

Chapter 10: Coastal and Sea Defence Decision Framework

1. Introduction

Much of the City's coastline has been developed with fixed infrastructure, leaving little room to accommodate coastal changes resulting from coastal erosion and accretion or the predicted effects of anthropogenic climate change. These two coastal risks are in fact what may be considered as compounding risks where coastal erosion exacerbates the risks associated with climate change.

Coastal erosion is occurring at a number of points along the City's coastline as a direct result of urban altered coastal processes through urban development. An example is the southern end of Table Bay where erosion (recession) of the coastline has been calculated at a little over 35m in the last 45 years.

Climate change on the other hand, predicts that a number of co-acting processes present long term risk to the City's coastline. These co-acting processes are the predicted increase in both the intensity and frequency of coastal storms in association with a slow and gradual increase in mean sea level. There is some uncertainty over the extent and rate of climate change induced sea-level rise. What is clear is that globally sea-levels are rising, the rate of rise is increasing and relatively small increases in mean sea-level have disproportionately large impacts on the damage that storms cause to the coastal zone. Current global consensus suggests mean sea level will rise by 0.76cm by the year 2100.

Brundrit et al., 2008 estimated that 25 km² of land interior to the City of Cape Town's 307 kilometre coastline is currently exposed to high sea-events 2.5 metres above land levelling datum (LLD), caused by a coinciding extreme high tide and storm surge.

As a result, the City will at some point in the medium term have to consider coastal and sea defences to protect the coastline and infrastructure. How these decisions are made, the type of coastal and sea defences implemented and the mechanisms for doing so have substantial implications for the city's coastal environment. Poor or ill-informed decision making may well exacerbate the problem and increase risk and accelerate erosion, while inappropriate decisions may lead to the permanent loss of existing beaches and coastal environments. As such, a well-considered and structured framework for making these decisions is presented here to ensure that when coastal and sea defences are justified, the most appropriate decision in the best interests of the long term future of the coastline are made.

Finally, coastal and sea defences are notoriously costly and this financial issue is further compounded by the complexity of private property and its exposure to risk. As a result, unique and novel financial mechanisms for coastal and sea defences will also need to be considered on a case by case basis.

2. Context: Risk is not equal across the coastline

Risk requiring likely intervention in the medium term is determined by a number of factors which give an indication of vulnerability, namely:

- a) **Wave set-up** as influenced by bathymetry, swell direction, swell conversion and shoaling. Wave set-up is a function of wind, swell direction and the extent to which waves are refracted by the coastal topography; refraction reduces wave energy. Brundrit shows that most significant sea-surges off the Cape Town coast approach from the south-west (200 - 260°). Coastlines that front directly to these seas are the most vulnerable. Offshore reefs, islands and wave refraction typically reduce exposure to wave set-up.
- b) **Wave run-up** as influenced by the topography of the coast and bathymetry. Wave run-up is defined by the extent to which waves advance inland once they have broken, and the energy with which they

advance. Wave run-up is reduced by bottom friction and accordingly coastlines with gradual gradients, coarse shallow sea-surface bottoms (such as those with reefs) and beaches protected by kelp tend to be less prone to wave run-up. Conversely where deep water is found close to the coastline, wave run-up can cause aggressive coastal erosion and damage. Wave run-up can be influenced by “wave focusing” – the convergence of waves from different angles, as is the case at Kogelbaai in False Bay.

- c) **Geological predisposition** of the coastline as influenced by the hardness or softness of the coastline. Coastal geology determines the hardness or softness of the coastline. The hardness (rockiness or sea-wall) or softness (sand or vegetation) of a coastline in turn determines its “natural” ability to withstand or recover from sea-level rise risks and its predisposition to storm damage. As a rule of thumb soft coastlines are more able to absorb wave energy and withstand sea-level rise impacts than hard coastlines, with the exception of high elevation cliff areas such as Chapmans Peak. Well engineered coastlines can, of course, reduce sea-level rise risk but the danger is that poorly engineered coastlines either transfer or concentrate wave energy onto a single point or are over-topped by high seas. The engineering of coastlines usually takes place at the expense of natural buffers, and where (hard) engineered defences are breached the coast is particularly vulnerable. In this way some of the most vulnerable coastlines are those that involve a combination of hard and soft surfaces. Roads built on beaches and sea-walls in conjunction with sand dunes, are particularly vulnerable.
- d) **The extent and nature of coastal development.** From the City of Cape Town’s perspective, coastal vulnerability is a function of the assets (natural or constructed) that the coastline contains. This is true in two ways. Firstly the assets, whether houses, roads or wetlands, are a part of the coastline’s composition and secondly, it is these assets that are vulnerable to damage and thus determine the value (both economic and strategic) that is at risk from sea-level rise.

3. Options

There are a wide range and variety of what could be considered coastal and sea defence options. These can however be categorised into three broad categories:

- Infrastructure engineered interventions – sea-walls, groynes, barrages and barriers, raising infrastructure, revetments, rock armour, dolosse and gabions, off shore reefs, water pumps, beach drainage.
- Biological interventions – dune cordons with vegetation, dune manipulation, estuary and wetland rehabilitation, kelp beds, beach nourishment
- Socio-institutional interventions – managed retreat, external insurance market corrections, land expropriation

4. Decision Making Framework: Principles

- Risk averse decision making
- Decisions centred on the common good
- Apply Multi-Criteria Assessment to decision making

5. Multi-criteria assessment (MCA)

Multi-criteria assessment is a robust means of decision making in the complex space of coastal and sea defences. Under this approach options are interrogated in terms of an agreed upon set of assessment criteria, with the intention being to create multi-disciplinary consensus on the most appropriate course of action. Crucially MCA is well suited to create the type of institutional capacity that is required for effective decision making in complex and dynamic environments such as the coastline.

MCAs have been criticised for their subjectivity. The questions, “Who gets to select the criteria?” and “Who gets to perform the assessment?” are legitimate, but crucially MCAs are capable of bringing together South Africa's particularly divergent development needs and integrating the needs of private land owners, local governments, provincial governments, various departments within national government and conservation authorities all of which have responsibilities towards Cape Town's coastline.

For the City of Cape Town the range of criteria that are relevant include:

- **Risk reduction:** The extent to which the options reduce risk.
- **Ease of implementation:** Not all desirable responses are possible, either due to the institutional complexity involved in implementing them or their cost. In the case of the City of Cape Town, it is particularly important to identify who is responsible and who will pay for the intervention. Options should be selected commensurate with capacity to deliver them effectively.
- **Positive externalities:** The extent of positive externalities associated with the option. Does the implementation yield, or make more likely, benefits that are not related to coastal erosion or sea-level rise.
- **Scope for mal-adaptation:** Some options, and particularly infrastructural options, are more difficult to execute correctly. Options should be selected cognisant of the need to avoid unintended negative consequences. This should include unintended negative consequences of uncoordinated private efforts.
- **Cost:** Budget constraints inform decisions and the extent of reduced impact per unit investment over the long term remains crucial.
- **Reversibility and flexibility:** Given that the precise extent and nature of erosion and sea-level rise impacts is not known, those options that can be reversed or altered as more information becomes available should be considered preferable.
- **Retention of complementary options:** Combinations of options tend to be more effective than single approaches but not all options permit complementary solutions. Where possible complementarily options are favourable.

Effective options should be socio-economically progressive and transfer risk away from Cape Town's communities.

6. The City's Coastal and Sea Defence Decision Making Framework

The following process will be applied when it has been determined that an intervention of coastal and sea defences is required to protect the City's coastline from erosion or increased infrastructural damage and risk arising from sea level rise and/or storm surge events.

- a) Determination of extent and special scale of the problem
 - Property ownership
 - Type of coastline – cliff/rocky/sandy
 - Nature and degree of risk
- b) Determination of responsibility and roleplayers
 - Government organisations
 - Private property owners
- c) Determine lead agency responsibility. Where this is deemed to be the City, the lead line department responsibility must be determined and agreed
- d) Establishment of project task team representing all relevant roleplayers
- e) Undertake relevant coastal studies to assess coastal dynamics and possible protection measures
- f) Application of the Multi-Criteria Assessment as per the matrix below to outcomes of studies in e) above:

	Risk reduction	Positive externalities	Institutional complexity	Scope for maladaptation	Cost	Contribution to GHG mitigation	Reversibility and flexibility	Retention of complementary options	Equality implications	SUM
Sea walls										
Groynes										
Barrage to lagoon										
Raising infrastructure										
Dolosse										
Off shore reef										
Beach nourishment										
Dune cordons and vegetation										
Estuary and wetland rehabilitation										
Kelp beds										
Vulnerability mapping										
Apply coastal buffer zone										
Early warning										
Insurance market correction										
Risk communication										
Disaster management focus										
Managed retreat										

1= poor, 2= neutral/ moderate, 3= excellent

Note: The quantification should not, however, be exploited for inference purposes. In drawing inference, however, the distinction between a cumulative score of 18 and 19 should not be seen as the basis for decision making. MCAs are useful in identifying generally better options, and screening the options confronting decision makers. It is possible to refine the screen, scrutinise options under new criteria and even re-weight specific criteria that are deemed more important than others.

- g) Based on the MCA, propose top two most suitable options
- h) For each of the two most suitable options, determine formal financial scenarios:
 - Budget allocation from a responsible City department where the City is deemed solely responsible for implementation
 - If multiple stakeholder responsibility (especially in the case of private landowner involvement) or other government agency, propose a financial model for financing implementation. This may require a number of agreements to be established and to date is a novel approach that will require development.
- i) Determine environmental authorisation requirements and responsibilities

- j) Submit detailed report on all options, recommending preferred option, to Council for decision making
- k) Financial and implementation options must include long term maintenance and management budgeting and responsibility
- l) Implement

7. Long Term Monitoring

As part of the Coastal Monitoring Programme, long term monitoring of the coastal impacts (positive and negative) must be recorded annually in the Coastal Monitoring Database.

Where negative impacts are established, such as increased or associated erosion, remedial measures must be applied as per this standard protocol.