouvrages de l'Aftout, de Cheyal, de Lemer qui permettent respectivement l'inondation des bassins du N'Diader, du Diawling, du Bell ;
- *barrage de Diama:* calcul des flux particulaires à l'amont en fonction des lâchés du barrage, sédimentation de la retenue et transformation des MES (phénomènes de floculation) en milieu salé à l'aval;
- *zone en aval:* l'effluent Ntiallakh aval, (apports maritimes) et amont (apports des bassins du Diawling): confluence avec le fleuve, Ebden, Moïdina, Dar Salam et confluence Bell - Khouroumbam.

La périodicité des prélèvements dépend de la crue du fleuve sachant que le pic particulaire précède toujours le pic de la crue. Des mesures physico-chimiques des eaux sont effectuées régulièrement depuis 1996. Les paramètres suivis sont: la conductivité, le pH, la température, la turbidité et l'oxygène dissous.

Les éléments chimiques analysés sont:

- des éléments organiques : carbone organique particulaire (COP), azote total, phosphore total,
- et des éléments inorganiques: Ca, Na, K, Mg , Cl, SO_4, NO_2, NO_3, Al, Si - Fe, Mn, Ti - Cr, Ni, Cu, Zn, Pb, Sr,

5. Conclusions

Dans un tel milieu artificialisé, un modèle hydraulique s'avère un outil indispensable pour définir un scénario optimal de gestion des eaux.

Au delà, pour être un véritable outil de gestion des ressources, une telle modélisation doit s'accompagner d'une recherche sur les liens fonctionnels entre l'eau, les écosystèmes et les systèmes sociaux. En effet, pour pouvoir arbitrer entre les différents choix hydrologiques, les gestionnaires doivent connaître les avantages et les inconvénients de chaque scénario envisageable. C'est dans

cette optique que les impacts des inondations sur le bas delta sont suivis le plus finement possibles.

Néanmoins, dans le bas delta même un modèle précis ne suffit pas à assurer une gestion optimale de l'hydrosystème car il existe des paramètres non contrôlés. Les quantités d'eaux douces apportées par Diama dans le système sont 20 fois supérieures à celles apportées par les ouvrages du Parc. A titre d'exemple, pour l'année 1997, les apports des ouvrages de Bell et de Lekser (Fig. 2b) sont d'une cinquantaine de millions de m^3 de juillet à octobre tandis que les apports de Dima s'élèvent environ à un milliard de m^3.

Le modèle hydraulique doit contribuer à l'élaboration d'un calendrier précis pour la gestion des ouvrages du Parc. Cependant deux scénarios principaux impliquent des priorités de gestion différentes (Plan de gestion du Diawling, 1997):

- années de faible pluviométrie, de crue minimale et donc de fermeture (quasi totale) du barrage de Diama. Cette situation impose l'évacuation vers le Ntiallakh pendant la période juillet-octobre.
- année de bonne pluviométrie, de bonne crue et ouverture plus ou moins prolongées de Diama. Dans ce cas, le remplissage des bassins au nord du Diawling (Tumbos sud, Chott Boul) est prioritaire.

En l'absence d'ouverture de Diama, la quantité d'eau douce que peut apporter les ouvrages du parc, bien que capable de soutenir les espèces halieutiques estuariennes et de favoriser le développement de la mangrove, est insuffisante pour une inondation permettant un bon développement des pâturages sur les terres hautes et la recharge des nappes dunaires. Il serait bénéfique pour le milieu que les capacités d'apport d'eau douce à l'estuaire soient augmentés (curage du Bell) et, surtout, que des consignes de gestion soient édictées pour l'aval de Diama.

Des ouvertures du barrage de Diama qui ne prennent pas en considération les nouvelles conditions du milieu, perturberont les cycles hydrologiques et par conséquent les cycles biologiques des espèces qui lui sont associées.

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Article 3.6

Une alternative à la gestion des eaux du fleuve Sénégal ?

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Mots-clés: barrages, zones humides, gestion, agriculture irriguée, delta du fleuve Sénégal.

Dans les années 1970, les Gouvernements du Mali, du Sénégal et de la Mauritanie ont créé l'Organisation pour la Mise en Valeur du fleuve Sénégal (OMVS), et ont lancé la construction de deux grands barrages pour réguler le régime du fleuve Sénégal et permettre le développement de l'agriculture irriguée, la production hydroélectrique et rendre possible la navigation fluviale.

Ces différents objectifs n'ont pas été atteints et les impacts négatifs de ces aménagements sont nombreux, notamment dans la basse vallée du fleuve. La gestion de la retenue de Diama à une cote élevée et constante a des effets néfastes sur les écosystèmes, sur la santé animale et humaine et sur les équilibres sociaux. La partie amont de la retenue subit les effets d'un excès d'eau stagnante tandis que l'estuaire du fleuve Sénégal en aval souffre plutôt d'un manque d'eau.

Dans le cadre de la construction de la centrale hydro-électrique du barrage de Manantali, une réflexion a été engagée sur une optimisation de la gestion des deux barrages. Mais le choix qui se profile est de gérer la retenue aval à une cote encore plus élevée et constante. Un tel choix de stocker l'eau à des fins exclusivement agricoles n'est pas une gestion adaptée à une plaine d'inondation sahélienne telle que la vallée du Sénégal.

Une gestion alternative des eaux de la retenue de Diama prendrait en compte l'intérêt des usagers non-agricoles (pêcheurs, éleveurs, maraîchers) et consisterait à faire baisser le niveau des eaux de la retenue entre deux saisons culturales. Les avantages et les inconvénients d'un tel scénario sont discutés.

An alternative for the water management of the Senegal river ?

Keywords: dams, wetlands, management, irrigated agriculture, Senegal river delta.

In the seventies, the Governments of Mali, Senegal and Mauritania have established the "Organisation pour la Mise en Valeur du fleuve Sénégal" (OMVS) and, in order to regulate the flows of the Senegal river, aimed at of two large dams enhancing the development of irrigated agriculture, the production of hydroelectricity and at facilitating river navigation were built .

These different objectives have not been reached and the negative impacts are numerous, especially in the lower basin. The high and constant water level in the Diama reservoir has negative impacts on ecosystems, on human and animal health and on social equilibria. Upstream of the reservoir there is an excess of stagnant waters while the estuarine part downstream of the dam is short of water.

With regard to the implementation of the hydropower production an optimisation study on water use is being undertaken. Still, the most probable outcome is a further increase in the constant water level. The sole objective of stocking water for irrigated agriculture is hardly appropriate for sahelian floodplain management.

An alternative management scheme for the Diama reservoir would take into account the wishes of stakeholders in the non agricultural sectors (fishing, animal husbandry, market gardening) and would lower water levels between agricultural seasons. The papers presents the advantages and disadvantages of this scenario.

1. Introduction

La volonté de maîtriser les eaux de la vallée du fleuve Sénégal existe depuis le XIXème siècle. Ce projet politique s'est concrétisé au XXème siècle lorsque, dans le contexte de baisse de la pluviométrie des années 1970, les gouvernements du Mali, du Sénégal et de la Mauritanie ont créé l'Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS) et ont lancé la construction de deux grands barrages:
- Le barrage anti-sel de Diama, opérationnel depuis 1986, a pour fonction d'empêcher la remontée des eaux salées marines;
- Le barrage réservoir de Manantali au Mali, mis en service en 1988, permet de contrôler 50% des écoulements du bassin versant du fleuve Sénégal.

Les trois grands objectifs assignés à ces barrages étaient de permettre l'irrigation des 375,000 hectares des anciennes plaines inondables, la production de 800 GWH d'hydroélectricité par an et le développement de la navigation sur le fleuve.

La réalisation de ces trois objectifs a été plus lente que prévue: les projets d'hydroélectricité et de navigation ont pris du retard et les prévisions concernant l'irrigation ont été trop optimistes. La rentabilité des périmètres a été surestimée: les exploitants ne sont pas prêts à se consacrer à plein temps à la riziculture, sont confrontés à des problèmes de salinisation des parcelles (Boivin P. *et al.* , 1995) et de multiplication des populations d'oiseaux granivores. Les conflits fonciers opposant les propriétaires traditionnels et les nouveaux exploitants sont nombreux aussi bien en rive droite qu'en rive gauche (Crousse, 1991; Ba, 1991).

Par ailleurs, les impacts négatifs de ces aménagements ont été mal évalués : la perte des fonctions traditionnelles des plaines d'inondation (alimentation des nappes souterraines, agriculture de décrue, pâturage, pêche, production de bois etc.) et l'augmentation de la prévalence de maladies hydriques affectant l'homme et le bétail (Handschumacher *et al.*, 1992; Nozais et Chieze, 1990) ont entraîné une dégradation des conditions de vie dans la vallée.

Depuis 1994, dans le cadre de la réalisation de l'ambitieux projet d'alimentation en énergie des trois pays à partir du barrage de Manantali (projet " Energie "), l'OMVS affiche la volonté de minimiser les impacts négatifs des aménagements sur l'environnement et de mieux gérer les eaux des réservoirs. L'accent est mis surtout sur l'atténuation des effets négatifs du projet pour la haute et la moyenne vallée. En revanche, les décisions retenues pour la gestion du barrage de Diama, dont la fonction a évolué de celle de barrage anti-sel à celle de barrage-réservoir, vont plutôt dans le sens d'une aggravation des impacts négatifs déjà existants.

Ces effets négatifs observés imposent de réfléchir à un scénario de gestion optimal des eaux pour la basse vallée du fleuve. Cet exercice est particulièrement ardu dans le delta du fleuve Sénégal car c'est une zone où la confrontation entre un modèle agricole d'irrigation intensive et une vision plus large incluant aussi les questions de conservation de la nature est permanente. En effet, la basse vallée a été une des premières zones choisie pour le développement de l'agriculture irriguée par l'OMVS mais c'est aussi un important site d'hivernage pour les oiseaux migrateurs, le Parc National du Djoudj, la réserve du N'Diaël au Sénégal et le Parc National du Diawling en Mauritanie figurant parmi les sites inscrits sur la liste de la convention sur les zones humides (Ramsar, Iran, 1971) (Fig.1).

Nous essaierons de dresser le bilan des effets de la gestion actuelle des eaux du barrage de Diama, de projeter les effets éventuels d'une gestion de la retenue à une cote plus élevée et constante et d'envisager les avantages et des inconvénients d'une gestion dynamique des eaux.

2. L'actuelle gestion des eaux de la retenue de Diama

2.1 Les consignes de gestion du barrage de Diama

Le barrage de Diama est construit à quelques 25 km en amont de Saint Louis. Conçu pour empêcher l'intrusion de l'eau de mer, il peut aussi être utilisé pour augmenter les niveaux d'eau dans le delta et réduire ainsi les hauteurs de pompage et les coûts d'irrigation.

L'OMVS s'est donné pour mission de garantir aux agriculteurs un niveau d'eau douce minimum toute l'année. En période de crue, l'OMVS veille également à sécuriser l'ouvrage de Diama. Le barrage est donc géré selon deux consignes principales:
- en saison sèche: maintenir une cote constante et élevée
- en période de crue: ouvrir le barrage tout en minimisant l'énergie dissipée à l'aval. Celle-ci ne doit pas dépasser 1000 m^4/s, c'est à dire 1000 m^3/s pour 1 m de chute (Coyne et Bellier, 1987).

De 1988 à 1991, ce niveau minimal n'était pas garanti en l'absence d'endiguement en rive droite. A partir de 1992, le niveau garanti était de 1,5 m au dessus du niveau de la mer (IGN). Ce niveau minimal est passé à 1,75 m IGN en 1995 puis à 1,90 m IGN en 1997 (Fig. 2). En pratique cependant, ces deux dernières années, il est souvent resté supérieur à 1,90 m IGN en saison sèche car l'objectif qui conditionne le plus le programme de gestion du barrage est d'assurer l'irrigation gravitaire des périmètres aménagés dans la partie inférieure du delta.

La gestion de la retenue à de tels niveaux est particulièrement risquée à l'approche de la crue annuelle. Ainsi en 1994, alors qu'une crue très moyenne a soudainement été renforcée par d'importantes précipitations locales, les gestionnaires du barrage, confrontés à une élévation rapide du niveau de la retenue ont ouvert les vannes au maximum. L'onde de crue consécutive à cette ouverture a détruit plusieurs digues en aval du barrage et a inondé la ville de Saint Louis, beaucoup plus exposée aux inondations depuis la construction du barrage (en partie en raison d'une sédimentation possible du fleuve à son embouchure).

Fig. 1: Aires protégées de la base vallée du fleuve Sénégal.

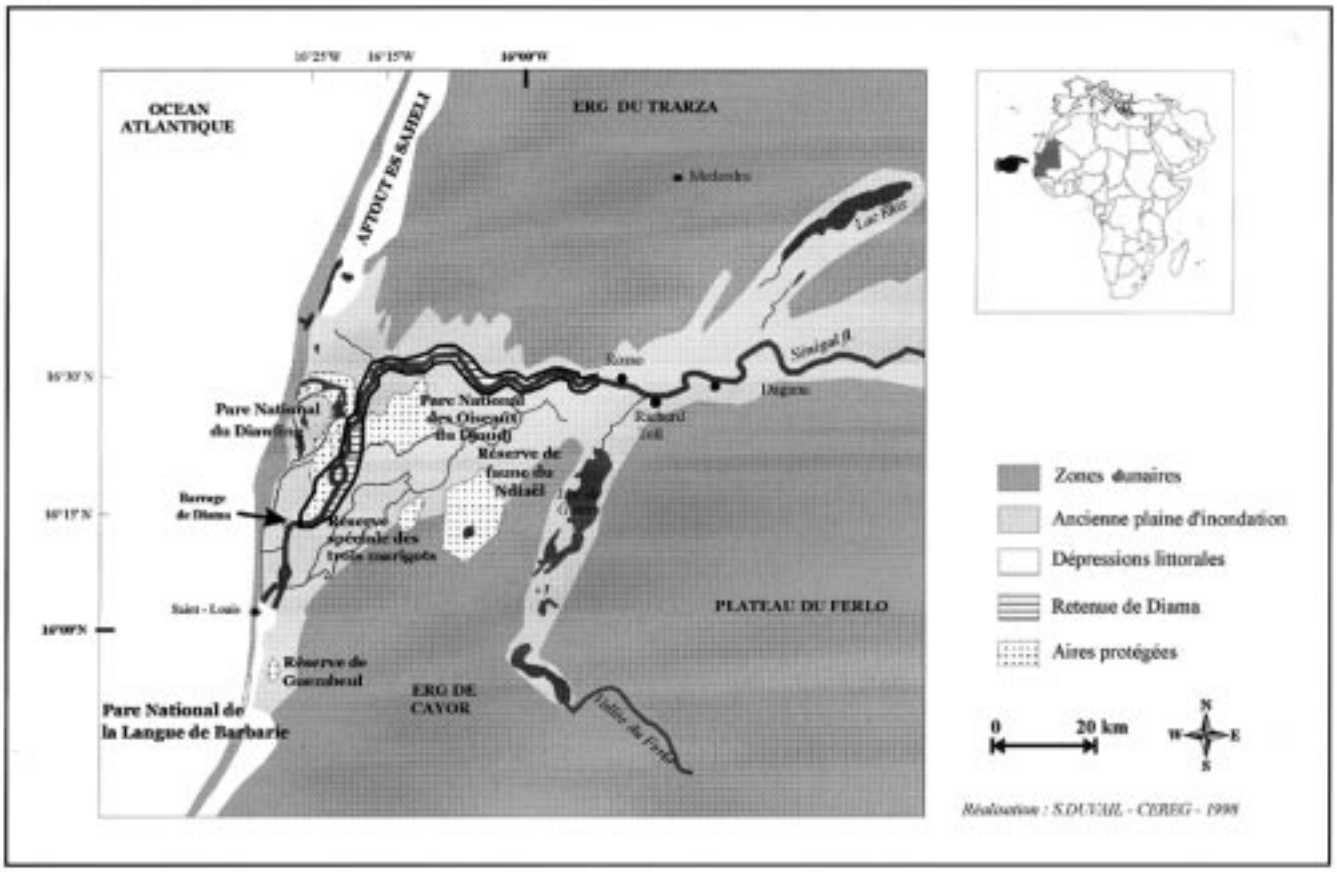
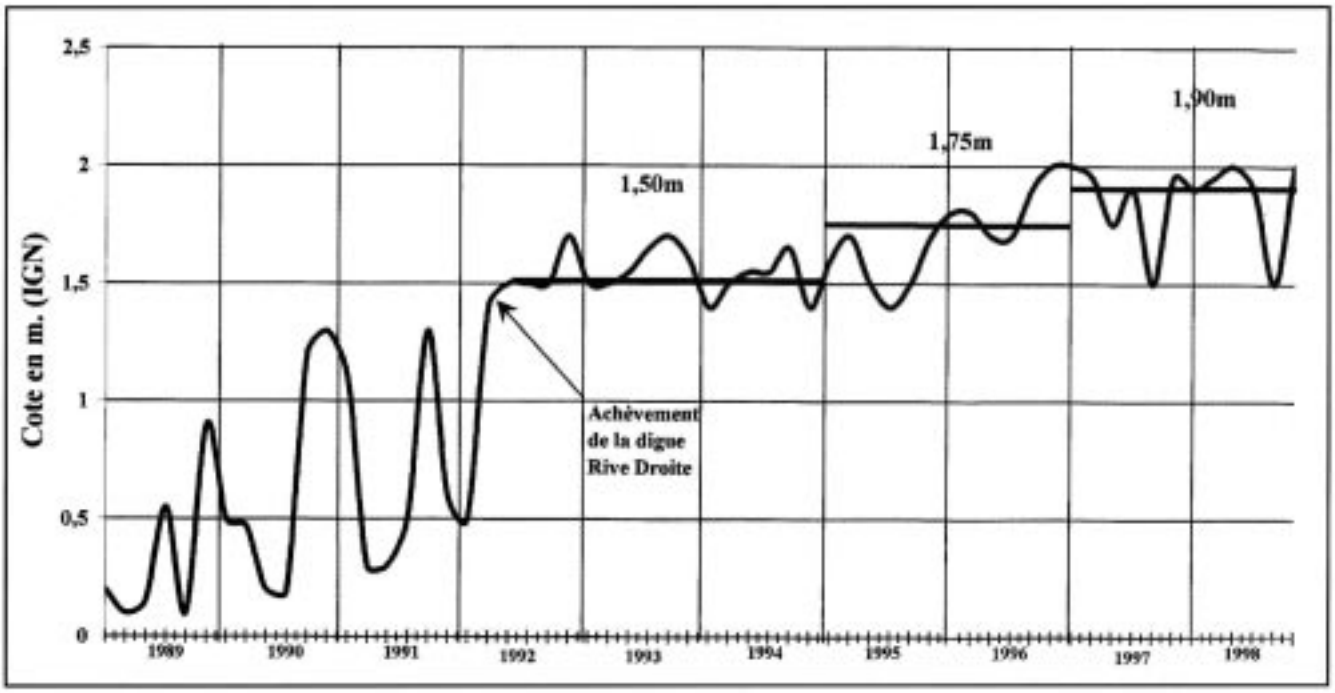


Fig. 2: Variation du plan d'eau de la retenue de Diama (1989 à 1998).



Depuis septembre 1997, la Société de Gestion de Diama (SOGED) qui a été chargée par l'OMVS de la gestion du barrage pratique une gestion plus prudente en faisant baisser le niveau avant l'arrivée de la crue et en essayant de ne pas dépasser le seuil des 1000 m^3/s (1000 m^3/s pour 1m de chute) d'énergie à dissiper, conformément aux consignes de gestion du barrage. Les effets des lâchers de septembre 1997 et septembre 1998 ont donc fait moins de dégâts.

2.2 Les effets de cette gestion sur le delta mauritanien

2.2.1 Les effets en amont : un niveau élevé et constant

La quasi constance d'un niveau d'eau élevé a des effets insidieux.

Remontée de la nappe salée

Le delta était encore une baie marine il y a quelques milliers d'années et, en raison de la forte évaporation (près 2 m par an), les eaux souterraines sont très salées. Un niveau élevé des eaux de la retenue de Diama favorise le rehaussement du niveau piézométrique. Les études de faisabilité du barrage avaient conclu que ceci n'aurait que des conséquences limitées du fait de la prédominance des argiles et vases peu perméables dans le delta. Un important réseau piézométrique avait été mis en place, mais l'évolution des niveaux piézométriques n'a fait l'objet que d'un suivi irrégulier.

Mais il est vraisemblable que le caractère sinueux du fleuve, qui a souvent remodelé des zones sablonneuses constituées d'anciennes plages et dunes, a donné naissance à une mosaïque de dépôts, dont certains sont assez perméables. Ainsi localement, notamment sur la dune de Birette, on constate une élévation de la nappe salée qui affleure dans les cuvettes à *Acacia nilotica* devenues sites d'extraction de sel. Ce phénomène est en nette progression vers l'ouest à partir de la retenue.

Carfantan (1996) a montré qu'en rive gauche du fleuve Sénégal le relèvement général de la surface piézomètrique facilite l'évaporation et par conséquent l'enrichissement des sols en sels. Dans les plaines inondables en rive droite, notamment dans le bassin de Bell, certaines zones se sont aussi salinisées récemment. Ce phénomène de remontée de la nappe salée nécessiterait que soit mis en place un suivi des piézomètres de l'OMVS .

Développement des maladies hydriques humaines et animales

La création d'un grand lac d'eau douce permanent dans une région tropicale a des conséquences sur la santé humaine (Verhoef, 1996). Après une épidémie de fièvre de la vallée du Rift en 1987, dont le bilan a été lourd puisqu'elle a tué au moins 200 personnes et de nombreux animaux domestiques, et la forte augmentation de la prévalence de la bilharziose intestinale depuis 1988 (Handschumacher *et al.*, 1992), on peut craindre une multiplication des maladies chroniques d'origine hydrique. Les poussées locales de choléra sont fréquentes, le paludisme est en recrudescence et certaines maladies parasitaires du bétail (distomatoses) qui étaient rares avant le barrage, ont maintenant une forte prévalence (Mulato & Jacquiet 1993).

Les risques sanitaires pour les populations sont particulièrement élevés lorsque les zones basses à proximité des villages sont ennoyées toute l'année. En rive droite du fleuve, de Rosso à Keur Macène, cinq ouvrages de prise d'eau au fleuve ont été construits pour alimenter en eau les périmètres agricoles. Les ouvertures et fermetures sont faites à la demande des exploitants agricoles pour les besoins en eau de leurs parcelles. En pratique, ces ouvrages sont ouverts toute l'année. Une des conséquences de l'ouverture de ces ouvrages est d'inonder également les cuvettes périphériques plus basses et non aménagées. C'est le cas de la cuvette de Louessa dans le bassin de Keur Macène. Dans cette zone, l'irrigation de 770 hectares en 1997 a entraîné la submersion de 7.000 hectares de bas fonds sans possibilité de vidange.

La situation sanitaire du bétail à l'Ouest de Rosso est préoccupante. L'espace pastoral s'est considérablement réduit sous l'effet conjugué de l'emprise croissante des périmètres et de l'assèchement des nombreuses cuvettes interdunaires du Chemama, espaces traditionnellement pâturés en saison sèche par les troupeaux bovins des pasteurs maures. Les pâturages restants sont insuffisants ou de mauvaise qualité : les pâturages secs de la périphérie dunaire ne peuvent nourrir les troupeaux que jusqu'au mois de décembre. Or les exploitants agricoles ne disponibilisent pas les sous-produits des cultures car ils souhaitent ne pas endommager leurs diguettes. Les éleveurs sont donc contraints de donner des aliments complémentaires aux troupeaux de décembre à juin. Par ailleurs, se pose un problème d'abreuvement du bétail: les seuls points d'eau disponibles sont ceux des cuvettes d'eaux stagnantes les plus proches du fleuve, milieu idéal de développement de la douve du foie (*Fasciola hepatica).* Les éleveurs sont conscients du danger sanitaire que représentent les cypéracées des bordures de ces cuvettes infestées de métacercaires de *Falsciola hepatica* mais sont dans impossibilité de contrôler la pâture du bétail venu s'abreuver.

Un effet positif: le développement spontané des cultures maraichères

Du côté positif, les cultures maraîchères se sont rapidement développées aux endroits où le réservoir est en contact avec des dunes fossiles, contribuant ainsi substantiellement aux revenus de certains villages. Cette évolution s'est cependant faite de manière anarchique et les champs sont généralement implantés sur une bande étroite en bordure du réservoir, ce qui crée des difficultés d'accès à l'eau pour le bétail et la faune sauvage, phacochères notamment, qui endommagent les cultures. Des enclos sont alors réalisés à l'aide de branches d'*acacias*, réduisant d'autant les réserves locales de bois. Comme le niveau de la retenue a progressé chaque année, les jardins maraîchers ont été régulièrement déplacés, ce qui augmente encore la demande en bois.

De même que l'agriculture de décrue dans le cours moyen du fleuve, les cultures maraîchères dans le delta ont été mises à mal par les "lâchers sauvages" de Manantali (tests de logements des turbines, lâchées pour réparations, etc.), qui ont entraîné des élévations soudaines et hors-saison du niveau d'eau, emportant les semis ou noyant les légumes mûrs. Certaines années, il y a eu une deuxième pointe de crue à l'automne; en 1996, on a déploré un importante lâcher au printemps, en rapport avec un test pour le projet de la "vallée fossile" qui prévoit de réinonder le Ferlo.

La prolifération des plantes envahissantes et des oiseaux granivores

La superficie noyée par le réservoir, qui était autrefois une importante zone de pêche, de cueillette et de pâturage, est actuellement envahie par *Typha australis*. Cette étendue de roseaux fournit un refuge et des sites de nidification pour les oiseaux granivores. Avant le barrage, les taux de mortalité de ces oiseaux étaient extrêmement importants pendant la saison sèche. Ils trouvent maintenant d'excellentes conditions de vie tout au long de l'année et leurs effectifs ont augmenté de façon sensible. Si leur impact sur les champs des petits producteurs, surveillés en permanence, est inférieur à 1%, ils causent des pertes pouvant atteindre 50% de la récolte sur les parcelles industrielles dont les exploitants sont absents.

Cette situation a incité les gouvernements à déclarer, avec l'aide de la FAO, une guerre sans merci aux oiseaux granivores. Des doses massives de pesticides sont ainsi épandues sur les sites de nidification et les dortoirs. Mais, dans certains cas, les doses employées dépassaient de plus de dix fois les quantités recommandées et des colonies de hérons ont été accidentellement éliminées.

Bien que l'on n'ait pas pu établir de relation de cause à effet, les effectifs de grues couronnées *Balearica pavonina* du delta se sont effondrés peu après le début des opérations d'épandage, passant d'un chiffre relativement stable de 500 à près de 150 individus. Des plans ont été préparés pour intensifier le programme de lutte contre les oiseaux (davantage de véhicules, d'avions et de pesticides) afin de parvenir à une éradication totale, et ce pour un coût dépassant celui des pertes de récolte selon des calculs préliminaires. Les incitations à l'étude de solutions de remplacement semblent assez limitées.

2.2.2 Les effets en aval

Mis à part la consigne sur l'énergie à dissiper les responsables du barrage n'ont pas de directive en ce qui concerne la partie du fleuve en aval de l'ouvrage. De 1986 à 1993, les lâchers sont restés minimes ou inexistants. L'hyper-salinité des eaux en aval du barrage a entraîné une importante mortalité des mangroves et des pâturages et vraisemblablement diminué la production de poissons et de crevettes dans l'ancien estuaire.

Les premières études réalisées à la fin des années 70 avaient déjà montré qu'un barrage à Diama en privant d'eau douce le bas delta mauritanien aurait un profond impact sur les ressources en aval. Il avait donc été proposé de créer un parc national sur le côté mauritanien et de le doter de vannes autorisant un apport d'eau douce dans la plaine d'inondation et permettant de créer un estuaire artificiel en aval du parc (une sorte de dérivation des eaux pour contourner le barrage), afin de préserver une partie au moins de la diversité biologique et de la productivité estuarienne.

Les partisans de ce projet avaient insisté sur le fait que les vannes et les digues qui s'avéraient nécessaires devaient être opérationnelles avant la fermeture de Diama en 1986. Le Parc National du Diawling, d'une superficie de 16.000 ha a ainsi été créé en 1991, mais sans aucune des infrastructures hydrauliques indispensables à son fonctionnement. En l'absence de terrains agricoles dans le bas delta, l'OMVS considérait que ces investissements n'étaient pas prioritaires et la zone inondable à l'ouest de la digue rive droite est devenue un désert salé. Dans le cadre d'un projet de conservation des zones humides, l'UICN a pu installer des infrastructures hydrauliques qui sont toutes fonctionnelles depuis 1998.

Heureusement, entre-temps les grands lâchers effectués à Diama en 1994 et 1995 ont contribué à inonder le parc par l'aval (au prix cependant de l'effondrement de quelques digues). Ces inondations, proches du projet de gestion du Parc, ont prouvé que les biotopes du bas delta avaient encore une énorme capacité de régénération. En revanche, en 1996, en raison d'une baisse de niveau à Manantali (fuites, réparations), l'inondation artificielle a été provoquée tardivement (en ratant l'occasion d'amplifier l'inondation naturelle due aux affluents non contrôlés) et les lâchers effectués à Diama ont donc été très limités.

3. La gestion future des eaux du fleuve Sénégal

3.1 Les prochaines contraintes de gestion des eaux

La mise en service de la centrale hydro-électrique prévue en l'an 2000 correspond à une nouvelle étape de l'aménagement de la vallée. Initialement, la création d'une crue artificielle par des lâchers de Manantali était une étape provisoire. Mais les 10 années de fonctionnement du barrage ont démontré la nécessité de maintenir et de renforcer une crue artificielle dont la programmation n'est plus actuellement remise en cause. Cependant les décisions de lancer les chantiers de réalisation du projet "énergie" et de relancer le projet "navigation", induisent de nouvelles contraintes de gestion des eaux.

En effet, la gestion des eaux du barrage-retenue de Manantali devra tenir compte de deux objectifs contradictoires: d'une part la nécessité d'effectuer des lâchers pour maintenir une crue artificielle et d'autre part la contrainte de garder à Manantali un stock d'eau suffisant pour assurer la production d'électricité.

Les futures consignes de gestion du barrage de Diama lui assignent une seule fonction: maintenir une cote constante

plus élevée encore que la cote actuelle puisqu'il est prévu que le barrage soit géré à la cote 2,50 m ce qui représenterait un stock d'eau de 535 millions de m^3.

3.2 Les effets probables d'une gestion de la retenue de Diama à la cote fixe de 2,50 m

La gestion de Diama à la cote 2,50 m risque d'amplifier les effets négatifs déjà observés. En effet, une telle augmentation de la cote nécessite un rehaussement de la digue en rive droite, déjà très endommagée par la circulation des véhicules en hivernage. A l'Est de Rosso, un prolongement de cette digue est envisagé sur près de 100 km augmentant ainsi la superficie de la retenue. Le principal inconvénient de la future gestion de Diama est qu'aucune fluctuation des cotes de la retenue n'est prévue. Les effets négatifs déjà observés dans la retenue et dans les cuvettes adventices à l'Ouest de Rosso (forte prévalence des maladies hydriques, prolifération des plantes envahissantes) seront reproduits à l'Est de Rosso.

L'augmentation des superficies inondées va également ennoyer les jardins maraîchers qui se sont développés à la périphérie de la retenue et si le niveau d'eau augmente dans les cuvettes adventices, l'ennoiement de certains villages installés en bordure de l'Erg du Trarza (Bneinadji, Nbegue, Bouteïdouma, Dara, Dar es Salam) est également probable. Par ailleurs, on peut supposer qu'une augmentation du stock d'eau dans la retenue aura des effets proportionnels sur la remontée de la nappe salée à la périphérie de la retenue.

Dans la gestion future de la retenue, il n'existe toujours pas de consignes pour la gestion des eaux en aval du barrage de Diama. Ceci est d'autant plus préoccupant que les années de faible pluviométrie il n'est pas certain que la quantité d'eau stockée à Manantali soit suffisante pour garantir à la fois la production hydroélectrique et la réalisation d'une crue artificielle. En l'absence de crue artificielle, le barrage de Diama restera fermé. Les années de faible pluviométrie les seuls apports en eau douce en aval du barrage de Diama seront donc ceux qui transitent par les ouvrages du Parc du Diawling.

Par ailleurs, la gestion à une cote aussi élevée n'est pas sans risque pour le barrage lui même. Le barrage a été construit pour être géré une cote en amont à 1,50 m. Une ouverture du barrage avec une cote de 2,50 m produit une énergie double du seuil à ne pas dépasser pour éviter les risques d'affouillement (Coyne & Bellier, 1987).

3.3 Les programmes d'atténuation des impacts négatifs sur l'environnement

Conscients des effets négatifs déjà observés sur l'environnement et des difficultés de gestion à venir, l'OMVS et ses bailleurs de fonds ont adopté en 1997 un "Programme d'Atténuation et de Suivi des Impacts sur l'Environnement" (PASIE). L'un des volets importants de ce programme consiste en un "Programme d'optimisation de la gestion des réservoirs" dont le but est la production d'un "Manuel de gestion des réservoirs" tenant compte des différentes contraintes de gestion des eaux et visant à minimiser les impacts négatifs des nouveaux projets.

3.4 La future gestion du barrage de Manantali

Dans le cadre d'un contrat avec l'OMVS, l'ORSTOM (devenue IRD) a été chargée de déterminer l'importance du soutien de la crue naturelle devant être assuré par les lâchers de Manantali tout en minimisant les pertes de production électrique. L'idée est de coordonner les lâchers de Manantali et la crue naturelle sur les affluents non contrôlés. Cependant il est probable que malgré ces possibles économies d'eau, il ne sera pas possible de satisfaire à la fois l'objectif de la crue et ceux de la production hydroélectrique en cas de faible pluviométrie. Dans cette éventualité, qui s'est révélée fréquente ces dernières décennies, il n'est pas certain qu'il y ait crue artificielle.

Le programme comprend également un volet "Programme de santé environnementale" dont le but est d'améliorer les conditions sanitaires dans la vallée, et en particulier de lutter contre la bilharziose et le paludisme observés autour des réservoirs.

3.5 Le cas de la retenue de Diama

Mais ces programmes d'optimisation de la gestion des réservoirs concernent pour l'instant surtout la gestion du réservoir de Manantali et très peu celle de Diama. Aucune des décisions prises jusqu'à présent ne va dans le sens d'une atténuation des effets négatifs observés autour de la retenue de Diama.

Il existe donc un décalage entre les effets négatifs de la gestion de la retenue à une cote constante, le discours de l'OMVS qui souhaite limiter ces effets négatifs, et le projet de gérer la retenue à une cote fixe supérieure.

Ce décalage est lié à la fois à un problème de perception (la retenue n'est pas perçue comme une zone humide à gérer en tant que telle) et de communication institutionnelle. Une gestion optimale des eaux de Diama prendrait en compte l'avis de tous les usagers y compris non-agricoles.

4. Vers une gestion alternative du barrage de Diama

4.1 Envisager une gestion dynamique des eaux ?

4.1.1 Les fluctuations du niveau de la retenue de Diama

Les multiples effets négatifs observés posent le problème de l'adaptation de ce type de barrage-retenue à un milieu autrefois rythmé par la crue. Tandis que le système naturel tirait sa richesse de la dynamique des eaux de crue, la logique de gestion du barrage de Diama consiste à stocker de l'eau à la hauteur la plus élevée possible pour satisfaire aux objectifs de production agricole. Les impacts négatifs d'une telle logique de stockage de l'eau ont contribué à fortement dégrader les conditions de vie des populations. Compte tenu

de l'irréversibilité de certains de ces effets et du coût économique, social et écologique qu'ils engendrent, il n'est pas rationnel de poursuivre ce type de gestion.

La poursuite de cette démarche de stockage de l'eau est d'autant plus illogique qu'elle est incompatible avec certains des objectifs affichés de l'OMVS: certes à court terme, les frais de pompage seront réduits mais à long terme, les effets de la salinisation des sols auront des impacts négatifs sur la rentabilité des périmètres et l'abondance de *Typha australis* gênera la navigation.

L'idée de faire varier les cotes de la retenue de Diama n'est pas nouvelle: à la fin des années 1970, les consultants du cabinet Ganett et Fleming (1981) suggéraient même une intrusion des eaux salées marines dans la retenue. L'objectif de cette opération visait à réduire les risques de bilharzioses et à améliorer le potentiel piscicole de la retenue (par réintroduction des espèces saumâtres). Les difficultés techniques de cette opération ont été jugées trop importantes et l'idée a été rejetée en décembre 1996 (OMVS,1997).

Une autre proposition plus simple à réaliser sur le plan technique est celle d'une fluctuation des cotes de la retenue pour limiter la prolifération des plantes envahissantes et réduire les risques de maladies hydriques.

Dès la construction du barrage, les ingénieurs-conseils envisageaient que soit "décidée à certaines périodes de l'année une baisse du plan d'eau sous la cote 1,50 m de façon à faciliter la vidange de certains casiers ou bas fonds ou à améliorer la qualité des eaux" (Coyne et Bellier, 1987).

C'est une proposition qui avait été faite par Cogels dès 1991 à propos du lac de Guiers (Cogels, 1991) et par le consultant Blue Niles Associates (1993) dans une étude commandée par la Banque Mondiale. Mais l'OMVS et les bailleurs de fonds ont estimé que l'instauration d'un programme sanitaire comprenant le désherbage et l'aménagement des abords de la retenue serait plus efficace et l'idée semble abandonnée pour l'instant. De même les solutions envisagées pour lutter contre l'envahissement du *Typha australis* sont des solutions mécaniques (emploi d'une faucardeuse).

Pourtant une telle fluctuation de la retenue permettrait, sinon d'éliminer, du moins de minimiser les impacts négatifs d'un plan d'eau fixe et prendrait en compte les intérêts des usagers non-agricoles.

4.1.2 La prise en compte des besoins de tous les usagers

Les effets négatifs d'une gestion de Diama à une cote élevée et constante sont d'autant plus minimisés que seul l'avis des exploitants agricoles est pris en compte dans les décisions concernant la gestion des eaux.

Les programmes de gestion des deux barrages sont arrêtés au cours d'un Conseil des Ministres au vu des recommandations faites par la Commission Permanente des Eaux (CPE). Cette commission est un organisme composée d'experts des trois pays membres qui se réunit deux fois par année. Dans la pratique, ce sont surtout des experts agricoles.

Sur ordre du Haut commissariat de l'OMVS, les consignes de gestion sont exécutées par la Société de Gestion de Diama (SOGED) et par la Société de Gestion de Manantali (SOGED). Ces deux sociétés privées créées en 1997 sont chargées d'appliquer la tarification des eaux aux usagers agricoles.

La gestion des ouvrages secondaires est confiée à la SONADER qui est l'organe de transmission entre les exploitants agricoles et l'OMVS. Pour la gestion de ses ouvrages hydrauliques, le Parc National du Diawling doit également passer par l'intermédiaire de la SONADER.

Les liens institutionnels entre le sommet et la base n'existent que pour le secteur agricole. Dans ce système où la notion d'usager se limite donc celle d'exploitant agricole, les intérêts des éleveurs, des pêcheurs et des petits maraîchers ne sont pas pris en compte. Au cours des nombreux entretiens menés dans le bas delta, ces usagers non-agricoles ont tous exprimé le souhait de voir fluctuer la cote de la retenue. Une telle fluctuation permettrait en effet aux éleveurs de réduire les risques de maladies hydriques affectant leur bétail et disponibiliserait des pâturages de décrue en saison sèche. La baisse des eaux de la retenue permettrait également aux petits maraîchers de réaliser des cultures de décrue sur la périphérie dunaire. Enfin, la disparition des typha permettrait aux pêcheurs de retrouver des espaces de pêches actuellement inutilisables.

4.2 Avantages et inconvénients du scénario hydrologique proposé.

L'hypothèse d'une fluctuation des cotes de la retenue a peut être été rejetée un peu rapidement. Nous nous proposons d'envisager les avantages et les inconvénients d'un tel scénario.

Cette opération est techniquement réalisable puisque la possibilité en est envisagée par le constructeur du barrage. Ce scénario aurait probablement des effets positifs sur les sols, la situation sanitaire, et les activités de pêche et d'élevage.

4.2.1 Les bénéfices attendus d'un tel scénario

Un apport d'eau douce en aval du barrage

L'expérience du Parc du Diawling a montré qu'un apport d'eau douce a des effets bénéfiques sur les écosystèmes de l'estuaire en aval qui souffrent principalement d'une augmentation de la salinité depuis la construction du barrage.

En l'absence d'ouverture de Diama, les ouvrages du Parc National du Diawling peuvent apporter du 1er juillet au 31 octobre environ 50 millions de m^3 d'eau douce à l'estuaire au maximum. Cette quantité, bien que capable de convenir aux espèces halieutiques estuariennes et de favoriser le développement de la mangrove, est insuffisante pour une

inondation permettant un bon développement des pâturages sur les terres hautes et la recharge des nappes dunaires.

Les quantités apportées par Diama sont vingt fois supérieures (de l'ordre du milliard de m^3 pour la période du 1er juillet au 31 octobre 1998). Il serait souhaitable que des consignes de gestion soient édictées pour l'aval de Diama, par exemple:
- assurer 1,20 m IGN dans le N'Tiallakh pendant 40 jours entre la mi-aout et la fin du mois d'octobre;
- ne pas dépasser une salinité de 40g/l dans la partie aval du N'Tiallakh en saison sèche.

Ces consignes seraient très bénéfiques pour les écosystèmes du bas delta et pour la production halieutique (mulets, etc.) d'une zone plus vaste.

Les effets sur les systèmes végétaux

Il est peu probable que quelques mois de baisse du plan d'eau suffisent à supprimer les étendues de *Typha australis*, mais une baisse du plan d'eau faciliterait l'utilisation de moyens de lutte mécanique complémentaires et permettrait à l'avenir d'en contrôler le développement excessif. Des études menées en rive gauche du fleuve ont démontré qu'une coupe à 50 cm sous la surface de l'eau empêche la repousse du typha. On pourrait donc par exemple envisager de brûler le typha lorsque le niveau des eaux est à son minimum puis remonter la cote rapidement.

Un autre avantage de cette possibilité de vidange des cuvettes interdunaires serait de disponibiliser des pâturages de décrue. Au delà, on pourrait même envisager de restaurer certaines parties du réservoir pour en faire des pâturages de haute qualité.

Des effets plus limités sur la santé humaine et animale

Il semble en revanche qu'une diminution du plan d'eau pour quelques mois ne soit pas une mesure suffisante pour éliminer les mollusques vecteurs de la bilharziose et des distomatoses animales. Mais à défaut de suffire à leur éradication, une cote moins élevée de la retenue aurait un effet probable sur leur rythme de ponte et présenterait au moins l'avantage d'éviter une colonisation des bas fonds proches des villages.

4.2.2 Les contraintes possibles

Les pertes en eau

Certes, dans un contexte de tarification de l'eau, on peut objecter que de telles ouvertures de Diama représenterait des "pertes" pour la SOGED. Cependant les pertes en eau pour la SOGED seraient compensées par les effets limités de l'évaporation sur la retenue: à la cote 1,50 m IGN le lac a une contenance de 250 millions de m^3, soit une surface d'environ 166 km^2 ce qui correspond très approximativement à une évaporation de 1 million de m^3/jour, tandis qu'à la cote 2,50 m, le réservoir pourrait contenir 535 millions de m^3, ce qui représenterait une surface de 214 km^2 et une évaporation d'environ 1,5 million de m^3/j. Une baisse de la retenue de Diama permettrait donc "d'économiser" 500,000 m^3/j.

Le coût agricole

La principale contrainte de ce scénario serait de concurrencer les objectifs agricoles considérés comme prioritaires de Keur Macène à Rosso. Cependant, si les dates de vidange tiennent compte du calendrier cultural, il n'y a pas incompatibilité entre l'agriculture irriguée et une gestion dynamique des eaux.

En rive droite du fleuve, il n'existe pas pour l'instant de double saison culturale pour le riz. Quelques agriculteurs ont expérimenté les cultures irriguées maraîchères en contre-saison, mais elles se sont avérées peu rentables (importance des *Quelea quelea*, appauvrissement des sols) et le seront encore moins à l'avenir s'ils doivent payer l'eau. Les cultures de contre-saison, notamment de la tomate, sont plus importantes en rive gauche.

Pour ne pas perturber ces cultures de contre-saison, on pourrait donc par exemple envisager de vidanger les eaux de la retenue au cours des mois de novembre, décembre et janvier ce qui laisserait une marge suffisante pour à nouveau remplir la retenue pour préparer les cultures de contre-saison froide (mars et avril).

Une baisse des eaux permettrait aussi d'augmenter les superficie du maraîchage de décrue sur les abords immédiats de la retenue de Diama, maraîchage qui se pratique déjà de manière spontanée lorsque les gestionnaires de Diama font baisser le plan d'eau.

De plus, l'assèchement des canaux d'alimentation des périmètres permettrait de programmer un curage des axes hydrauliques et limiterait au moins durant une partie de l'année les coûts de pompage pour le drainage des périmètres. Ce drainage est tout à fait essentiel si l'on souhaite développer l'irrigation de ces terres basses. Une étude menée (JICA, 1997) souligne les très mauvais résultats de l'agriculture irriguée de Rosso à Keur Macène. En 1997, la surface aménagée représentait un tiers des plaines inondables mais le taux de mise en culture de ces périmètres serait seulement 15% et la moyenne de rentabilité de 1,1 tonnes/ha. Cette étude souligne que ces mauvais résultats sont liés à une importante salinité de ces sols (sur 13.730 ha, seuls 1.040 ha ont été classés "très adéquats" ou " moyennement adéquats " à la riziculture soit moins de 8%) et à l'absence de pratique de drainage. Le projet qui vise à réhabiliter des périmètres insiste donc sur la nécessité d'adapter les infrastructures hydrauliques à un drainage.

La première idée de la SONADER consistait à drainer gravitairement les eaux vers la dépressions du Chatt Boul, site écologique d'importance internationale (Ould El Haçen, 1997). L'étude japonaise exclut cela et préconise un pompage des eaux usées vers la retenue de Diama. Pour favoriser le développement des pâturages, le projet prévoit également que les niveaux d'eau dans les bas fonds soient maintenus à la cote 0,75 m IGN grâce à un important dispositif de pompage. Une cote moins haute de la retenue diminuerait donc les coûts de pompage pour le drainage et la vidange des cuvettes.

5. Conclusions

Si l'on veut atténuer les effets négatifs du barrage de Diama et réellement envisager une gestion optimale du réservoir, il convient de prendre en compte les intérêts de tous les usagers, y compris non-agricoles (pêcheurs, éleveurs, cueilleurs) et qui limiterait les risques sanitaires et environnementaux. Une telle gestion pourrait être de faire baisser le niveau des eaux de la retenue en début de saison sèche. Les avantages de ce scénario sont nombreux tant pour les écosystèmes que pour les différents systèmes d'exploitation y compris l'agriculture irriguée. Un véritable calcul coûts - bénéfices permettrait de vérifier la validité de ce scénario de gestion intégrée des eaux.

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Part IV:

International Co-operation for Integrated Wetlands and Water Resources Management

Article 4.1
Priorities for Wetland Biodiversity Conservation in Africa

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Keywords: Africa, wetlands, biodiversity, conservation, policy, inventories.

The African continent and its islands are bound to be preoccupied by water issues. As a matter of fact, water is the determining element for the availability of natural resources throughout Africa. Most African people directly rely on natural resources for drinking water, food, shelter, health and domestic energy supply. In this regard, wetland ecosystems cannot be ignored, as they are providers of key functions and water resources. Priorities for wetland conservation are complex issues ranging from the individual concerns of a local fisherman to the global targets and objectives of international agreements such as Agenda 21.

African countries share a common interest and view in relation to wetland biodiversity conservation. The main problems and threats that face wetland biodiversity conservation in Africa are linked to insufficient political will, poor policies and strategies and a lack of suitable legislative frameworks. This is leading to insufficient programmes and activities for the protection of wetland functions and values. There is also a dilemma when it comes to making decisions about short-term benefits that are derived from inadequate land use practices versus medium and long-term programmes that sustain wetland functions and values.

In response to these challenges, water and wetland policies/strategies, legislation and regulation, pollution control, economic valuation techniques, training and environmental education and public awareness are some of the areas where efforts are being made to conserve wetland biodiversity in Africa. The present paper explores those priority actions that are likely to overcome or alleviate the major problems associated with the loss of biodiversity due to wetland ecosystem degradation.

Priorités pour la conservation de la biodiversité des zones humides en Afrique

Mots-clés: Afrique, zones humides, biodiversité, conservation, politiques, inventaires.

Le continent africain et ses îles sont préoccupés par des questions d'eau. En effet, l'eau est l'élément déterminant pour la disponibilité des ressources naturelles dans l'ensemble de l'Afrique. La plupart des africains dépendent directement des ressources naturelles pour l'eau potable, la nourriture, l'abri, la santé et l'approvisionnement en énergie domestique. A cet effet, les écosystèmes des zones humides ne peuvent être ignorés car ils sont les fournisseurs de fonctions écologiques clé et des ressources en eau. Les priorités pour la conservation des zones humides sont des questions complexes qui s'étendent entre les soucis personnels d'un pêcheur local et les cibles et objectifs principaux des accords internationaux tel que l'Agenda 21.

Les pays africains partagent un intérêt et une opinion communs par rapport à la conservation de la biodiversité des zones humides. Les problèmes et les menaces principaux qui s'opposent à la conservation de la biodiversité des zones humides en Afrique sont liés à une volonté politique insuffisante, aux politiques et aux stratégies faibles et à un manque de cadres législatifs appropriés. Ceci mène à des programmes et des activités insuffisants pour la protection des fonctions et des valeurs des zones humides. Il y a également un dilemme lorsqu'il s'agit de prendre des décisions au sujet des avantages à court terme qui sont dérivés des pratiques d'utilisation de la terre indadéquates, et des programmes à moyen et à long terme qui soutiennent les fonctions et les valeurs des zones humides.

En réponse à ces défis, des efforts pour conserver la biodiversité des zones humides en Afrique sont entrepris, notamment dans les domaines suivants: l'eau et les zones humides, les politiques et strategies de l'eau et des zones humides, la législation et les règlements, la lutte contre la pollution, les techniques d'évaluation economique, la formation, l'éducation et la conscience environnementale publique. Cet article explore ces actions prioritaires susceptibles de surmonter ou d'alléger les problèmes principaux associés à la perte de biodiversité due à la dégradation des écosystèmes des zones humides.

1. Introduction

Wetland biodiversity conservation in Africa is facing many problems including poor policies and a lack of suitable legislative frameworks as a result of insufficient political will. Another important issue is the dilemma of making choices between attractive short-term benefits that can be derived from unsustainable practices and long term programmes that sustain productive wetland ecosystems. This paper addresses these issues with particular attention to the question of how African countries can mobilise existing knowledge and capacity to foster political will and activate decision-makers for wetland conservation and wise use.

Many scientists and some resource managers are aware of the importance of wetlands and recognise that they are among the most valuable ecosystems on earth. Table 1 illustrates the monetary value of wetlands as defined by the Convention on Wetlands (Ramsar, Iran, 1971).

Taking into account the definition of wetlands, the economic value of wetland ecosystems includes not only the value relating to "wetlands" as specified in this table but also the coastal, lacustrine (lakes) and riverine (rivers) ecosystems. Wetlands, including lakes and rivers contain at least US$ 6.6 trillion/year of the world's natural capital, corresponding to 20% of the global value.

Despite their global importance, wetlands are still perceived as waste lands by many decision- makers in African countries. Some water users are even considering wetlands as competitors for water. At the Regional Pan-African Meeting in Uganda (Kampala 1998), Contracting Parties to the Convention on Wetlands recognised that "in many cases, the greatest threat to wetlands is land use which does not take water conservation objectives into account, since the shortage of land makes wetlands a target for gaining land through drainage". The new approach of the Convention on Wetlands to incorporate water resource management when dealing with wetland biodiversity conservation, is one of the answers to this problem. In this context, the conservation and wise use of wetland biodiversity is addressed through the wider perspective of the sustainable use of land and water.

2. Major issues linked to wetland conservation in Africa

The major challenge facing wetland conservation in Africa is how to identify and apply efficient incentive measures to maintain and improve the livelihood of local people in wetland areas while safeguarding wetland functions including biodiversity. Land use and water management are important issues to be addressed as they form the basis for sustainable development of wetlands. This requires however an interest and willingness within numerous local, regional and national institutions and interest groups that deal with land and water management at local, national and international levels. Wetland management in contrast is mostly considered a sectoral issue under the responsibility of a single national institution. Given the close link between wetland management and land and water use, there is an urgent need to establish mechanisms to co-ordinate the work carried out on wetland conservation and wise use between these various institutions at all levels.

The Convention on Wetlands offers a framework for national co-operation through the Ramsar National Committee that includes representatives from governmental institutions, NGOs and local communities. A number of ecological, socio-cultural, economic and political constraints have to be addressed through this co-ordinating mechanism. In response to these constraints, the Convention on Wetlands and its Partner Organisations (IUCN, WWF, Wetlands International and BirdLife International) are being instrumental in urging African countries to work on various key issues for the conservation of wetland ecosystems in Africa. These include: economic valuation and development of incentives to change public and decision makers' behaviour; training, environmental education and communication in order to raise

Table 1: THE ECONOMIC VALUE OF ECOSYSTEM SERVICES

Ecosystem	Area	Value	Global Value	% Total
	(Million ha)	(US$/ha/yr)	(US$ trillions/yr)	Value
Open Ocean	33,200	252	8.4	24.7
Coastal	3,102	4,052	12.6	38
Tropical forest	1,900	2,007	3.8	11
Other forests	2,955	302	0.9	3
Grasslands	3,898	232	0.9	3
Wetlands	330	14,785	4.9	15
Lakes and Rivers	200	8,498	1.7	5
Cropland	1,400	92	0.1	0.3
Total annual worth of the services provided by the Biosphere:			**US$ 33.3**	**100%**

Reference: Costanza *et al.*, 1997

the profile of wetland issues among young people; water and wetland policies, legislation and regulation; community empowerment and capacity building to promote an enabling environment and pollution control; climate change; invasive species control; threatened species conservation and programmes on representative ecosystems to adapt to a changing environment.

3. Identifying priorities for wetland biodiversity conservation in Africa

Identifying priorities for wetland conservation is a complex exercise since it involves a number of interests ranging from local to global levels. In addition, the decision about priorities can be made on different grounds: scientific, social, economic or political. So far, in Africa decision-makers are mainly politicians and as such they prefer to make decisions on political grounds. However, economic and social considerations can considerably influence political decisions. To promote the conservation of wetland biodiversity in Africa, we need therefore to improve the understanding of the socio-economic relationships between wetland resources and the interests of stakeholders. This knowledge can then be used to persuade politicians and incite them to take action for the conservation and sustainable use of wetlands.

Hence it is useful to identify and collaborate with the interest groups with the most direct dependency on wetlands, such as fishermen for whom wetland biodiversity is the primary means of income and food security. Empowering those interest groups can be an efficient strategy for promoting partnership between stakeholders and political decision-makers when it comes to define how to manage and use wetlands best. Indeed, African political leaders are very receptive to any actions that can contribute to food security. As a result, identifying and implementing pertinent options, which combine food security and biodiversity conservation, are critical for wetland biodiversity conservation in Africa. In this respect, it is useful to recognise the rights of local communities over the biodiversity that exists in the wetlands they manage and their traditional knowledge and practices. The value of sustainable use to local people should be promoted through a combination of traditional knowledge and practices and the latest appropriate technologies and scientific understanding.

Decisive steps should be taken to promote the wise use concept and practices. This requires a number of actions to create an enabling environment that supports and encourages the efforts of different actors. These actions include for instance adequate policies, co-ordinated conventions and guidelines on land use. Development of wetland policies and strategies and legislative reviews are essential tools to adopt in each country. At present, Uganda is the only African country which has a National Wetland Policy along with a National Wetland programme to implement it. Ghana has recently developed a draft National Wetland Strategy and several other countries are drafting wetland policies including Botswana, Kenya, Namibia, South Africa and Zambia.

Most French speaking countries do not have a wetland policy including Algeria, Burkina Faso, Chad, Congo, Ivory Coast, Democratic Republic of Congo, Federal Republic of Comoros, Guinea, Mali, Morocco, Niger, Senegal, Tunisia and Togo. In some of these countries conservation and management of wetlands is considered through Biodiversity Strategies and Action Plans as for example in Algeria, Burkina Faso, Chad, The Gambia, Malawi, Mali and Niger. In Tunisia, the conservation and wise use of wetlands forms part of the water management policy. National Environmental Action Plans are integrating wetland issues in the Democratic Republic of Congo, the Federal Republic of Comoros, Guinea, Senegal and Togo.

The information above indicates that there is a clear need to co-ordinate the work of environment-related conventions in each country to create a synergy for the effective implementation of these international treaties. In consequence, it will be valuable to assist African Contracting Parties in implementing the Memoranda of Co-operation between the Convention on Wetlands and other environment-related conventions.

African Contracting Parties to the Convention on Wetlands recognise that the greatest threat to wetlands in Africa arises from inappropriate land use practices. Given the fact that wise use of natural resources is a complex issue, African countries need guidelines on various aspects of this concept. In response to this need, the Convention on Wetlands and its partner organisations are developing such guidelines. A new direction to these guidelines is based on a river basin approach. This approach integrates conservation and wise use of wetlands into local, regional and national planning and decision making on land use, groundwater management, catchment and river basin and coastal zones and related management issues. Since it is critical to involve all stakeholders at the river basin scale, joint action plans on shared wetlands and catchments, and concerted action at a national level is needed.

Fortunately, many African countries are increasingly committed to the decentralisation of governance and decision-making to local levels. When local administrations take responsibility for wetland management, there is an opportunity for local communities to be involved in decision making processes.
At a regional level, where a river basin is shared between two or more countries, the establishment of an international river commission can facilitate the development of a common vision for the efficient management and use of these wetlands.

4. Major questions to be answered for wetland biodiversity conservation in Africa

In trying to identify priorities for wetland biodiversity conservation, it is useful to consider the following questions:

a) Which are the most important wetlands in Africa?
   Unfortunately, most African countries do not have complete national wetland inventories to allow them to know the

full range of wetland types and to be able to identify the most important wetlands for biodiversity conservation. In addition, there is a lack of monitoring making it difficult to identify the problems in each wetland. A possible answer to this weakness is to promote integrated river basin management as indicated above. This approach will take into account every important wetland in each river basin, including those, which are shared by two or more countries.

b) Should we focus on threatened wetland types, on rare wetland types, on wetlands with rare and endangered species, on wetlands with endemic species, on wetlands with high diversity of species or on wetlands which are important habitats for useful species?

To answer this question we need again a complete wetland inventory in each country. The analysis of National Reports from the Contracting Parties to the Convention on Wetlands for the 7th Conference of the Parties indicates that Botswana, Malawi and Tunisia are the only African Contracting Parties, which have a complete national inventory for their wetlands. Zambia has almost completed one. Kenya has many wetland inventories that are being developed at various levels. Namibia indicates that a national inventory is in preparation and a first edition will be available before the end of 1999. Ivory Coast, Ghana, Kenya, Mali, Morocco, Senegal, South Africa, The Gambia and Uganda have planned comprehensive national wetland inventories for the near future. Ten countries have directories of "important" wetlands, namely, Botswana, Ivory Coast, Egypt, Kenya, Morocco, Namibia, Senegal, Uganda, Tunisia and Zambia.

Despite the lack of wetland inventories in most African countries some suggestions can be based on existing information to avoid inaction. The "*WWF Priorities and Guidelines for the Conservation of Freshwater Ecosystems in the Africa & Madagascar Region*" provides some useful suggestions. It suggests for instance to target a variety of representative freshwater ecosystems such as the Niger River, Lake Malawi, Lake Tanganyika (Tanzania), Lake Barombi (Cameroon), Lake Nawampassa (Uganda), Lake Kanyaboli (Kenya) and Lake Nabugado (Uganda). The flooded grassland and savanna, particularly the inner delta of the Niger River in Mali and the Okavango in Botswana, are also target wetlands.

Undertaking programmes for wetland biodiversity conservation should not be delayed because of insufficient information. Taking action should go in parallel with inventory development, so as to make the best use of existing information. So far the directories of "important" wetlands which already exist in at least ten African countries have not been used adequately to identify priority sites for biodiversity conservation. In fact, at the time of preparing this paper there were only 76 Wetlands of International Importance in Africa. This does not reflect the important role of wetlands in Africa for biodiversity conservation. Indeed, while Africa has only 76 Wetlands of International Importance under the Convention on Wetlands, the United Kingdom alone has 118 Ramsar sites out of the 960 sites globally. One reason for this is that most African countries do not have a clear vision for the List of Wetlands of International Importance. Some of the responses to this situation will be discussed at the 7th Conference of the Contracting Parties to the Convention on Wetlands (COP7) and it is expected that COP7 will adopt a strategic framework and guidelines for the future development of the List of Wetlands of International Importance. Another alternative for redressing this situation in Africa is to take a broader view of the criteria for the designation of Wetlands of International Importance.

c) What are the most important features to be conserved for any particular wetland?
The way Africa is described by many experts does not always help in establishing priorities, it could be advisable to avoid standardised options for wetland conservation and wise use. In fact, the range of potential solutions is diverse and they should be integrated in an attempt to combine the satisfaction of the basic needs of people while ensuring biodiversity conservation. It is essential to identify various responses to soil and wetland degradation and to apply the best practices to maintain soil fertility, wetland functions and values. To that end, it is recommended to take into account the following guidelines proposed by WWF International (1997):

- Promote healthy and productive wetland ecosystems with an emphasis on measures to be taken for pollution control, toxics and excess nutrients;
- Focus on maintaining ecological processes in areas of high biodiversity, or high conservation value in terms of biodiversity, and functional links with important forests or coastal systems;
- Address the interdependence of human and nature with respect to water resources, by taking into account the hydrological cycle, ecosystem needs, and human development imperatives.

5. Conclusions - Some tactics to be applied

In order to promote wetland biodiversity conservation in Africa, economic policies and strategies that decrease the food security of local communities should be avoided. Excessive research that does not lead to action should also be avoided. Furthermore, the understanding of possible solutions to soil and wetland degradation has to be reviewed encouraging effective local strategies.

To achieve wetland biodiversity conservation, building partnerships is essential to mobilise existing knowledge on wetlands, existing capacity and funding mechanisms at local, national, regional and global levels. At a local level, partnerships are needed between various interest groups to gain a better understanding of the major issues surrounding wetlands and to prevent conflicts. At a national level, building

partnerships means strengthening solidarity among national institutions and reaching consensus on the seriousness of problems. At an international level, partnerships should help mobilise expertise and financial assistance to promote sustainable use practices in wetland management.

Finally, it will be useful to remain realistic about the feasibility of policy and strategy implementation and law enforcement. It is essential to take into account the ecological, cultural, economic and political context in each country so as to make the best use of existing human capacity and financial resources.

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Article 4.2

International Co-operation for the Management of the Okavango Basin and Delta

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Keywords: Okavango delta, wetlands, management, Ramsar.

Wetland ecosystems are among the most productive areas in the world, but they are disappearing at an alarming rate. The Okavango delta is particularly significant as one of the largest remaining inland wetland ecosystems world wide. The main threats to the Okavango delta arise from patterns of unsustainable development. These destructive trends are outpacing policy and institutional responses in the riparian countries. While the use of the delta's water for agriculture, mining and domestic use is not necessarily ecologically unsustainable, water resource development plans must be carefully considered. In 1994, Angola, Botswana and Namibia established the Permanent Okavango River Basin Commission (OKACOM) to co-ordinate and collaborate on the sharing of the basins water resources. In 1998, the riparian states jointly requested support from GEF for the formulation and implementation of an Integrated Management Plan.

The Government of Botswana ratified the Convention on Wetlands (1971, Ramsar, Iran) in April 1997. The National Conservation Strategy (Coordinating) Agency of Botswana has sought assistance from the Ramsar Bureau and commissioned a review of the management options for the Okavango delta. The review is planned to lead to the development of an Integrated Management Plan for the Okavango Delta. This will foster the adherence of the Botswana Government to the obligations of the Ramsar Convention as well as facilitate the design of a long term development plan for the delta which will allow effective planning and a sustainable use of the delta's natural resources.

Coopération internationale pour la gestion du bassin et du delta de l'Okavango

Mots-clés: delta de l'Okavango, zones humides, gestion, Ramsar.

Les écosystèmes de zones humides sont parmi les plus productifs du monde, mais ils disparaissent à une vitesse alarmante. Le delta de l'Okavango est particulièrement notable puisqu'il est l'un des plus grands écosystèmes de zones humides continentales du monde. Les menaces principales qui pèsent sur le delta de l'Okavango résultent des tendances du développement non durable. Ces tendances destructrices dépassent la politique et les réponses institutionnelles des pays riverains. Alors que l'utilisation de l'eau du delta pour l'agriculture, l'exploitation minière et l'usage domestique n'est pas nécessairement écologiquement non-durable, les programmes de développement des ressources en eau doivent être soigneusement considérés. En 1994, l'Angola, le Botswana et la Namibie ont établi la Commission Permanente du Bassin du Fleuve Okavango (OKACOM) pour coordonner et collaborer sur le partage des ressources en eau du bassin. En 1998, les états riverains ont conjointement demandé l'appui du GEF pour la formulation et la mise en place d'un plan de gestion intégré.

Le Gouvernement du Botswana a ratifié la Convention sur les Zones Humides (1971, Ramsar, Iran) en avril 1997. L'agence de coordination de la stratégie nationale de conservation a sollicité l'aide du Bureau de Ramsar et entrepris une investigation des diverses options de gestion du delta de l'Okavango. Cette analyse prévoit de mener à bien le développement d'un plan de gestion intégrée pour le delta de l'Okavango. Ceci stimulera l'application par le Gouvernement du Botswana de ses engagements auprès de la Convention de Ramsar, et facilitera la conception d'un programme de développement à long terme pour le delta qui permettra une planification pertinente et une utilisation durable de ses ressources naturelles.

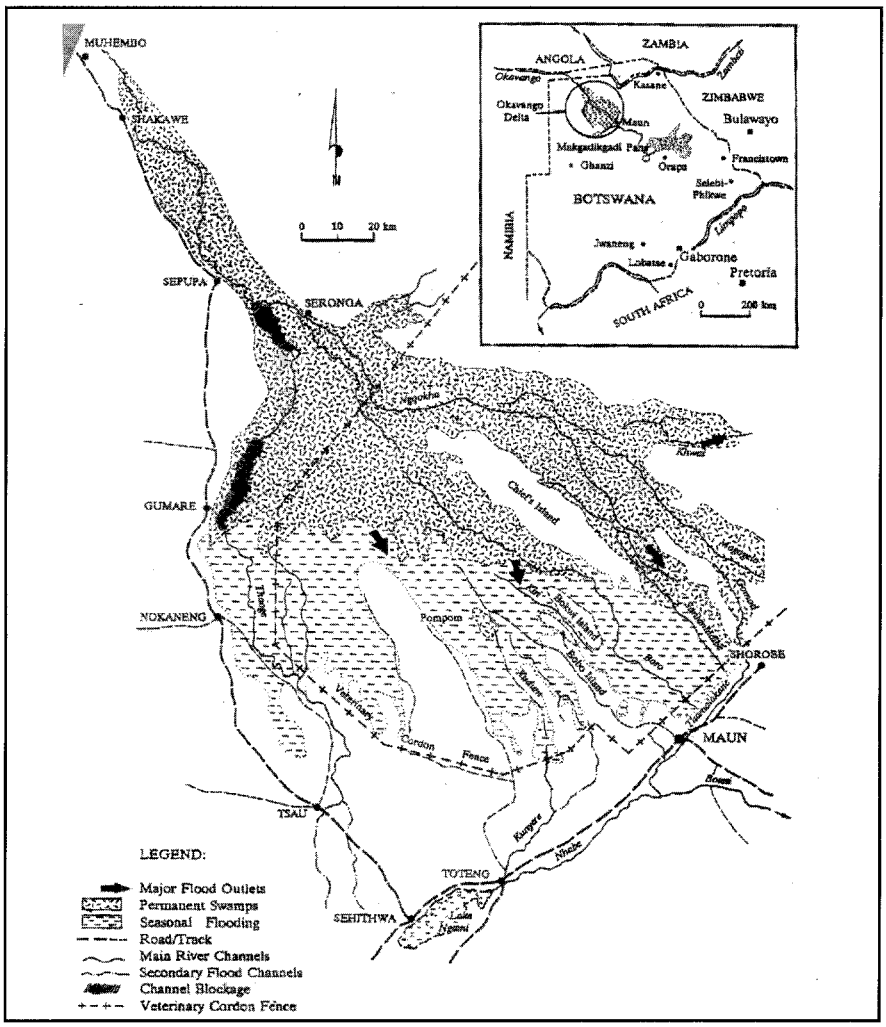
1. Introduction

Wetland ecosystems are among the most biologically productive in the world, but are disappearing globally at an alarming rate. The Okavango delta (Fig.1) is particularly significant as one of the largest remaining inland wetland ecosystems in the world. While it is not known how many rare or threatened species of flora and fauna exist in the Delta, the wetland ecosystem as a whole is a critically endangered environment of international significance. The Okavango is the habitat for two to three thousand species of plants, more than 65 fish species, over 162 arachnid (spiders, scorpion, ticks and mites) species, more than 20 species of large herbivores, and over 450 species of birds, including the endangered wattle crane. The Okavango delta is a Ramsar site listed by the Botswana Government at the time of ratification of the convention as one of the largest and most important inland wetlands in the world, covering over 15,000 km^2.

Water supplying the Okavango river originates in the highlands of Angola and after passing briefly through the Caprivi Strip in Namibia, enters Ngamiland, in the northwestern corner of Botswana. The river then flows in a well defined channel for approximately 95 km, before fanning out into a delta of interconnected rivers and reed-lined channels. Water flows out of the delta in the Boteti River and, in years of high rainfall, supplies Lake Xau. Within the Okavango delta, five broad ecological zones have been defined – perennial swamps, seasonal swamps, seasonal grasslands, intermittently flooded land, and dry land. Approximately 140,000 people reside in Ngamiland and the north western portion of the Boteti Sub-District, with 50 percent of the population in villages of less than 500 people. The economy of the region is quite diverse and includes floodplain and dryland agriculture, cattle rearing, wage labour and craft and tourist related enterprises.

While it is understood that the perpetual change of the Okavango delta's composition is necessary for the maintenance of the biodiversity of the wetland, the critical functions of the flora and the fauna in this process is only beginning to be studied. It is thought that the reeds and grasses of the Delta play a critical role in the dynamics of the water flow and the salinity of the Okavango river. Variability and salinity control maintain a wetland environment in which both human and animal populations can thrive. Although much more research is needed on the Delta's resources, it is well known that numerous plants from the area are used extensively by local people for purposes ranging from construction to medicinal uses.

Fig.1: The Okavango delta



2. Currently the Okavango delta is facing several serious threats

The main threats to the Okavango River Basin (ORB) arise from patterns of unsustainable development. If these threats are allowed to persist, they will result in fundamental and irreversible changes in the basin's water balance, energy balance, and hydrochemical and hydrogeomorphological responses. All of these will impact on the productivity of the basin as a whole.

The biodiversity of the Okavango delta is threatened primarily by the use of the delta's water resources for development purposes and by the lack of a comprehensive natural resources management plan which accommodates local participation and sustainable resource use. Additionally, tourism offers an incentive for conservation if well developed but a threat to sustainability, if unmanaged.

Key threats include overgrazing, which is already resulting in accelerated land and soil degradation in Namibia and Botswana; unplanned developments in Angola along the de-mined transport routes/corridors in the Cubango and Cuito sub-basins as post-civil-war resettlement occurs; and pressure for new and increased abstraction of water to service urban expansion and irrigated agriculture.

The foregoing trends are outpacing policy and institutional responses in the riparian countries. The primacy of national interests is resulting in the imposition of transboundary externalities on specific sectoral and cross-sectoral developments. These include the quality and quantity losses of water supplies for the cross sectoral activities which include *inter alia*, loss of biodiversity and compromised nature tourism. It is these intermediate causes related to policy and institutional failures where intervention is necessary.

3. Threats from resource development

While the use of the Delta's water for agriculture, mining and domestic use is not necessarily ecologically unsustainable, water resource development plans must be carefully considered. One such project, entailing major excavations of the Boro river and the construction of three large resevoirs, was the Southern Okavango Integrated Water Development Project (SOIWDP). The SOIWDP was designed to augment water from the Boro River to meet the needs of Maun, 10,000 ha of irrigation, and the Orapa diamond mine. While major proposals for utilizing the waters of the Okavango river and delta within Botswana date back to the beginning of the twentieth century, the origin of the SOIWD can be dated back to early 1950s with elaboration in the 1970s. Focusing on the lower portion of the Okavango delta and the Boteti River, the SOIWD was intended to achieve broad goals. These include improved utilization of land and water resources, increased food production, creation of employment opportunities and raising the living standards for the people of Ngamiland and the Boteti Sub-District.

In January 1991, following major meetings and public hearings to solicit the views of the local communities, the Government of Botswana (GOB), showing its responsiveness to local concerns, suspended the project to further review. At the invitation of the GOB, IUCN – The World Conservation Union evaluated the proposed project in 1992 and judged it ill-conceived and detrimental to the ecosystem and communities of the delta (IUCN, 1992). The GOB accepted the recommendations of the report and supported the proposed sustainable alternatives such as for instance the conjunctive use of ground and surface water. These and other sustainable and economically attractive uses of the delta, such as ecotourism, are important in alleviating the pressure to use the resources in potentially non-renewable ways.

While the Okavango delta has been used for centuries by the populations in Botswana, increasing population pressure has led to unsustainable use of the natural resources by the residents of the two districts. The expansion of human activities without assistance in management, control and ownership places tremendous pressure on the biophysical resources of the delta.

The wildlife and aquatic scenery of the delta channels and the adjacent Chobe District is the principal tourist attraction of Botswana. The Government's 1989 Tourism Policy provides guidance to tourism development, promoting improved local management and participation. Key elements stemming from the policy include support of community organisations, training activities and the development and use of guidelines for the protection of the fragile ecosystem.

4. Regional developments threatening the delta

In 1994, Angola, Botswana and Namibia established the Permanent Okavango River Basin Commission (OKACOM) to coordinate and collaborate on the sharing of the basins water resources. The agreement establishing OKACOM specifically advocates the use of Agenda 21 principles of natural resource management and acknowledges the Helsinki rules on the use of international waters.

In 1998, the riparian states jointly requested through OKACOM GEF support for the execution of a basin wide Environmental Assessment (EA) and the formulation and implementation of an integrated management plan. The integrated management plan is intended to promote the sustainable development of the Okavango river basin and the protection of the hydro-environmental and ecological intergrity, its unique wetlands and delta system.

The draft Trans-Boundary Diagnostic Assessment (TDA) which has been compiled as part of the baseline data for the Okavango Commission (OKACOM, 1998), has initiated a consultative process between the basin stakeholders, established the current status of the basin as a whole, identified causes of degradation and imminent threats, and indicated critical gaps in knowledge, policy and institutional arrangements. It is apparent from the TDA preliminary

findings that the natural resources of the basin are already subject to competing demands for water and land from agriculture, urban and industrial development both within and outside the basin.

Despite the progress made at the technical and assessment levels, the current policy and institutional arrangements are insufficient to address the externalities associated with the basin's freshwater resources management. The consequences are twofold. First, the primacy of national interests is resulting in the imposition of transboundary externalities on specific sectoral and cross-sectoral development. This includes: quality and quantity losses of water supplies for urban centres in the basin (Rundu, Maun); reduced supplies for irrigated agriculture (Caprivi and the fringes of the delta; degraded stock watering (Caprivi, Ngamiland); reduced supply for mining (Orapa); loss of biodiversity; and compromised nature tourism (Caprivi, Panhandle, Delta). Second, the costs of co-operation are high where barriers to communication, knowledge, and understanding persist. (Fig. 2)

5. A possible way forward through assistance from the Convention on Wetlands (1971, Ramsar, Iran)

The Government of Botswana ratified the Convention on Wetlands in April 1997 and is currently formulating a wetlands policy and strategy. This is being executed through a consultancy that aims at completing the work by the end of 1999. The policy and strategy will provide the framework for designing appropriate and effective management plans for each of the key wetlands.

The National Conservation Strategy (Coordinating) Agency of Botswana has sought assistance from the Bureau of the Convention on Wetlands and commissioned a review of the management arrangements for the Okavango delta. The review is planned to lead to the subsequent development of an Integrated Management Plan for the Okavango Delta. This will foster the adherence of the Botswana Government and hopefully OKACOM to the obligations of the Convention on Wetlands as well as facilitate the design of a long term development plan for the delta which will allow effective planning and a sustainable utilisation of the delta's natural resources.

The outcome of the review, as well as the Management Plan thereof, will help Botswana and OKACOM to manage the delta's resources sustainably and assist in decision making processes.

The Secretariat of the Convention on Wetlands has offered to provide funds and additional expertise to the government of Botswana to enable it to face the major challenges of the delta. In particular the Secretariat supports the development of a detailed and comprehensive proposal for a management plan, which will be carried out by a team comprising of the

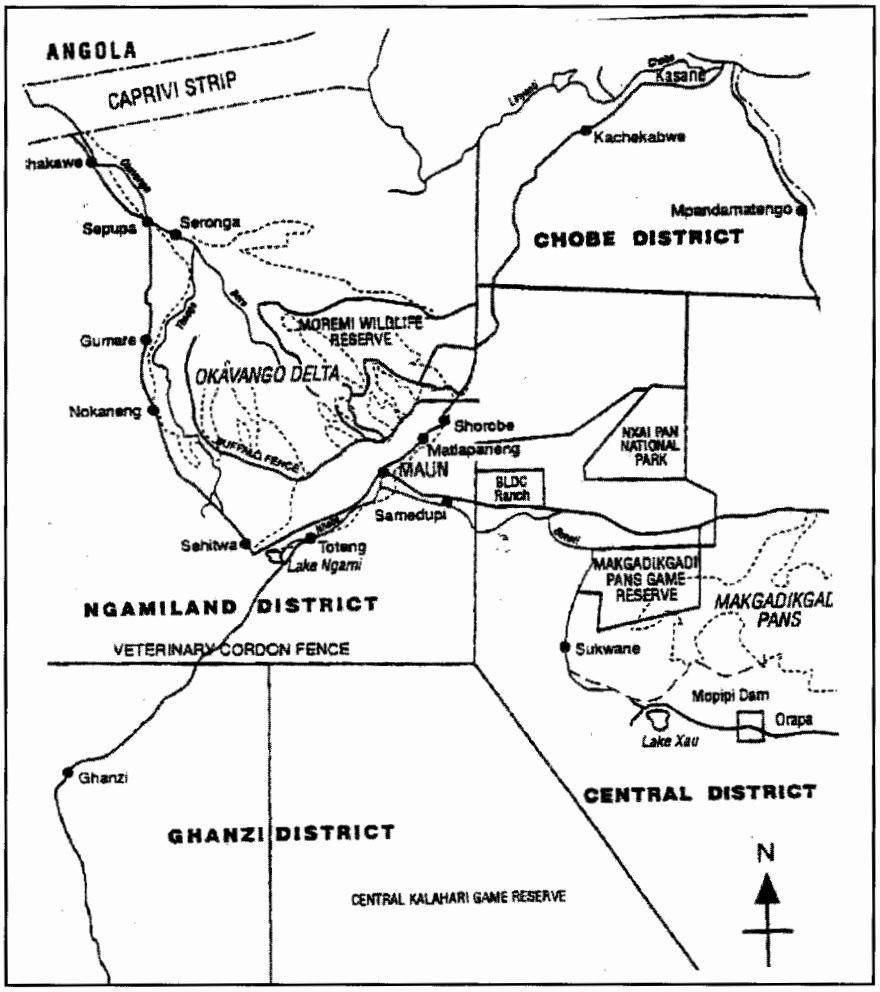


Figure 2. Southern Okavango Planning Region. In 1991 IUCN – The World Conservation Union evaluated the proposed Southern Okavango Integrated Water Development Project, designed to augment water from the Boro River to meet the needs of Maun, 10'000ha of irrigation, and the Orapa diamond mine.

relevant experts from the Botswana Government, the Ramsar Regional Co-ordinator for Africa and possibly the HOORC, University of Botswana. The mission will be required to identify existing plans and ongoing planning processes that include wetland issues or can have significant impacts on wetland conservation and wise use in the delta such as legislation review and policy and strategic formulations. The mission will also undertake a review of existing information including the positive and negative factors of resources uses and how they impact local, national and regional interest. The review will cover not only ecological aspects, but also social and economic conditions along with an analysis of the legislative framework. Discussions will be held with key stakeholders and governmental agencies and officials, including the National Conservation Strategy (Coordinating) Agency, members of the National Wetlands Co-ordinating Committee and other central government officials.

The mission will prepare a draft proposal for undertaking a management planning exercise and organise in return a small workshop to discuss the draft proposal to be submitted in final form to the government of Botswana. Subject to the approval of the Government, this proposal will be used to raise funds for the actual planning excercise.

Key elements of this proposal will be:

- the need to analyse the relationship between land users, settlement patterns and the status of the delta ecosystem;
- the fact that social and economic factors within the Okavango basin should be considered from the national and regional context. Special attention should be given to economic and social needs of the whole population using the basin, especially the needs that can be satisfied through environmentally sound uses (wise uses);
- the present and potential future needs: in this regard, the proposal will examine what information is available from the review exercise and what data are needed to have a better understanding of the trends; and,
- the generation of data and information that takes into account the view and interests of stakeholders based on establishing or strengthening communication and consultations with stakeholders.

The above activities will be carried out during the first phase of the process for which the Ramsar Secretariat will provide funding. The activities relating to the next phase will be recommended by the workshop, to lay the basis for the development of the future management plan for a Okavango delta and basin.

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Article 4.3

Wetland Conservation and the Management of the Lake Chad Basin

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Keywords: Lake Chad, basin, wetlands, integrated management, ecosystem, participation

The Lake Chad Basin is an area with a wealth of wetlands and natural water resources. Desertification, drought and climatic change, and the increased population pressure, are leading to a range of environmental problems. The countries within the Basin joined their forces in the Lake Chad Basin Commission to develop an integrated ecosystem approach to counter these effects. This paper provides an overview of both plans, their principles and objectives, and some of the actions resulting from them.

Conservation des zones humides et la gestion du bassin du lac Tchad

Mots-clés: lac Tchad, bassin, zones humides, gestion intégrée, écosysteme, participation.

Le bassin du lac de Tchad est une zone de richesse en zones humides et en ressources en eau. La désertification, la sécheresse le changement climatique et l'augmentation de la population, mènent à divers problèmes écologiques. Les pays du bassin ont réuni leurs forces au sein de la Commission du bassin du lac Tchad pour développer une approche intégrée écosystémique basée sur l'écosystème pour contrecarrer ces effets. Cet article donne une vue d'ensemble des deux plans, leurs principes et objectifs, et certaines des actions qui en résultent.

1. Introduction

The Lake Chad Basin Commission (LCBC) was created by the Fort Lamy (now N'Djamena) Convention signed on 22 May 1964 by the Heads of State of the four countries which share the Lake Chad Basin (Cameroon, Chad, Niger and Nigeria). In 1994, the number of member states was increased to five with the admission of the Central African Republic.

The Lake Chad Basin extends over an area of about 2,355,000 km^2, of which the area of jurisdiction of LCBC, known as the conventional basins (CB) covers about 967,000 km^2. The most important rivers flowing into the lake are the Chari and its tributaries the Logone, the Komadougou-Yobe, the El-Beid and the Yedseram. The lake is very shallow and has since 1972 continuously reduced in size from about 25,000 km^2 to less than 2,500 km^2 while its volume has decreased by close to 60%. The population of the conventional basin is about 20 million and the majority of these people practice agriculture, nomadic and semi-nomadic animal husbandry and fisheries.

A diagnostic study found that drought, climatic change and desertification, together with increased population pressure, were the major causes for the destabilisation of the entire ecosystem. Environmental degradation could be seen in the:

- Erosion of productive soils;
- Overexploitation of groundwater resources;
- Overexploitation of pastures;
- Loss of biodiversity; and
- Deforestation.

From the diagnostic study, a Master Plan and Strategic Action Plan were developed to establish environmentally sound management of the basin's natural resources. This paper will first mention some of the wetlands in the area, before dicussing the Master Plan and the Strategic Action Plan that are being developed by the LCBC to deal with the threats that are facing the Lake Chad Basin.

2. Wetlands in the basin

The wetlands in Lake Chad Basin play a crucial role in the lives of the local people, to which they provide essential sources of water, pasture, fisheries and general food security. In the basin, the following wetlands can be identified. Of the first three more information is provided below:

- Lake Fitri (Chad)
- Hadejia-Nguru wetlands (Nigeria)
- Waza-Logone floodplains (Cameroon)
- Wetlands of Mayo Kebbi systems (Chad)
- Wetlands of Northern region of Central African Republic (CAR)
- Lake Chad (Chad, Nigeria, Cameroon and Niger)
- Sambissa wetlands (Nigeria).

Lake Fitri covers an area of 500 km^2 and is one of the most important ecosystems in the conventional basin. *Phragmites Mauritianus Echinochloa Stagnina* and *Vossia Cuspidata* dominate the permanent swamps on the lake fringes. The lake acquired international reputation serving as a major wintering and breeding site for millions of migratory and resident waterbirds. In July 1990 the Convention on Wetlands (Ramsar, 1971) contracting parties in Africa designated the lake as a Ramsar site. Lake Fitri is also a biosphere reserve under the Man and Biosphere programme of UNESCO.

The Hadejia-Nguru wetlands are at the conjunction of the waters of the Hadejia and Jama'are. It covers an area of about 5,000 km^2 and provides livelihood to approximately 1 million people through agriculture, fishing and pastoralism. The wetlands are of regional importance, as it is an important site for migratory birds. Counts of water birds as at January 1997 revealed a total of 224,500 waterbirds of 76 species.

The Waza-Logone Floodplain located in the north of Cameroon plays an important role, especially in terms of herding, fisheries and flood recession farming. In the 1997 waterfowl census, a total of 90,244 waterbirds of 71 species were identified. Since 1988, IUCN – The World Conservation Union is carrying out a project aimed at the maintenance of biodiversity and creation of conditions favourable for the sustainable development of the region. The project also aims to rehabilitate the floodplains.

The LCBC has a direct bearing on all these wetlands. The LCBC has been co-operating with the WLP in the areas of data collection and topographic surveying. A hydrodynamic model from the HYDRO-CHAD available at the Commission has been used in the Waza Logone project to simulate floodplain inundation under various rehabilitation options. The model has been upgraded to predict the effects of the re-flooding proposals on the plain and to observe the effects on Lake Chad.

Lake Chad basin wetlands and their protection are an important part of the work of the LCBC. In the face of rising population and several years of low rainfalls, the wetlands in the conventional basin have come under increasing pressure. Droughts in the 1970s and 1980s and water engineering projects developed for intensive irrigation system are considered the main causes of the decline in lake levels.

3. The Master Plan

In response, LCBC developed a master plan and a strategic action plan in 1992 with assistance from UNEP, FAO and UNSO. The purpose of this plan was to establish a strategy for the environmentally sound management of wetlands and development of the basin's natural resources in order to ensure sustainable development. The objectives of this Master Plan (MP) are:

1. To prevent soil erosion and improve soil fertility;
2. To increase the availability of water resources and promote rational utilisation and environmental and socio-economic assessment of water resources projects;
3. To restore and rehabilitate denuded landscapes;

4. To maintain and improve vegetative cover and,
5. To work towards food security preparedness.

The Master Plan contains 36 projects classified in order of priority, which all have the following components:
1. Environmental considerations;
2. Socio-economic aspects;
3. Agricultural aspects; and
4. Institutional capacity building.

For instance, the Master Plan included projects in the Hadejia-Nguru wetlands, the Sambissa wetlands, and the Biosphere reserves at Lake Fitri and Lake Léré. The Master plan was adopted at the 8th Summit of the Heads of State summit held in Abuja in March 1994.

4. Strategic action plans

The diagnostic study and the Master Plan lead to the preparation of a Strategic Action Plan (SAP) in collaboration with UNDP-GEF and UNO-DESA. The principal objective of this plan is to prepare a regional framework for environmental protection and sustainable development of the basin resources. Four principles are adopted in the SAP:
1. The integrated management of the basin;
2. A long term view and adaptability;
3. Respect for ecosystems; and
4. Participation through involvement of all stakeholders.

The SAP presents a holistic, multi-sectoral and integrated approach. To allow for such an approach, different sources of information were used in the SAP's development. The development of the SAP was a reason to update the diagnostic study to include the new membership of the Central African Republic. Several other sources of information were used including baseline data, allocation of water resources, production activities, environmental status and institutional frameworks.

Finally, reports were produced on the physical hydrological system, the socio-economic and institutional framework, and the environment and international waters. The SAP also divided the basins into three sub-basins (Lake Chad and its basin, the Chari-Logone-El Beid, and the Komadugu-Yobe). The SAP has the following principal objectives:
1. to establish a basin water policy in each country, taking into consideration the value of hydrological systems and aquatic ecosystems in sectoral economic policies;
2. to establish the institutional mechanisms for co-operation, co-ordination and consultation in each country of the Lake Chad Basin;
3. to create essential links between research programmes, poverty eradication, biodiversity programmes, fight against desertification through concrete actions, involving major stakeholders;
4. to implement concrete priority actions to restore and protect Lake Chad and its feeder rivers, in order to protect the aquatic ecosystems against new cross-border risks (e.g. sediment deposition, pollution and droughts); and,
5. to develop suitable mechanisms for monitoring and mobilising internal and external financial resources, aimed at progressively achieving self-sufficiency for the sustainable management of the resources of the Basin.

The SAP has a long term (20 years) and short-term (8 years) programme. The short-term programme is divided into 3 and 5-year phases. The objective of the three-year plan is to complete the work necessary to formulate GEF's regional programme and to begin implementation of activities already identified. It entails the mobilisation of national and international assistance to finance the implementation of the other programmes. The LCBC tries to involve all relevant agencies in the preparation and implementation of the programmes. GEF is already co-operating with the Convention on Wetlands (1971, Ramsar, Iran), WMO and UNESCO on the implementation of the SAP.

The 3-year phase will also include the collection of important baseline data. The objective of the following five-year phase is to fully implement all elements of the GEF's regional program. This phase will be more operational, while keeping its steering and research-oriented characteristics.

Other elements of the eight-year action plan are:
1. Integrated management of the Chari-Logone-El Beid sub-basin;
2. Integrated management of the Komadugu-Yobe sub-basin; and,
3. National projects of regional importance for the protection of lake Chad.

The SAP defined the following priority actions:
1. Initiating shared management of water resources, with mechanisms for co-operation, co-ordination and integration;
2. Setting up a viable network for collection of baseline data;
3. Carrying out basic measures to combat desertification and the loss of biodiversity;
4. Ensuring the prevention and control of contaminants and preserving fisheries resources;
5. Improving methods of exploiting aquatic ecosystems and protecting floodplains in consonance with regional development;
6. Feasibility studies relating to intra- and inter-basin water transfers.

The Strategic Action Plan (SAP) was approved by the Council of Ministers at its 45th session held at N'djamena, Chad in June, 1998. A Basin wide Committee for Strategic Planning (BCSP) will supervise the implementation of the SAP.

5. Current Activities

Since approval, work has been done to formulate a GEF project with the assistance of UNDP-GEF and UNO-DESA. A brief document is already available, which after revision was scheduled to be presented to the GEF Council for approval in June 1999. After visiting major donors in a

consultative round, a donor conference should have taken place in 1999 and more detailed projects should have been formulated. At the moment, the following projects are ongoing:

- Ground water investigation of the Chari-Logone formation (LCBC/UNESCO). Funded by BMZ (Bonn, Germany);
- Lake Chad fisheries program (LCBC/University of Portsmouth). Funded by the European Union (Brussels, Belgium);
- Chari-Logone integrated rural development (LCBC/IDB). Funded by the Islamic Development Bank (Jeddah, Saudi Arabia); and,
- Cooperation with the IUCN Waza-Logone project on Hydrodynamic model for the Logone-Chari and the Lake Chad. Funded by the European Union (Brussels, Belgium).

One major programme under the SAP is the inter-basin water transfer, which is so far considered to be the only available option for the restoration of the lake and adjacent wetlands, such as Lake Fitri, Hadejia-Nguru, Waza-Logone and Lake Chad itself. The restoration of the Lake is not only necessary to counter desertification, but also to restore the ecosystem itself, the habitat it provides for European migratiory birds, and to provide food security for the population of the basin.