The challenges of integrating marine sciences with coastal management in the western Indian Ocean region

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ABSTRACT

About 30% of the 100 million inhabitants of the western Indian Ocean (WIO) region reside in the coastal strip and are heavily dependent on goods and services provided by oceans and coasts. Coastal areas provide food and resources which support the economies of coastal states of the western Indian Ocean such as fisheries, shipping, petroleum exploitation, seabed mining, energy and tourism. Coastal and marine areas house a bounty of biodiversity and the oceans are also responsible for balancing the extremes of climate conditions. However, our efforts to effectively manage the use of coastal resources in a sustainable manner are constrained by inadequate knowledge in the ecosystems and inadequate capacities to generate the knowledge. This is compounded by the lack of prioritisation of issues and integration of coastal and marine management and marine science in most maritime states.

This paper examines the challenges in integrating ecosystem-level coastal and marine science with integrated coastal and marine management, as well as the opportunities for bridging the gap between science and coastal management in the western Indian Ocean. The integration of ecosystem management and ecosystem science will ensure the sustainability of the marine and coastal resources.

INTRODUCTION

Today, this Conference is organised to mark the 20th anniversary of the Institute of Marine Sciences (IMS). We should also be reminded that the IMS resides at the premises of the former East African Marine Fisheries Organisation (EAMFRO)—established about 40 years ago—of the former East African Community. During these four days the conference will receive presentations demonstrating significant advances in marine sciences both in terms of capacity and information. My own presentation sets the basis for our aspirations in advancing the scientific knowledge on marine ecosystems.

THE GLOBAL CHALLENGE

The ocean covers more than 70% of our planet and plays an important role in many ways. The bounty of goods and services provided by coastal and marine ecosystems attracts population increase in coastal areas. These goods and services include food that to most coastal societies is the only source of protein. Coastal areas support the economies of many maritime nations through fisheries, shipping, petroleum exploitation, seabed mining, energy and tourism. In addition to these tangible benefits to humanity, coastal and marine ecosystems perform critical ecological functions.

The coastal strip is where we live. A significant proportion of the world's human population resides in the coastal strip not exceeding 150km from the shoreline. For example, it is estimated that 60% of the world population lives in the coast and about 70% of the world's cities with populations exceeding 2.2 million are near tidal estuaries. It is also estimated that the population of the coastal zones will double by the year 2020 (Olsen et al., 1999).

However, the resources that we depend on are declining at an unprecedented rate and the environment that we enjoy is degrading faster than we can ever imagine (Box 1). There has been a long-standing understanding that users have an open access to marine resources. In the early days, the presence of people did not harm coastal and marine environments. The uses of marine and coastal resources, mainly fisheries, caused some local environmental changes without threatening sustainability. Today, we are witnessing increased uses of coastal and marine resources as well as growing beach erosion and amplified sea level changes. Without linkage between good science and proper management, these uses and natural changes will impact on the environment and create competition and conflict.

Box 1: Vital and critical statistics from ocean fisheries

- 70% of the world's commercially-important marine stocks are fully fished, overexploited, depleted or slowly recovering.
- Some staple species such as the northern cod and Atlantic halibut have been excessively fished to commercial extinction.
- Worldwide, governments pay an estimated $54 billion per year in fisheries subsidies to an industry that catches only $70 billion worth of fish.
- Contemporary fishing practices kill and waste 18–40 million metric tonnes of unwanted fish, seabirds, turtles, marine mammals and other ocean life annually and this represents about one-third of the total world catch.

Source: Hinrichsen (1998).

MARINE AND COASTAL PRESSURES AND OPPORTUNITIES IN THE WIO REGION

The coastal and marine pressures confronting the WIO Region include population increase, poverty, environmental degradation, declining coastal and marine resources, poor governance and lack of appreciation of coastal and marine resources (Ngoile et al., 2001).

It is estimated that more than 30% of the 100 million inhabitants in the region are living in the coastal zone. In 1992–93, the estimated GNP per capita of the WIO Region ranged from $80 (Mozambique) to $330 (Kenya) making it one of the world's poorest regions. The combination of poverty, rapid population growth and poor understanding and management of coastal resources, particularly in the mainland countries and Madagascar, has resulted in a number of environmental and resource-use problems, including habitat destruction, over fishing, human-induced coastal erosion and flooding, and marine pollution mainly from land-based sources.

The western Indian Ocean, compared to the other oceans, is not particularly productive with respect to fisheries. Approximately three million tonnes of fish, crustaceans and molluscs are caught in the western Indian Ocean each year. The total fisheries production within the region increased by 72% from 1980 to 1990. However, annual fish consumption per capita has decreased from 3.7 to 1.9kg per year over the same period (Ngoile and Linden, 1998). The fisheries productivity is further reduced by the use of destructive fishing practices and habitat destruction, particularly that of coral reefs.

Several land-based activities are impacting on marine ecosystems. Land reclamation projects have filled extensive intertidal areas, particularly on islands, where flat coastal land is in high demand. In Victoria, Seychelles, for example, the airport, two ports and relatively large residential areas and roads have been built on reclaimed land, as are the main port and coastal industrial zones in Mauritius. Beaches and sand dunes in Mozambique and Tanzania are mined for construction materials and black sand minerals, causing direct habitat destruction and subsequent coastal erosion. Coastal vegetation, including the mangrove forests, is being cut and degraded in many areas throughout the region.

The industrial sector is not strongly developed in most of the region (except in South Africa), and focuses primarily on the processing of agricultural products, petroleum and other goods (e.g. textiles, fertilisers) for domestic consumption. In the coastal zone, these industries are clustered around the larger cities and ports, such as Mombasa, Dar es Salaam and Maputo. In Mauritius, the Export Processing Zone has attracted considerable foreign investment, and manufacturing is now the largest component of the island's GDP (24%). Wastes from these industries tend to be organic- and nutrient-rich, and are commonly discharged to sewers or directly into rivers and coastal waters without pre-treatment. Similarly there is no treatment of domestic wastes in the coastal

cities and rural areas of the region. Many coastal ecosystems are also damaged indirectly by hydrologic alterations to rivers.

Governance on coastal and marine resources is characterised by the absence of effective and integrated coastal and marine management, which has resulted in growing environmental problems in all the countries of the WIO region.

In spite of these pressures, however, the western Indian Ocean region has great potential for development, which if tapped in a sustainable manner, could lead the region to economic and social prosperity. These include:

- *Development of tourism.* There are considerable areas, which are relatively undisturbed and which have pristine coral reefs, less exploited fisheries, beautiful beaches and pristine stands of mangrove forests. These areas are found in southern Tanzania, northern Kenya, Mozambique and Somalia. These areas present great potential for the development of tourism.
- *Mariculture.* There are significant areas suitable for the development of mariculture.
- *Fisheries.* Most of the fisheries in the region is artisanal and as such has not succumbed to massive overcapitalisation. Fishing pressure is only experienced in nearshore waters, which can be reached by the traditional crafts, most of which are wind-propelled.
- *Hydrocarbons and minerals.* Large deposits of hydrocarbons have been discovered along the coast of southern Tanzania and black sand minerals are found along the coast of Kenya.

ECOSYSTEM-LEVEL SCIENCE

Integrating natural and socioeconomic scientific knowledge as well as analysis of management structures are key components for advising the successful implementation of sound policies, development plans and management strategies for the sustainable use of marine and coastal resources. Box 2 provides the basic components of the scientific research required to inform integrated coastal and marine management (GESAMP, 1998; Olsen et al., 1999) and Figure 1 shows the processes for integrating science with coastal and marine management. The scientific tools, which are particularly useful in generating information relevant to coastal management, include resource survey techniques, hazard and risk assessments, modelling, economic valuation and evaluations and analysis of legal and institutional frameworks for coastal management.

Traditionally the scientific approach employed in marine and coastal research has concentrated on the state of natural ecosystems, i.e. identifying the damage and disturbances to the ecosystems. Therefore, the scientific advice has always been biased towards the natural ecosystem and the management measures/actions have lacked the human dimension. Whereas natural sciences are vital for the understanding of the functioning of ecosystems (*state variables*), socioeconomic sciences including the analysis of governance structure are essential to comprehending patterns of human behaviour

Box 2: Components of ecosystem based research for supporting integrated coastal and marine management

The following research components are important in ensuring ecosystem approaches to gathering information in support of integrated management of marine and coastal resources.

1. Assessment of resources and the environment

(a) Assessment of ecosystem health and conditions:
- marine biodiversity and biogeography;
- populations, species, habitats, ecosystems;
- fragile and sensitive ecosystems;
- coral reefs, mangroves, coastal wetlands, coastal lagoons, estuaries, seagrass beds, small islands;
- threatened and endangered species.

(b) Resources:
- natural resources (fisheries, mangroves, seaweed);
- non-living resources;
- services, e.g. transport, recreational.

(c) Threats:
- land-based activities—coastal development, coastal and river basin agriculture and livestock, tourism, river impoundment, deforestation;
- ocean-based activities—impacts associated with marine transport, seabed mining, hydrocarbon exploitation (ocean based oil drilling).

2. Assessment of socioeconomics of coastal stakeholders

(a) Assessment of socioeconomic and demographic patterns for:
- safeguarding livelihoods;
- equitable sharing of proceeds from resources uses;
- capturing indigenous knowledge that is then used in policy, planning and management process;
- ensuring transparent tenure systems;
- assessing the development alternatives, including cost-benefit analysis.

3. Assessment of the effectiveness of the governance

(a) Assess existing policies and management mechanisms for their effectiveness.
(b) Select appropriate approaches to improve the management, e.g. ICM, MPAS, LMES.
(c) Assess the level of inclusion of the following characteristics:
- community/stakeholder/private sector involvement
- cooperative management
- collaborative management
- cross-sectoral and multidisciplinary management actions based on scientific information

(d) Development of policy, management plans, guidelines and legislation.
(e) Synthesise and document successful ICM experiences and facilitate their replication so as to avoid 'reinventing the wheel'. This will save time and money as well as enhancing the sharing of experiences.
(f) Promote the referencing of successful ICM experiences during regional and global debates and negotiations for the best code of conduct leading to the conservation and sustainable use of marine and coastal resources.

Source: Ngoile et al. (2001).

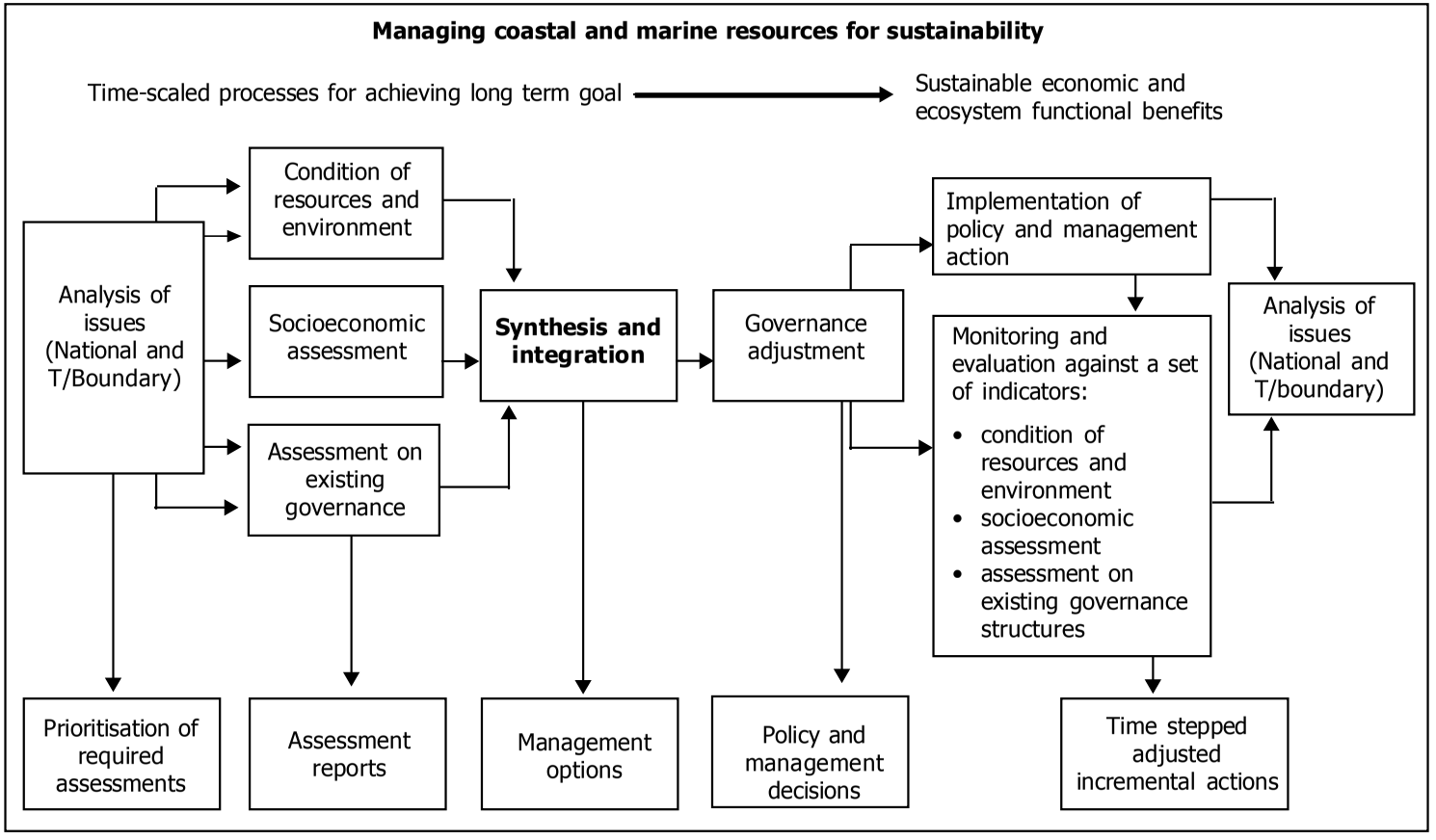

Figure 1. Integrating science and coastal management

that cause ecological damage (*pressure variables*) and to finding effective solutions (*management measures*) (Olsen et al., 1999). Scientists and managers must work together to reach an agreement on the scientific work needed to address priorities, which are essential for and guide management.

The existing information base on marine sciences in the WIO region is inadequate and cannot inform public policy and management processes. The state of the information is further aggravated by the fact that most of it exists as grey literature under the custody of government departments and not in universities and public libraries.

Another dimension of hindrances to the successful development of science-based marine and coastal management in the WIO region is associated with inadequate communication between resource users, scientists, planners and policy makers. The lack of coordination between different uses, together with lack of appreciation on the dynamics of the coastal resources has resulted in highly sectionalised policies and management strategies that have little consideration to intersectional issues and the natural linkages between different resources.

THE EVOLUTION OF MARINE SCENCES IN THE WESTERN INDIAN OCEAN

The history of marine sciences in the western Indian Ocean dates back to the 1960s during the Indian Ocean Expedition. To date the Expedition is the most comprehensive marine scientific venture ever undertaken in the region. The expedition has provided the knowledge base on the physico-chemical-biological processes, especially how these are influenced by the Monsoons. In the 1970s marine research in the region concentrated on fisheries and related sciences. The emerging independent states of eastern Africa prioritised the development of fisheries resources to meet protein requirements of coastal populations as well as to provide foreign exchange earnings.

The Food and Agriculture Organisation of the United Nations (FAO) has been assisting eastern African states in their endeavour to sustainably develop marine fisheries for over two decades (Insul et al., 1995). Estimation of the level of fish stocks can only be achieved through surveys and catch landing statistics. Poor fisheries statistical collection in the countries of the region limits the accurate assessment of stocks and reliability of estimates hence the level of exploitation can only be guessed at. Secondly, most fisheries resources have open access, a condition that leads to competition in the exploitation of resources without due regard being paid to sustainability. FAO has addressed these problems by providing support for resource surveys and building capacity and tools for national fisheries statistics.

During 1982/84, the Norwegian research vessel *Dr Fridtjof Nansen*, conducted fisheries surveys in Mozambique, Tanzania, Madagascar and Kenya. Scientists from these countries joined scientists from Norway in data analysis and presentation. The results of the surveys were presented to the various governments through national

workshops. There is a potential for increasing the current level of fish production through the improvement of fishing and preservation techniques (Iversen and Myklevoll, 1984). This could be achieved through training and education as well as introduction and development of new methodologies based on those developed in Asia and the Caribbean. In addition, Bianchi (1992) analysed the data collected during the surveys and has established the pattern of distribution of demersal fish species in the western Indian Ocean.

Several mechanisms, which provide a regional setting for the discussion and exchange of national experiences on the scientific information and management of coastal and marine resources in the western Indian Ocean region, have been developed since the mid 1980s. Regional mechanisms of this type include the East African Action Plan (coordinated through UNEP's Regional Seas Programme and the Nairobi Convention), the Western Indian Ocean Fisheries Sub-Commission, the Intergovernmental Oceanographic Commission's Regional Committee for Cooperative Investigation in the North and Central Western Indian Ocean (IOCINCWIO) and Western Indian Ocean Fisheries Sub-Commission, a subsidiary body of the Indian Ocean Fisheries Commission. The Western Indian Ocean Fisheries Sub-Commission is currently coordinating national mechanisms for the management of tuna stocks within the region.

PRESENT REGIONAL MARINE SCIENCE INITIATIVES IN THE WIO REGION

The current (1990s) marine scientific activities in the region are carried out under the concept of Integrated Coastal and Marine Management (ICM). The ICM approach was concretised and endorsed as appropriate for the sustainable use of coastal and marine resources during the processes leading to the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil. The application of ICM in the WIO region was subsequently reviewed in the region during the Workshop and Ministerial Conference on Integrated Coastal Zone Management in Eastern Africa, including the Island States, held in April of 1993 in Arusha Tanzania (Linden, 1995).

During the workshop, experts discussed the environmental problems of the region's coastal zone and formulated a number of technical recommendations. Reflecting the multiplicity of coastal issues, the following approaches were proposed: review of national policies to enhance sectoral integration, inclusion of ICZM philosophy in national planning processes, institutionalisation of cooperative management and a multidisciplinary approach in conducting research.

The participating ministers discussed the recommendations presented by the experts and they formulated and signed the 'Arusha Resolution'; a policy statement calling upon the states of the WIO Region to give emphasis to sustainable development and integrated management of coastal areas for the primary benefit of coastal communities. The Arusha Resolution emphasised the need for integration of all issues,

involvement of all players in the planning process, coordination between sectoral agencies, integration between science and management and application of cooperative management during the implementation of ICM. The Arusha Resolution directed the scientific community and called for an inter- and multidisciplinary approach to research in order to provide the required knowledge for ICM.

The Arusha Conference has stimulated the development of a number of coastal and marine programmes. Under the East African Action Plan, several programmes have been implemented, including EAF/6, which focuses on the assessment of land-based pollution and EAF/5, which specifically addresses coastal zone management. Within the framework of EAF/5, ICM pilot projects are being implemented by national institutions in Kenya, Tanzania and Mozambique, with support from the United States Agency for International Development (USAID) and United Nations Environment Programme (UNEP).

IOCINCWIO is a regional intergovernmental committee that meets every three years to assess scientific achievements and formulate/prioritise areas of marine research to be carried out in the region. The Regional Marine Science Program for Eastern Africa supported by Sida-SAREC undertakes research and training activities aimed at providing the capacity and scientific knowledge required to formulate management measures for the sustainable use of coastal resources. The IOC and Sida-SAREC processes have encouraged and supported the development of a regional scientific non-governmental organisation—the Western Indian Ocean Marine Science Association (WIOMSA).

CONCLUSION

The western Indian Ocean region is at crossroads, where on the one hand there are pressures on the coastal environment, but which exist in 'hot spots' and on the other, great opportunities for sustainable coastal development. Unfortunately the pressures are increasing at an alarming rate. Recognising the complexity of coastal and marine ecosystems, we need to move as rapidly as possible to ecosystem level science and management. ECOSYSTEM SCIENCE AND MANAGEMENT considers both human activities and natural dynamic processes as one integrated system.

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