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COASTAL MANAGEMENT: GLOBAL CHANGE.....GLOBAL OBSERVATION?

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Abstract

The theme of the present discussion is to consider coastal observation needs in the broader context of a sustainable, integrated management response to coastal change. Thus underlining the notion that observations are an element of a more comprehensive process. We will therefore first explore the process of ICZM, and find that deficits in international co-ordination and concertation are large. An overview of salient coastal zone issues emphasises the spatial, spectral and temporal diversity of observational needs, which is concluded to be an important reason for the relative underdevelopment of coastal zone observation systems. A "global" coastal observation effort should give due consideration to these aspects, and aim to help resolve this in concertation with national and international institutions carrying responsibility for a sustainable development of the coastal zone. The interpretation of the meaning of global appears to be twofold, global in the sense of a generic, universal need (although many coastal problems are local), and global in the sense of institutionalisation and co-ordination on a global level.

Introduction

Where water meets the land, global change is perhaps most conspicuous to mankind. The dynamics of the land water interface are intense, not only due to natural causes, but also due to human exploitation of coastal resources. The central question that this paper intends to answer is whether a sustainable response aimed at combating negative global coastal change will benefit from a "global" coastal observation effort. Undoubtedly, the answer to this question is positive, but this is not as trivial as it appears. A focus on the true needs develops from viewing the nature of the process which is central in developing ICZM (Integrated Coastal Zone Management), and from there on the role of observations in this process. By reiterating the main problems that we face in coastal regions we are able to derive those observational needs that should be central in the context of a global effort. When receiving the invitation to present this paper, the request was to focus on the needs of developing countries, but we would argue that there exist only gradual differences between the needs of developed and developing countries.

Generic experiences of the "process" of Integrated Coastal Zone Management

The main objective of ICZM or, basically, of any government policy is to encourage changes in human behaviour in order to achieve desired goals (WCC, 1993). In this process, the main

purpose of management is to provide the conditions that will facilitate development and stimulate progress. ICZM is such a *management process*, which can anticipate and respond to the needs of the coastal society. Public participation in the development of ICZM is therefore essential.

The *management procedure* generally involves the formulation and implementation of coastal zone management plans, not as a one-off exercise but as a continuous and cyclic process. This process requires a substantial input of basic resources, such as: human and financial resources, equipment, education and training. More specific needs are associated with the various tasks of ICZM, which are discussed furtheron. The way in which this process is executed will depend to a large extent on cultural, political, economic and historical conditions, and its success will therefore depend on the degree of public endorsement achieved.

Recognising the above, the WCC '93 Conference Statement defines the frame of ICZM as follows:

> *Integrated coastal zone management involves the comprehensive assessment, setting of objectives, planning and management of coastal systems and resources, taking into account traditional, cultural and historical perspectives and conflicting interests and uses; it is a continuous and evolutionary process for achieving sustainable development.*

Initiatives have for some time been under way to develop common approaches and to help the world's coastal nations prepare for ICZM. Vulnerability assessments of coastal areas to climate change offer a way of helping governments to review existing capabilities and performances in coastal zone planning and management. The picture provided through the vulnerability assessment case studies was complemented by ICZM case studies performed in the preparation of the WCC '93 Conference. The following elements and aspects have been identified as common to many ICZM experiences.

A national ICZM programme should facilitate integrated decision making through a continuous and evolutionary process of co-operation and co-ordination among sectors. Sectoral-based approaches have proven unable to meet the management challenges posed by resource use conflicts, because from the perspective of one sector it is difficult to make efficient trade-offs that best utilise coastal resources.

For a successful implementation of a national ICZM programme, some essential prerequisites can be identified. The first of these is the need for *initial leadership* for the planning process. For effective ICZM, institutional responsibility must be distributed intersectorally and hierarchically, both within the government, and between government and local groups. Thus, the second necessary element of ICZM is the provision of *institutional arrangements*. Third, *technical capacity* (both technological and human capacities) is necessary for compiling inventories in the planning phase, during the implementation of the programme, and for monitoring the changes. The final necessary element of ICZM is *management instruments*. These include tools ranging from command-and-control to incentive-based, all with the aim of encouraging stakeholders to comply with the ICZM plan.

Although it is possible to identify several prerequisites for ICZM, a screening of the available case studies has revealed that there are no indications that a particular implementation possibility is uniquely suited in a particular underlying condition. Thus, the quest for a single, unique "recipe" for ICZM is misguided, at most there are a number of elements and aspects common to ICZM approaches.

We may therefore conclude that while there exists no recipe for ICZM, the nature of the process is that of cyclicity, iteration, integration, co-ordination, participation and learning. Of these aspects it appears that co-ordination is the most critical of aspects not only on national or subnational level, but also on international level. The European experience illustrates this convincingly:

> * *Since the beginning of the 1970s, awareness of the need to strengthen the protection of the coast and political commitments to this end have led to numerous measures resulting in specific legislation and national strategies. However, this has not halted the deterioration of the coastal environment, which continues apace in many areas. Recent studies on this question tend towards the same conclusions: existing legislation and instruments are relatively complete, but are not as effective as they could be due to lack of co-ordination between the numerous actors influencing upon the development of the coast. This not only concerns the horizontal relations between sectors of activity, but also the intermeshing of the policies and actions carried out at various levels of territorial authority. Over-zealous application of the subsidiarity principle too often leads to a parcelling out of responsibilities, which are simply distributed between the levels of competence, with no scope for taking account of the numerous interactions between them. Owing to this lack of co-ordination, the complex relations between human activities and the coastal environment described are neglected and the isolated measures fail to achieve their goal or may even be mutually contradictory* (European Commission, 1996).

Obviously, this implies that the development and implementation of a global coastal observation system needs to be done in full awareness of this conclusion. The implication is that the theme global observation includes important aspects besides that of the technical question, viz. institutional co-ordination on national and international levels.

With this conclusion in mind we may now assess the various management tasks and supporting tools involved with the implementation of ICZM. Our objective is to derive the role of observations and monitoring.

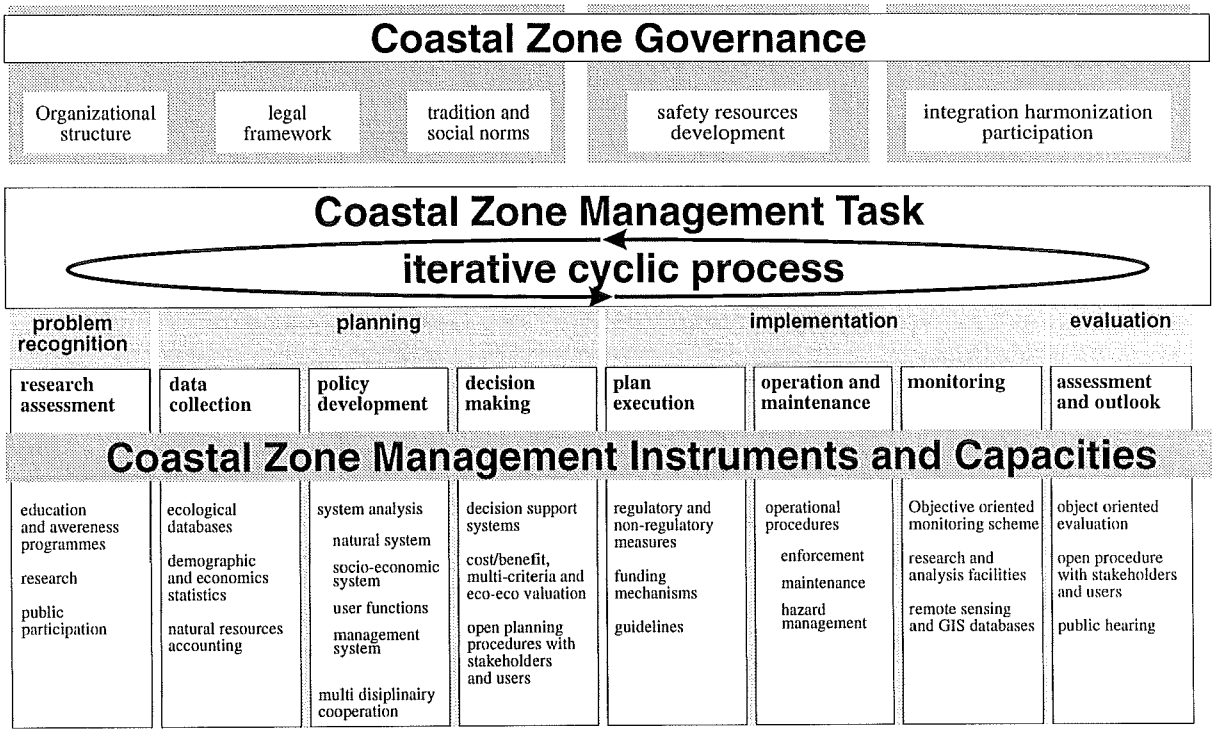
Observations supporting ICZM tasks

The main management tasks that we may distinguish in the context of ICZM concern problem recognition, problem analysis, policy development, planning, implementation, monitoring and evaluation (see Scheme 1). The central political/societal stage is that of *policy development*, which is preceded by a partly socio-political and partly technical stage of *recognition and analysis* and followed by the mainly technical stage of *planning and implementation*. The role of observations is of large importance in both technical stages.

ICZM aims to control the interaction between the natural coastal system, the coastal resource functions and the socio-economic system. These three elements are externally forced, primarily by global or regional socio-economic requirements, and secondarily by global or regional climatic changes. At the stage of problem recognition and analysis observations are central in assessing the nature of the problem as apparent in the natural system and the coastal resource functions. In order to analyse the problems in depth we are often faced with the need to have observations available over longer time spans, because of the intrinsic dynamics of the system and the external forcing. Also, historical developments provide insights into possible future evolutions. Observations in the "post policy stage" are commonly of an on-line

character. For planning, the actual state of the coastal resources needs to be well assessed, while during and after implementation the implemented response measures need to be monitored.

Scheme ICZM management arrangements, tasks and tools



Based on the above we are able to define three main categories of information needs, viz.
- information on coastal zone characteristics,
- information on processes and impacts,
- monitoring/warning systems.

The subsequent section focuses on the nature of the main coastal zone issues, that trigger the need for ICZM with these three categories as a background.

Coastal zone issues

From the experiences of countries which have implemented or are in the process of implementing an approach for ICZM, we may derive a number of salient coastal zone issues. While we draw upon the experiences of developing countries, we argue that there are marginal differences only in the issues compared to developed countries. It is simply the intensity of the user conflicts and the available means that may differ, not the nature of the user conflicts.

From a policy viewpoint and focused on the non-process side of ICZM, we would list the central issues as follows:

- coastal land-use, development (including reclamation) and planning,
- coastal erosion, flooding and hazard control,
- water and sediment resource management including aquatic pollution and salinity intrusion,
- nature preservation and nature development,
- port and harbour operation and development,

- aquaculture and coastal fisheries.

An identification of significant observational needs and drawbacks is central in the below discussion, distinguished for each of the above issues.

Coastal land-use , development (including reclamation) and planning

Under this issue we may consider to fall the variety of exploitation objectives based on socio-economic demands, such as housing, industry, agriculture, aquaculture, recreation, tourism and related infrastructure. While the user and use conflicts that need to be resolved under this issue mainly require a balanced policy development, observations on existing land-use and on the potential suitability of coastal lands for a particular development can be of vital importance. Current spatial resolutions (pixel resolutions of 30m to 100m)of remote sensing based observations are commonly sufficient in low-lying coastal regions, thus providing a relatively quick and cheap alternative to traditional ground exploration.

A particular point-of-attention, however, concerns narrow coastal zones, as found on leading edge coasts. When only a marginal coastal zone is available, user and use conflicts are intense and the scarce space is precious. In this case, coastal management reduces often to shoreline management. Planning regulations are strict and every meter of shore retreat has large consequences. In this situation, high spatial and temporal resolutions of shore changes and shore use are required. Present precision of satellite remote sensing is insufficient in this case, and, awaiting the development of airborne or groundstation-borne remote sensing techniques, relative expensive, traditional ground surveying is necessary.

Since the majority of the world's population lives already near the coast and the demographic projections indicate that the coastal population density will inevitably increase, coastal land reclamation and development is becoming an increasingly important topic. Since the scale of land reclamation is expanding vastly and thus the impact on the original coastal system is significant, it becomes more and more important to have available a reliable assessment of the present state of the coastal system. The need for a thorough environmental impact assessment and the principle of nature compensation are already accepted as a policy.

A particular upcoming issue in the context of land reclamation is that of sediment resource management. It may be expected that the quest for borrow sites with suitable sediment, delivering sediment at acceptable costs, is a prime issue. Development of cost-efficient (remote sensing) detection methods of suitable borrow sites is in its infancy, so that one still has to rely on expensive ground surveying.

Coastal erosion, flooding and hazard control:

This issue is particularly relevant for low-lying coastal and deltaic regions with relatively gently sloping hinterlands. Here, both natural and human causes of coastal erosion are strong. Cross-shore retreat due to relative sea-level rise is high due to the gentle slope, while the increase of eustatic sea-level rise is high and sometimes very local due to compaction and subsidence caused by groundwater and/or natural resource extraction. Longshore supply of sediment is low due to coastal protection and due to sediment starvation of rivers caused by river regulation. Concerning the topic of observational needs, it may be postulated that there is a strong need for assessment of reliable subsidence rates. In some cases subsidence can be shown to be the prime cause of erosion. Commonly, ground surveying of absolute subsidence

is omitted, exactly because of the subsidence. Remotely sensed coastal altimetry may be listed as a highly recommendable requirement.

Subaquaous bottom morphology is an especially difficult aspect to monitor against reasonable costs. It provides advance insight into the state of the coastal defence functioning and into the performance of hard and soft defence measures. Promising, cost-effective remote techniques, such as assessment by SAR and ARGUS video imaging, need to be stimulated in their operational applications.

Gently sloping hinterlands are particularly prone to flooding, while the exceedance frequencies of flooding increase quickly for small rates of relative sea-level rise. In many developing countries management of flooding hazards, both from sea or river origin, is of literally vital importance. While terrestrial surveying may indicate the proneness to flooding, it is very important to obtain observations of flooding events. Again, (optical) remote sensing of these events or after-events can provide the required information, but this would require responding to episodic events.

Water and sediment resource management including aquatic pollution and salinity intrusion:

The provision of fresh water may be considered to be one of the prime concerns of human mankind in the present and near future. While the direct use of fresh water from river and alternative run-off sources is a river catchment area issue, the extraction of groundwater is an issue which directly impacts on coastal erosion (see above). Subsequent and consequent issues are aquatic pollution due to discharging by outfalls and salinity intrusion due to decreased coastal run-off. Besides the aquatic pollution caused by fresh water use (domestic, agricultural or industrial) we also face the problem of independent sources such as due to industry and harbour and ship operations. Direct observations of pollution spreading and salinity intrusion are essential for coastal management, while indirect observations (of the consequences, such as oil slicks and algal blooms) are of help.....[include the impacts on coastal resource exploitation]. A particular observational problem that we face in this context is that of the strong temporal and spatial gradients in pollution and salinity intrusion, thus making observational requirements complex.

Nature preservation and nature development:

The decline of intertidal areas, coastal wetlands, mangroves and coral reefs is occurring at rates of global concern. The Global Vulnerability Analysis (Rijkswaterstaat and Delft Hydraulics, 1993), for instance, indicates that coastal wetland decline occurs at a global rate of 1% to 2% per year. While current observation techniques are able to assess the extent of intertidal areas and wetlands, this is much less so for mangroves and fairly difficult for coral reefs. The development of observational techniques for this purpose is of great importance.

An upcoming topic is that of nature development, either as a substitute for nature loss in case of development or as a policy response to earlier decline. The observational assessment of historical and actual nature value is an issue of global heritage.

Port and harbour operation and development:

The water transport sector may be considered to be the most benefiting of all economic exploitation sectors of the coastal and nearby oceanographic zones. On-line observations, using both in-situ and remote observations combined with oceanographic modelling, for navigation and offshore operations are high on the agenda of oceanographic service providers.

The special circumstance of direct benefit through direct observation is the prime reason. The challenge here is to integrate the observational needs with those of the other sectors.

Aquaculture and coastal fisheries:

Coastal ecosystems tend to have very high biological productivity, being the reproduction and nursery grounds of most fish and shellfish. A significant proportion of the catch of species of economic value comes from the coastal zone, which, e.g. in the EU (European Commission, 1996), accounts for almost half of the jobs in the fisheries sector. In this context, the quality of coastal waters is a major cause of concern, where regional monitoring of water quality influencing phenomena, such as oil slicks and algal blooms, should help preventing that coastal communities frequently suffer the consequences of events or developments beyond their control.

While the above description is not exhaustive, we may summarise the several aspects per information category as shown in Scheme 2, thus highlighting the diversity of information needs.

ICZM issues					
Coastal land use and planning	**Coastal erosion, flooding and hazard control**	**Water and sediment resource management**	**Nature preservation and development**	**Port and harbour operation and development**	**Aquaculture and coastal fisheries**
Information on coastal zone characteristics					
Existing human activities and infrastructure facilities Land use suitability Sediment sites	Topography/ bathymetry Coastal protection system	Water resources Sediment sources and types	Existing vegetation and wildlife	Bathymetry of port sites	Fish production, spawning and nursery grounds
Information on processes					
Waste discharges Salinity intrusion	Water levels, currents, tides Subsidence Sediment budgets	Water and sediments flows	Ecological development/ succession	Wave climate erosion and sedimentation patterns	Primary productivity Fish stock development
monitoring/ warning systems					
Storms Oil spills	Shoreline development Storms	Water sediment quality	Condition/ productivity/ population of nature areas	Ship traffic Navigation depths Weather conditions	Water quality Algal blooms Oil spills

Conclusions

Summarising and interpreting the observations made in this paper we set forth the following three conclusions and two recommendations.

First, we conclude that ICZM is a *management process*, which can anticipate and respond to the needs of the coastal society. The nature of this process is that of cyclicity, iteration, integration, co-ordination, participation and learning. The most underdeveloped aspect is that of international co-ordination and concertation, to which a global observational effort can and must contribute (cf. EC, 1996).

Second, a picture of great diversity with little *overall direction or coherence* emerges. The coastal zone transcends operational boundaries, while its resource base does not, the range of economic and environment actors is wide, often temporary and always divergent in competence. Oceanography has institutions and institutes to which oceanographic programmes can relate, but the coast does not. It is in effect institutionally under-developed (cf. Steeley, 1994).

Third, there exists a huge *variety of observation needs* in coastal regions. This is due to the fact that the diversity of spatial, spectral and temporal resolution for the different types of monitoring needs is so great that it is difficult to produce a "coastal zone observation agenda". The coastal zone is a highly dynamic region, with a wide range of spatial variability. The spatial and temporal resolution of satellite data is usually too poor to study the subtleties of many coastal processes. Conversely, aircraft-flown and ground-station-based data would seem to have the temporal and spatial flexibility desired for this type of work, but very often over only restricted parts of the region of interest. The complexity of the coastal environment implies that no single instrument or platform can hope to provide data for more than a restricted range of applications, yet many phenomena are highly interdependent. Hence, no aspect of environmental monitoring can benefit as much from a synergistic approach as the study of coastal zones (cf. Vaughan, 1995).

Finally, based on the above conclusions, our recommendation would be to adopt the view that when speaking about the need for "global" coastal observation global has a twofold meaning, viz. global in the sense of a generic, universal need (although many coastal problems are local), and global in the sense of institutionalisation and co-ordination on a global level. More specifically, we would stress the *need for operational research* into the generic potentials of high resolution observation platforms, bridging the resolution gap between satellite remote sensing and in-situ ground observations. While, because of its obvious inter-regional importance, oceanography already benefits from the EU RTD programmes, "coasteanography" does not. The main causes being the complexity and variety of coastal zone phenomena and the importance of local effects, thus concealing and complicating the generic aspects of coastal zone observation systems.

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