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Analysis of potential coastal zone climate change impacts and possible response options in the southern African region

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WHY STUDY COASTAL CLIMATE CHANGE IMPACTS?

Predicted climate change and sea level rise have far-reaching consequences for southern Africa's coastal provinces. In excess of 80% of the southern African coastline comprises sandy shores susceptible to large variability and erosion. The problem with sea level rise is not just the relatively modest mean predicted, but its interaction with changing storm intensities and wind fields to produce sea conditions that overwhelm existing infrastructure.

SEA LEVEL RISE AND POTENTIAL MODIFICATION IN STORMINESS

Projections of sea level rise: Recent observations from satellites, very carefully calibrated, are that sea level rise 1993-2006 is 3.3+/-0.4 mm/y (Rahmstorf et al, 2007). The IPCC AR4 Report (2007) concludes that anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilised.

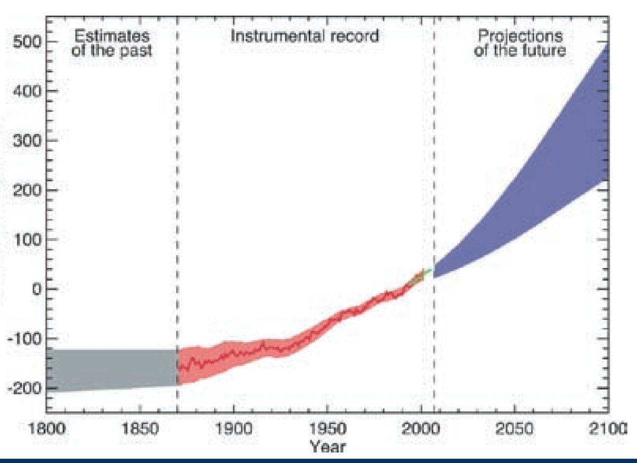

Figure 1: Measured and predicted sea level rise (IPCC, 2007)

Estimates of sea level rise for southern Africa: Comparisons between about 30 years of South African tide gauge records and the longer term records elsewhere, show substantial agreement. A recent analysis of sea water levels recorded at Durban confirms that the local rate of sea level rise falls within the range of global trends (Mather, 2008).

Accelerated sea level rise: The probability of sudden large rises in sea level (possibly several metres) due to catastrophic failure of large ice-shelves (e.g. Church and White, 2006) is still considered unlikely this century, but events in Greenland (e.g. Gregory, 2004) and Antarctica (e.g., Bentley, 1997; Thomas et al, 2004) may soon force a re-evaluation of that assessment. In the longer term the large-scale melting of large ice masses is inevitable.

SOME IMPORTANT POTENTIAL CONSEQUENCES OF GLOBAL WARMING ON THE SOUTH AFRICAN COAST

Wind: Average wind velocity is expected to increase in all seasons in SA. If due to climate change, winds become only 10% stronger, then wave height increases by 26%, and coastal sediment transport rates potentially increase by 40% to100%.

Storms: The increase in storm activity and severity is likely to be the most visible impact and the first to be noticed. For example, higher sea levels will require smaller storm events to overtop existing storm protection measures.

Infrastructure:
Breakwaters, revetments and sea walls, which protect infrastructure such as harbours and houses from direct wave action and under scouring, will require more maintenance. The longevity of such structures and facilities will be reduced.

Figure 2: Present SA example of breakwater maintenance required. (Photo: D Phelp)

In some instances, roads and railway lines have been located too close to the sea. The foundations of such a structure could be under scoured due to the combined impacts of sea level rise and increased sea storms, resulting in structural damage and potentially fatal accidents if not rectified.

Figure 3: Present SA example of railway line located too close to sea. (Photo: D Phelp)

Some others

- Altered freshwater inflows and sea conditions (waves, water-levels, sediment) will (further) reduce environmental function of some estuaries, which will impact fisheries (e.g. nursing grounds). Also: estuaries are exposed to changes in salinity regime.
- Shorelines are very sensitive to sediment supply and budgets – erosion is influenced by various factors affected by climate change.

Figure 4: Impact of March 2007 KwaZulu-Natal storm. (Photo: D Phelp)

Examples of complexities, thresholds, discontinuities and non-linearities

- A certain beach width is for example required for natural variability in shoreline location and certain ecological functioning. Once the average beach width reduces to less than this amount (due to the 'squeeze' between fixed present development and sea-level transgression up the coastal slope), there will be detrimental and progressive impacts on the ecology and on anthropogenic development.
- Sediment transport and thus erosion is exponentially related to wave height, which in itself is not linearly related to (increasing) wind conditions. Some impacts of increased sediment transport would be particularly noticeable where there are disruptions in alongshore transport or discontinuities. For example, harbour entrance channels that trap alongshore transport could trap much more sediment in future, requiring increased preventative dredging (potentially in the order of 50-100% more), thus higher costs.

IDENTIFICATION OF SOME OF SOUTHERN AFRICA'S MOST VULNERABLE AREAS AND LOCAL ISSUES

The most vulnerable areas along the coast will almost invariably be located where problems are already being experienced at present. In most cases these are the areas where development has encroached too close to the high-water line, or at a too low elevation above mean sea level.

Namibia
Breaching of the Walvis Peninsula by the sea poses a real threat because the peninsula is so low-lying; both sea level rise and increased sea storminess could greatly increase this risk. A large breach of the Walvis Peninsula would have disastrous consequences for Walvis Bay.

Increased storminess due to climate change would impact costs, for example increased beach-wall maintenance and protection, and increase the difficulty of coastal diamond mining in certain areas.

However, it appears that apart from some important potential impacts in the Walvis Bay area, the Namibian coastline is relatively invulnerable to climate change impacts (compared to many other countries).

South Africa
Fortunately, due to the relief of much of the South African coast and the location of existing developments, relatively few developed areas are sensitive to flooding and inundation resulting from projected sea level rise (to 2100).

The most vulnerable coastal areas (resulting from predicted climate change impacts) that have been identified are Northern False Bay, Table Bay, Saldanha Bay area, the South Cape coast, Mossel Bay to Nature's Valley, Port Elizabeth and developed areas of the KwaZulu-Natal Coast.

According to Tol (2004), by 2100 South Africa would lose some 11% of its wetlands due to full coastal protection measures and structures erected to mitigate sea level rise impacts, making South Africa potentially the 5th most vulnerable country worldwide in terms of wetland losses.

Mozambique
Tol (2004) predicts that by 2100 Mozambique will have lost 1,3 % of its 'dryland' area due to sea level rise, potentially making it the 5th most vulnerable country worldwide to sea level rise.

Mozambique's reefs comprise tough, algal-clad intertidal bars composed largely of coral rubble and provide protection from wave attack to the inshore areas and beach sands that are susceptible to erosion (Arthurton 2003). If the coast is subjected to the predicted sea-level rise, the protective role of the reef bars will be diminished if their upward growth fails to keep pace.

Maputo is likely to be one of the most problematic areas in Mozambique from a climate change perspective and appropriate local planning and adaptation measures should be initiated in the short-term.

POSSIBLE RESPONSES AND GUIDELINES TO MITIGATE CLIMATE CHANGE IMPACTS

In general, regarding developed areas and existing infrastructure, southern African states have very little adaptive capacity. Where this is deemed acceptable and space permits, the best policy in the long-term is probably not to combat coastal erosion and allow the natural progression of coastal processes. In any case, our ability to halt the coastal impacts of climate change on a large scale is virtually non-existent and may well lead to other detrimental impacts.

Tol (2004) predicts that adaptation would reduce impacts by a factor of 10 to 100 (globally), and that adaptation would come at a minor cost compared to the potential damage incurred.This strongly emphasises the need for setting and implementing adaptation measures sooner rather than later.

Each vulnerable stretch of coastline should be studied in terms of aspects such as wave energy, sand budgets, future sea levels and potential storm erosion setback lines, including accounting for at least a Bruun-type erosional response, as well as expanded profile envelopes.

Our best 'adaptive capacity' appears to lie in planning and research-related initiatives, such as quantifying increased storminess, and determining appropriate coastal erosion and development setback lines.

CONCLUSIONS

Locally-applicable methods have to be developed urgently to quantify realistically the impacts along the southern African coast. To mitigate the detrimental impacts of climate change, we have to understand the adaptation options available to southern African society, which is considerably different from first world approaches, and still largely undefined.

To mitigate the detrimental impacts of climate change on the southern African coast, research is directed at an improved understanding of what is happening to our coastline and what is likely to happen as climate change intensifies.

Quantitative information remains largely unavailable and the resulting somewhat speculative predictions presented here are uncertain. Some important potential consequences of global warming on the southern African coast are highlighted, and there is a clear and urgent need for improved understanding of these issues and, especially, predictive capabilities.

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