PLANNING FOR OUR MISTAKES: HOW TO COPE WITH RISING SEA LEVELS

P Hughes and G B Brundrit

Department of Oceanography
University of Cape Town

Manuscript accepted April 1991

INTRODUCTION

The South African coastline extends for some 3000 km and must be regarded as an enormous national asset in terms of its aesthetic, recreational and economic value. More than 80% of the shoreline is made up of shifting sandy beaches and dunefields which are highly sensitive to interference from external and unnatural forces. Whilst much of the remainder consists of rocky shores which are to an extent less vulnerable, there are the estuaries, lagoons and coastal wetlands which are generally extremely sensitive to disturbance, and yet are the most attractive to developers.

In order to counter the various forms of environmental degradation which have become evident in the South African coastal environment, legislation is necessary to guide and control land use and future development. This requirement is adequately catered for by the principles of Integrated Environmental Management (IEM) and the policy for Coastal Zone Management (Council for the Environment, 1989a and b). The latter backed by a series of objectives, policies and guidelines has four main aims:

1 the incorporation of environmental (ecological, social and economic) considerations into regional planning which affects the coast;
2 the integration of ecological considerations with the planning and execution of development which affects coastal land forms;
3 the rehabilitation of disturbed areas;
4 the integration of aesthetic consideration with urban and resort development.

This Coastal Zone Management policy is likely to work well under climatic conditions normally experienced in South Africa and is designed, to a certain extent, to cope with extremes of drought and flood. However, in recent years there has been growing concern over what impacts rising sea levels and future climatic changes will have on the environment when viewed on a time scale of decades. The outcome of these changes will in many instances be detrimental and any environmental management policy must therefore be flexible enough to incorporate the effects (impacts) of these changes.

CLIMATE CHANGE

A recent report by the International Panel for Climatic Change (IPPC, 1990) states that it is *certain* that human induced increases in greenhouse gases will lead to a warming of the earth's surface at a rate greater than that which has occurred over the last 10 000 years. In the absence of other factors "by the year 2020, global mean temperatures will have risen 1,8 °C above pre-industrial (levels), with a probable range between 1,3 °C and 2,5 °C. By the year 2070, the range of temperature increase will be 2,4 °C to 5,1 °C with a best estimate of 3,5 °C". This temperature rise will induce a rise in sea level and may alter atmospheric and oceanic circulations causing further changes in local climate and sea levels.

Analysis of South African tide gauge records (Hughes *et al*, 1990 and Hughes and Brundrit, 1991) have shown rises in sea level over the last 30 years comparable with estimates of global sea level rise. It is reasonable therefore to accept the modelled estimates of future global sea level rise as being applicable to South Africa. The best estimates of these predictions indicate approximately 20 cm rise in sea level within the next 35 years (IPPC, 1990, Thomas RH, 1987) which may be followed by as much as 1,5 m rise by the end of the next century (Thomas, 1987).

CONSEQUENCE OF SEA LEVEL RISE

The effects (impacts) of sea level rise on the coastal environment can be categorized as follows; increased coastal erosion, increased flooding and inundation, increased salt water intrusion and raised groundwater tables and increased vulnerability to extreme storm events. These effects (impacts) must be viewed from both an economic and environmental standpoint. The economic standpoint considers the natural loss of development, infrastructure and agriculture etc. with rising sea levels. The environmental standpoint considers the potential loss of biological diversity and resources that may occur as a result of poor planning procedures.

An example of the environmental standpoint would be to consider the fate of an estuary, surrounded by wetlands rich in wildlife, with a small development on the edge of the wetland. With time, pressures for housing and the natural beauty of the area would tend to spread development around the perimeter of this wetland. As the sea level rises, a greater expanse of open water will be created within the estuary as the wetlands become flooded. This effectively reduces the wetland area and unless the wetland is allowed to migrate naturally inland (into areas which have since been blocked by a perimeter of development) the wetlands become squeezed between the open water and the development. Hence the natural habitat for the wildlife is damaged and ultimately the quality of life of the nearby residents, who were originally attracted to that area for its outstanding natural beauty, is reduced. Judicious planning of development with cognizance of rising sea levels in this example could avoid a lowering of quality of life for the residents and economic losses including possible legal action resulting from flood damage etc. or forced purchase of certain properties restricting the wetlands' evolution.

A recent study of the south Cape coast

(Hughes and Brundrit, 1990) which developed a procedure for the analysis of vulnerability of existing development to rising sea levels showed that within these study area, estuaries, rivers and backing lagoons were at highest risk. The greatest risk was perceived to be that due to storm damage and elevated groundwater tables with private housing and minor roads being most susceptible. Although the impacts of sea level rise are site specific, the application of a Coastal Vulnerability Index (CVI) (Hughes and Brundrit, 1990) to the whole coast would give a clear indication of the legislation necessary for incorporation into the policy of Coastal Zone Management and Integrated Environmental Management.

Some of the policies of setbacks, buffer zones and non-development contained within the policy of Coastal Zone Management go a long way towards countering the impacts of sea level rise but unfortunately do not extend across the full range of potential impact variables which may be expected.

REACTION TO SEA LEVEL RISE

At present there are a number of impediments to considering sea level rise in design and planning criteria (Gerstle, 1989). The first is the lack of resolution of the present global climate models to make accurate predictions on a local scale or to narrow down the range of future sea level rise. The second, in light of the uncertainty of the impacts, is the cost of over-designing for these impacts. The third relates to the community perception of the problem in that as the problem is not currently visible, it is difficult to conceptualize an accelerating problem which will become more extreme with time. In traditional areas of engineering there tends to be a high dependance on historical methods and a reluctance by professionals to recognise the predictions of future change. The fourth area of difficulty in implementation is a lack of experience in dealing with conceptual problems. "Politicians are constantly pressed to deal with immediate concerns. Planning for eventualities well outside their parliamentary term would be described in 'Yes Minister' parlance as a 'courageous' approach" (Gerstle, 1989).

When considering what action may be taken, there are according to Gerstle (1989) four main courses which may be followed and within each course are a number of possible methods for achieving each aim. The courses of action are:

1 Do nothing and see what happens. If sea level rise predictions are correct then remedial action may become very expensive.

2 Restrict development to well behind areas of potential risk and front the development with a series of natural undeveloped buffer zones. This approach may be beneficial from an environmental point of view but could unnecessarily sterilize large tracts of valuable land.

3 Planned retreat. As the sea level rises allow the development to retreat landward in an organised fashion possibly allowing free market policy to dictate the time of migration. This would involve some complex legislation to provide for the assurance of the right to protection or non-protection of certain shores, forced purchases of properties, lease options etc.

4 Defend the development with either hard options such as walls or dykes or by soft options such as beach nourishment programs. After a certain period, either option is likely to become prohibitively expensive.

Each course of actions is correct in its appropriate location. The problem hinges on deciding what is the appropriate location and at what cost. A comparison of international approaches to the problems of sea level rise may therefore be useful.

INTERNATIONAL APPROACHES TO SEA LEVEL RISE

The New South Wales Government is presently formulating a coastal management manual which introduces a Coastal Hazards Policy. The primary aim of this policy is "to reduce the impact of coastal processes on owners and occupiers of the coastal area and to reduce public and private losses resulting from such processes" without unnecessarily sterilizing land (Hibbert and Tainsh, 1990).

According to Hibbert and Tainsh a number of strategies have been adopted to implement the policy based on the premise that the day to day development and planning decisions lie with local government. The key elements of the strategies are:

* Introduction of financial assistance and the continuation of technical assistance to local government by the State to pursue organizing studies necessary for the development of management strategies and for the implementation of those strategies.
* Continuation of financial assistance for projects aimed at improving the recreational amenity of the State's beaches.
* Preparation of a Manual containing guidelines and principles to assist Local Government in dealing with development proposals, and in preparing and implementing plans of Management.
* Legislation to protect public authorities against claims for damages providing they act in accordance with the Manual.

The Management system places emphasis on "merit based balanced planning and development decisions" and has elements as shown in Figure 1.

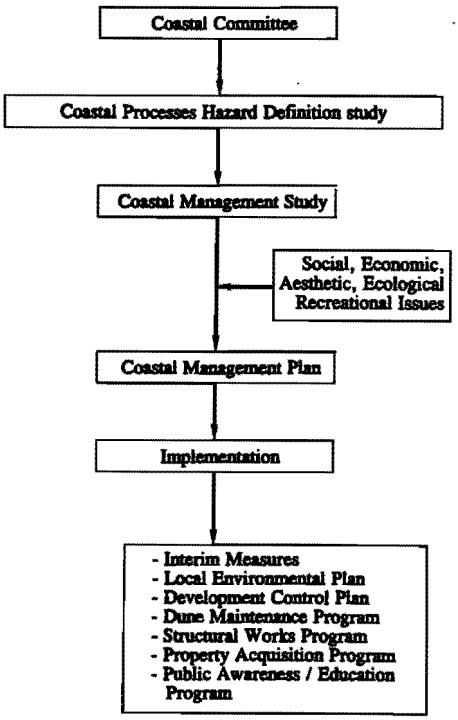

FIGURE 1. *Elements of the Coastal Management System (after Hibbert and Tainsh, 1990).*

The Committee comprises senior Council (Local Government) staff, elected technical members and community group leaders. The Coastal Process/ Hazard Definitive Study is a specialist technical investigation aimed at identi-

fying coastal hazards which is threatening a particular length of coastline. The Coastal Management Study considers all feasible management options. The Coastal Management Plan involves the formal adoption of a defined coastline management strategy and the Plan Implementation uses various approaches to implement the various elements of the said plan. With reference to climatic change the policy states "in the light of present uncertainty (of climatic change), an adaptive approach towards planning and design in the coastal zone is necessary. This approach should be sufficiently flexible or 'robust' to be able to cater for a range of possible outcomes, i.e. Management decision should be subjected to a 'hazard risk sensitivity analysis' (Houlahan, 1989). This effectively forces the local planners to acknowledge their professional responsibility towards sea level rise without necessarily forcing design changes at this stage.

The Western Australian State Government has evolved a unique and non-statutory approach to coastal management which meets its own needs (O'Brien, 1988). The system is based on a policy of cooperation between State departments and local government authorities. The State has over many years, retained public ownership of the majority of coastal land through a policy of non-alienating State land and by resuming foreshore reserves when freehold land is subdivided. This effectively provides for a buffer zone between ocean and privately owned land and results in minimal storm damage being incurred by the private sector. In 1983 the Western Australian State Government made a conscious decision to continue with its non-statutory approach and it is likely that because of its lengthy coastline, small population and limited tax base, this approach will be continued despite rising sea levels.

Coastal Zone Management in the United States is accomplished through a cooperative federal and state program to manage and protect coastal resources. Significant coastal erosion affects approximately a quarter of the U.S. coastline (Houlahan, 1989) and fifteen states or territories use a system of setbacks or building restrictions to counter this erosion. Of the fifteen, four use fixed setback policies where the setback distance is determined *prior* to permit applications. The fixed setback is usually referred to a stationary reference point such as a beacon or road and is therefore easy to locate on maps and structural plans. It is, however, unresponsive to shoreline dynamics. The remaining eleven states and territories use a principle of floating setback where the setback distance is determined *when* a permit is requested and is based on a multiple of average annual long-term recession rates. The multiplier is usually of the order of 30 to 100 years recession. In addition to the floating setback some states divide the coastline into high and low hazard areas, requiring a greater or lesser degree of setback: considerations regarding structure size influence the setback distance. Within the operation of management procedure these states endeavor to make the setback program understandable to the general public. With the flexible setback program a planned retreat in the face of rising sea levels could be easily accommodated.

A study using relative sea level rise in the Mississippi River delta to illustrate eustatic sea level rise in wetlands, emphasize two important factors (Day and Templet, 1989).

1 There may often be a lag of decades before a response in the natural system to sea level rise becomes evident.
2 Changes may be slow at first but will accelerate.

This study recommends that "coastal wetlands can be managed to survive rising sea levels but that only comprehensive, integrated, long term planning can effectively deal with the problem of sea level rise."

THE SOUTH AFRICAN CONTEXT

Planning and decision making authorities in South Africa are aware of the projected rise in sea level but as yet no legal or policy initiatives have been adopted or proposed to deal with the problem (Sowman et al, 1990). A recent poll (Sowman et al, 1990) of people in key planning positions in the Cape Town Metropolitan area indicated a need for central government to play a coordinating role to effectively deal with the range of issues associated with sea level rise. Having considered various possible engineering solutions, planning measures and strategies that could be adopted, the participants of the poll recognised the significance of the impacts and the effects rising sea levels would have on existing development. However there was some confusion over who should take responsibility for and bear the costs of losses and damage to property. Most interviewees were of the opinion that the responsibility lay with the authority which approved the development in the first place. In other words within South Africa the potential problem is recognized, as too that it must be addressed in a professional manner and that someone or some authority must be held accountable for bad planning and management decisions -made in the face of current knowledge pertaining to rising sea levels.

After considering the approaches of other governments and the impending problems it is clear that "by acceptance in principle, and adopting a policy that includes conservative (low) short term estimates of change, a 'reasonable approach' to the issue can be achieved. As more conclusive evidence becomes available, it is a matter of improving the 'numbers' rather than belatedly establishing a policy." (Gerstle, 1989)

It is suggested that planning and management procedures for future climate change and sea level rise in South Africa should be based on a two tier system. One tier should address the overall problem of potential risk on a macro scale to ensure that planners and coastal engineers take cognizance of the essential issues. The second level of management should be more specific and be aimed at local development projects which may be envisaged in areas identified as potentially vulnerable to sea level rise, and that these be subject to a sea level rise "hazard test". The system should form an integral part of IEM and Coastal Zone Management policy and should not be regarded as a separate entity or addendum.

The incorporation of the application of a Coastal Vulnerability Index (CVI) to sea level rise within the Coastal Zone Management Policy (Environmental Guidelines for Regional Planning) could form part of the evaluation process at the first tier of the planning. In these guidelines Policy 2 calls for "an

inventory of coastal landforms, visually appealing landscape features and biological resources." An assessment of general vulnerability (CVI) to sea level rise could improve this inventory.

Within Part 2 of this policy - "Guidelines for the Use of Coastal Landforms" - the application of the sea level rise "hazard test" as applied to management procedures on a case study basis where the inventory and CVI of Policy No 2 require it could be beneficial. Within these procedures the strategies of non-protection, planned retreat, hard and soft engineering controls may be examined with respect to any new or existing development. These steps may also serve as a mechanism to protect the authorities from claims for damage: similar to the NSW case, provided that decisions have been taken in accordance with the prescribed procedures.

REFERENCES

Council for the Environment 1989(a) IEM. *A Framework for Harmony between Development and Environment.* Pretoria.

Council for the Environment 1989(b). *A policy for COASTAL ZONE MANAGEMENT in the Republic of South Africa. Part 1 - Principles and Objectives* (May). *Part 2 - Guidelines for Coastal Land Use* (in press). Pretoria.

DAY, J.W. Jr AND TEMPLET, P.H. 1989. *Consequences of sea level rise: Implications for the Mississippi Delta, Coastal Management.* 17, No. 3, pp 241-257.

GERSTLE, M.B. 1989. *Does Your Local Council Live in a Greenhouse? Proceedings of the National Environmental Engineering Conference. Planning for Environmental Change.* Institute of Engineers, Australia, Sydney. Publ. No 89/3.

HIBBERT, K. AND TAINSH, J. 1990. *Coastline Management Manual. Proceedings of the Local Government Engineers Association of N.S.W.,* Annual Conference: Sydney, Australia.

HOULAHAN, J.M. 1989. *Comparison of State Construction setbacks to manage development in coastal hazard areas. Coastal Management.* Vol 17, No. 3 pp 219-228.

HUGHES, P. AND BRUNDRIT, G.B. 1990. *The Development of an Index to assess South Africa's Vulnerability to Sea Level Rise. South African Journal of Science.* (submitted)

HUGHES, P. AND BRUNDRIT, G.B. 1991. *The Vulnerability of the False Bay Coastline to the Projected Rise in Sea Level. Transactions of the Royal Society,* Volume 45, Parts 4 & 5, pp 501- 508. (in press)

HUGHES, P., BRUNDRIT, G.B. AND SHILLINGTON, F.A. 1990. *South African Sea Level Measurements in the Global Context of Sea Level Rise. South African Journal of Science.* (in press)

IPCC. 1990. *Sea level rise. Inter-governmental Panel for Climatic Change. Peer Reviewed Assessment for Working Group 1.* Section 9.

O'BRIEN, R.J. 1988. *Western Australia's Non Statutory Approach to coastal Zone Management: An Evaluation. Coastal Management* Vol 16, No.3, pp 201-214.

SOWMAN, M.R., GLAZEWSKI, J.I., FUGGLE, R.F. AND BARBOUR, A.H. 1990. *Planning and Legal Responses to Sea Level Rise in South Africa. South African Journal of Science.* Vol 86, No. 7-10, pp 294-299.

THOMAS, R.H. 1987. *Future Sea Level Rise and its Early Detection by Satellite Remote Sensing. Progress in Oceanography,* Vol 18, pp 23-40.