A Coastal Hazard Adaptation Study for Townsville: Pilot Study

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Abstract

The study considers the potential ongoing cumulative impacts of coastal hazards on the Townsville regional community in Far North Queensland for both present extremes of climate and also projected changes in future climates up until the year 2100. This included the effects of ocean inundation from storm tide events (both tropical cyclone and non-cyclonic events) together with long-term sea level rise and consideration of likely coastal recession due to erosion over time. The study represents the first step in identifying potential practical coastal adaptation strategies to respond to existing and future threats from coastal hazards in the region; these being categorized nominally as either to Defend, Retreat or Accommodate. The results are expected to be used for informing decision making in the preparation of the new Council planning scheme, infrastructure plan and asset management plan.

The results identified regions likely to be affected by high coastal hazards, assessed the vulnerability and risk to key Council and community assets, developed potential coastal adaptation options to mitigate the impact of these hazards and assessed the viability of adaptation options through stakeholder engagement and detailed economic assessments (costs and optimal timing). The study provided an assessment of over 150 separate potential adaptation options for 11 coastal districts. The study shows that the ‘optimal’ timing of adaptation for some districts may be much sooner than otherwise anticipated (e.g. prior to 2030). A compendium of coastal adaptation options suitable for Queensland coastal environments was also prepared as part of the project.

Keywords: coastal hazards, climate change, adaptation, planning.

1. Introduction

Queensland has a highly dynamic and complex coastal zone, featuring shallow coastal margins and complex estuary systems with significant exposure to coastal hazards, including erosion, storm tide inundation and sea level rise. Many of Queensland’s large regional cities and towns are on the coast and are therefore potentially exposed to such hazards.

Climate change is projected to increase the frequency and intensity of many of these hazards along the coast. Queensland Government policy calls for coastal hazard risks to be addressed in planning and development decisions [3]. However, dealing with hazards on a development by development basis is not efficient and will not provide a suitable holistic outcome for a community at risk. Adaptation strategies are intended to ensure a planned approach is taken to address coastal hazards for at-risk communities from the immediate to long-term timeframes.

Townsville City Council (TCC) is the first in Queensland to consider a Coastal Hazard Adaptation Strategy (CHAS). This landmark pilot project [1] was undertaken by GHD Pty Ltd, in collaboration with the Local Government Association of Queensland (LGAQ), Queensland Government (DERM/DEHP) and TCC. The study was a pilot project funded by the Commonwealth Department of Climate Change and Energy Efficiency’s Coastal Adaptation Pathways Program (DCCEE-CAPP)

The Townsville CHAS has been developed to assist and inform TCC on methods to minimise risks to both existing infrastructure and properties and new development in areas projected to be at high risk from coastal hazards by the year 2100.

While the study provides Townsville-specific detail of the risk and potential mitigation to ocean hazards, the overall CHAS process can be used to inform other coastal Local Government Authorities (LGAs) in undertaking their own future strategies/studies.

GHD was assisted by Griffith University Centre for Coastal Management who assembled the bulk of the material that formed an accompanying Compendium of Adaption Options (hereafter termed The Compendium).

2. Overview

The imperative for the Pilot Study was the previous Queensland Coastal Plan – State Planning Policy for Coastal Protection (SPP 3/11) which required all coastal councils to undertake a coastal adaptation strategy study within a period of five years following its enactment. However, after a change in government the operation of this policy was suspended in October 2012 awaiting a revised State Planning Policy. A new DSDIP draft coastal hazard policy [2] replaces SPP 3/11, supported by updated DEHP guidelines for assessment of coastal hazards [3] and for undertaking (non-mandatory) adaptation strategies [4].

The CHAS study was underway at the time of the policy change and aimed to provide three key deliverables:

- A Compendium of Coastal Adaptation Options for Queensland Coastal Councils detailing options suitable for the Queensland coast that Local and State authorities can utilise [5];
- The specific Townsville CHAS Study Report [6] with recommendations for possible future incorporation in the TCC Planning Scheme, Infrastructure Plan, Community Plan and Financial Plan; and
- A CHAS Learnings Report detailing project learnings and recommendations for updating the existing SPP 3/11 coastal adaptation guideline and assisting other LGAs in development of their own future strategies/studies. This forms part of [6] but key aspects therein have been repeated in the updated strategy guideline [4].

3. The CHAS Process

A summary of the process is outlined in Figure 1.

3.1 Defining Coastal Hazard Areas

High coastal hazard areas were nominally defined by DERM (DEHP) as either:

- Erosion-prone areas within a coastal management district;
- Land that will be affected by the Highest Astronomical Tide (HAT) when a 0.8 m sea level rise allowance relative to 1990 levels is considered; or
- Land that is affected by more than 1 m of depth during the defined storm tide event (the 1% AEP storm tide event occurring in 2100).

The critical coastal hazard information was available from the previous GHD/SEA storm tide study [7] completed in 2007 for TCC and followed the endorsed Queensland Government and Bureau of Meteorology storm tide methodology [8]. However the 2007 study considered only the effects of tropical cyclones (TCs) and the additional impact of non-cyclonic events was included by considering tidal residual analyses. This was important to ensure that ocean levels with Average Recurrence Intervals (ARI) less than around 100 y were adequately represented. These statistically combined (TC and non-TC) water levels were then mapped inland as horizontal surfaces (the so called 'bathtub' approach).

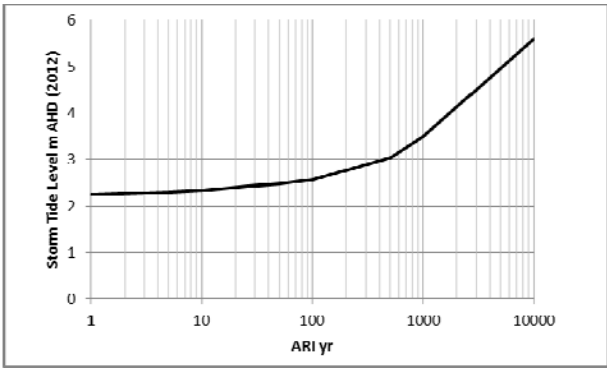

Figure 2 Combined TC and non-TC tide plus surge 2012 ocean level ARI for South Townsville.

3.2 Vulnerability and Risk Assessment

A total of 11 coastal hazard Districts were defined in consultation with TCC (Figure 3). and a standard qualitative risk assessment was undertaken to assess risk to infrastructure and risk to property as a result of the imposed hazard. The vulnerability classifications adopted were:

- Acceptable risk – individuals and society can live with this risk without feeling the necessity to reduce the risks any further
- Tolerable risk – society can live with this risk but believe that as much as is reasonably practical the risks should be reduced further. Individuals may find this risk unacceptable and choose to take their own steps, within reason, to make this risk acceptable
- Unacceptable risk – individuals and society will not accept this risk and measures must be put in place to reduce risks to at least a tolerable level

Figure 1 A summary of the CHAS study process.

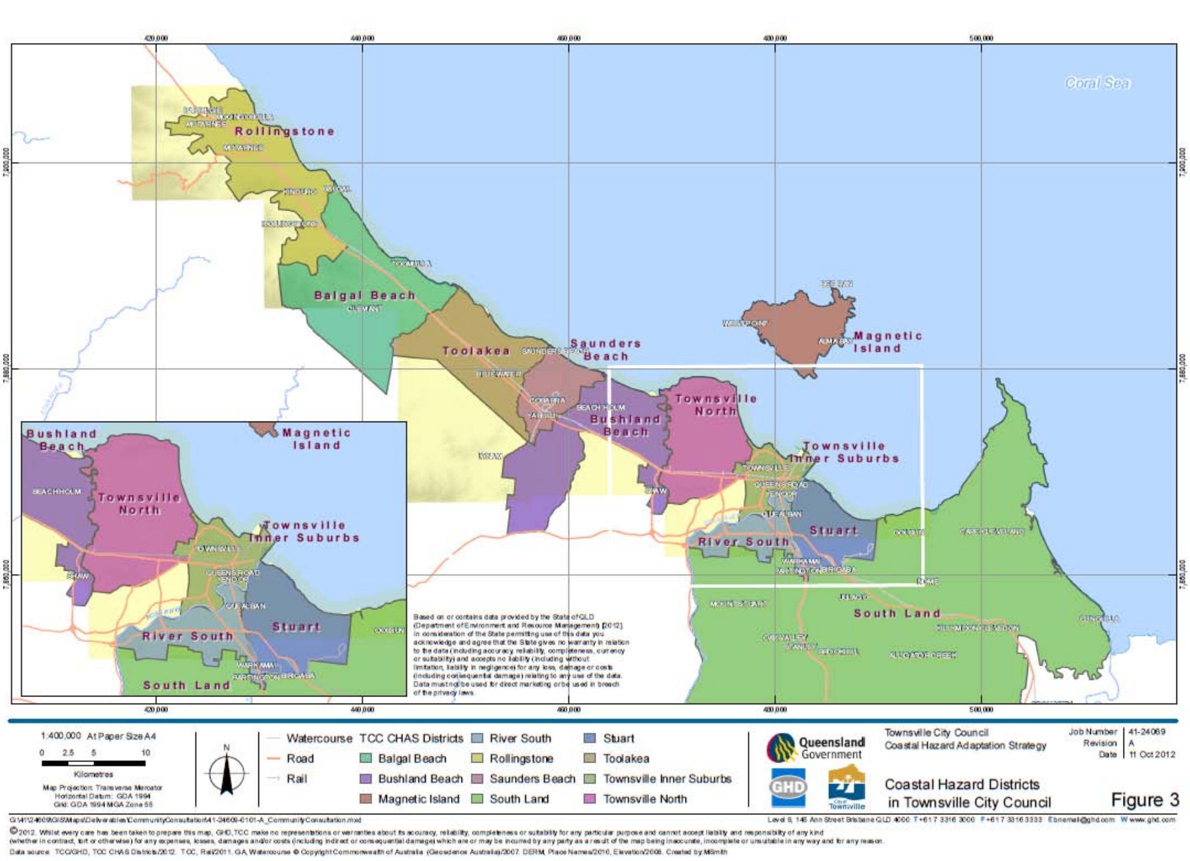

Figure 3 The adopted coastal hazard Districts.

Specific risk hazard thresholds to inform the vulnerability assessment were developed. This included a property floor level database that was assembled from a variety of sources. An extract from the qualitative risk assessment process is shown in Figure 4 for current 2012 hazard conditions.

3.3 Evaluation of Adaptation Options

Following consideration of coastal and floodplain morphology, the identification of high coastal hazard areas and associated risk to infrastructure and property, over 100 separate adaptation options were developed for 39 specific Localities.

A Locality was defined as an area within a District:

- Allocated as an urban footprint or rural living areas in a regional plan; or
- Zoned as urban or rural residential purposes in a local planning instrument equivalent to one of the standard suite of zones for urban development (where there is no regional plan urban footprint) or
- An existing settlement or township (not designated as above).

These adaptation options were refined through a series of Consultant, State Government, Townsville City Council and Local Stakeholder Workshops.

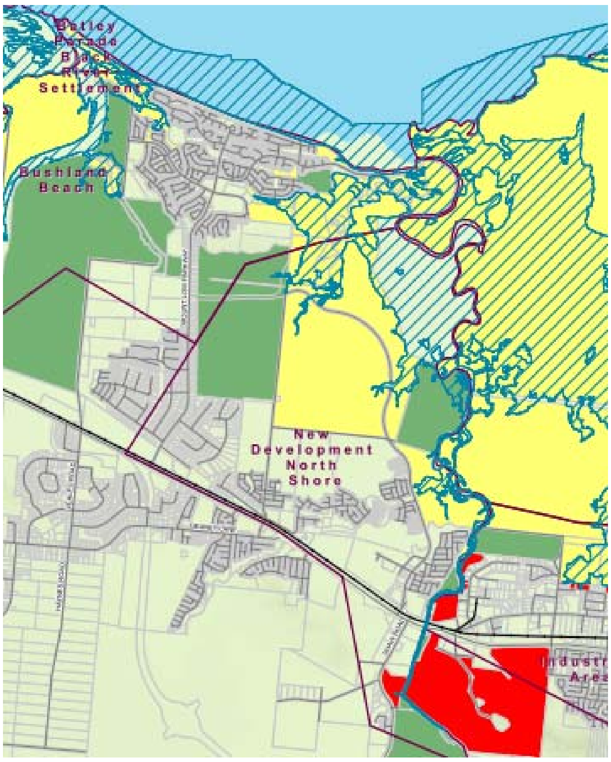

Figure 4 Example of qualitative risk assessment mapping for the Bushland Beach District (refer [6] for legend and details)

Table 1 MCA decision criteria.

Category	Criteria
Adaptation effectiveness	Severity of inundation on humans as well as buildings and community infrastructure
Climate uncertainty	Flexibility to respond to unexpected climate outcomes (upside / downside)
Social and environmental impacts	Impact on access to coastal areas for recreation (e.g. camping, fishing, swimming)
	Impact on natural coastal ecosystems
	Indirect economic / industry impacts (e.g. tourism, fishing)
	Impact on cultural heritage and landscape
Complexity and cost	Capital cost
	Complexity of implementation (technical, stakeholder / social, institutional)
	Operating and maintenance costs

3.4 Economic assessment of adaptation strategy options

An economic appraisal was undertaken for each adaption option, comprising a multi-criteria analysis (MCA) and a benefit cost analysis (BCA). The economic appraisal focussed on assessing the merit of each option from a range of economic, environmental and social criteria and included:

- Development of the MCA criteria (Table 1);
- Development of the MCA weightings and scoring;
- Provision of the MCA results including guidance on the highest scoring options for input to the BCA modelling;
- Development of the BCA modelling framework;
- BCA modelling of Localities for selected adaption options from the MCA.

Following the MCA process a BCA was undertaken to estimate the optimal timing and economic viability of adaptation options. This required further development of the previously recommended DCCEE BCA framework. Key components of this work included:

- Development of the enhanced BCA model including Monte Carlo NPV;
- Development of sea level rise asset losses and storm tide damages for coastal communities as a function of water level;
- Cost estimation of adaptation options (levees, retro-fitting) for input to the BCA;
- BCA modelling of urban localities without adaptation;
- BCA modelling of urban localities for selected adaption options;
- Summary of proposed adaptation options, and
- Sensitivity testing of a number of key model inputs

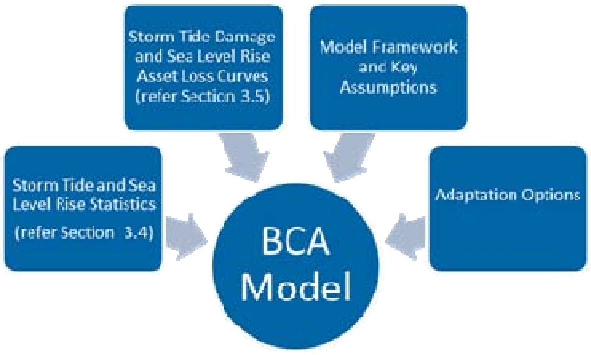

Figure 5 Key inputs to the BCA model.

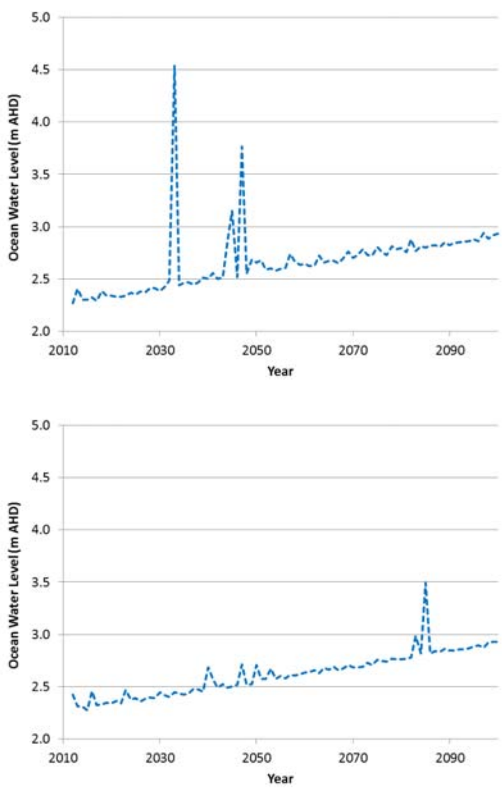

Figure 6 Examples of two of the 1,000 future realisations of ocean water levels that were modelled.

The Monte Carlo BCA sampled the projected sea level rise and slowly modifying storm tide hazard over the study horizon of 88 y (2012 to 2100), accumulating the variability in potential outcomes over 1,000 separate possible realisations. Figure 6 shows examples of just two possible future scenarios where the slow rise in sea level is the base for randomly occurring storm tide episodes of varying magnitudes. This approach importantly allows very extreme events to occur at any time and does not assume a fixed risk level (e.g. the 100 y ARI).

When combined with the detailed mapped exposure and vulnerability information, and in conjunction with a specific estimated cost of adaptation (e.g. levee construction), the distribution of the Benefit-Cost Ratio (BCR) of the strategy can be calculated for a specific Locality (Figure 7).

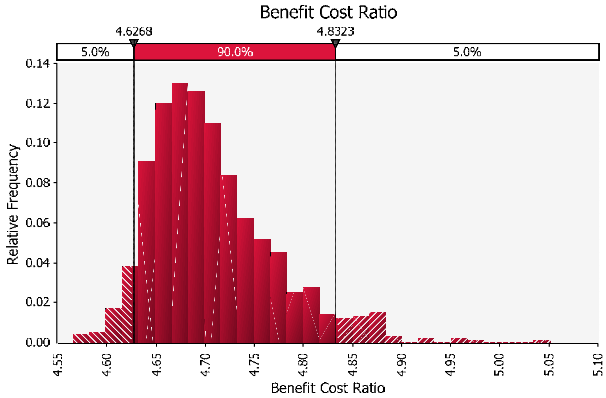

Figure 7 Example distribution of the BCR of an adaptation option after 1,000 future realisations of an 88 y period of ocean water levels.

By systematically modifying the year of implementation of an adaptation option, and reperforming the simulation, the mean NPV and mean BCR can be plotted as a function of the year of implementation. Figure 8 (top) shows an example, of the variation in the minimum, mean, maximum, 5 and 95 percentile BCR for the simulated planning period. Each simulation has assumed a different year of implementation of the adaptation option to obtain an understanding of when the maximum benefit can be achieved. These results indicate that the NPV and BCR is maximised in the year 2027 and that the spread of the distribution (the difference between the 95% and 5% lines) is reasonably narrow. Similarly the BCA model can be used to investigate the sensitivity to the assumed discount rate as shown in Figure 8 (bottom). It can be noted that 3% was the adopted reference rate.

In an additional step the model sensitivity to uncertainty in the projected rate of sea level rise was also able to be explored, which acts to modulate the optimum time of implementation of an adaptation option. Furthermore, low growth and high growth in population were also explored.

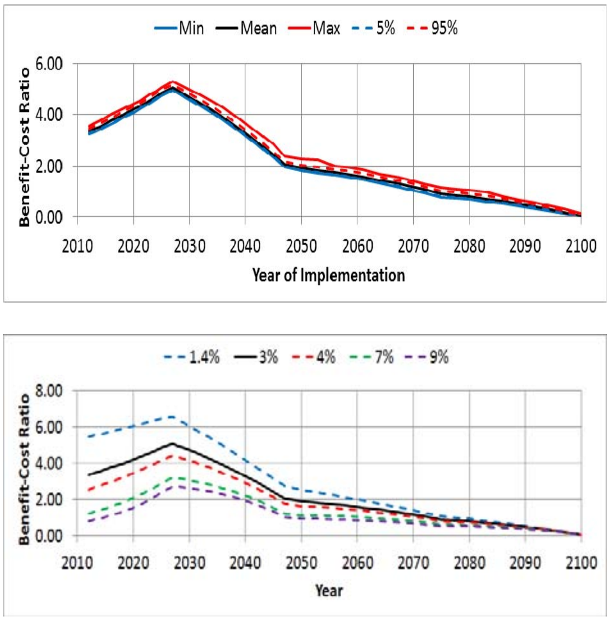

Figure 8 Example year of implementation optimisation (top) and sensitivity to discount rate (bottom)

4. The Compendium of Adaptation Options

The Compendium provides information on a range of adaptation options, based on currently available information at the national and international level. Options included hard and soft engineering measures, water-resilient designs, and a range of environmental and planning mechanisms that can be used to:

- Allow for development intensification by defending the current shoreline position and controlling erosion and storm tide inundation (defend);
- Maintain the current level of use and reduce the risk of storm tide inundation by applying innovative designs when redeveloping or upgrading existing building and infrastructure (accommodate); and/or
- Gradually retreat buildings and infrastructure to safer grounds (retreat).

A technical description of each adaptation option is provided, with examples of implementation from Australia and internationally. Further details of how each option can contribute to adapting to current and future coastal hazards, and potential synergies and conflicts with other adaptation options are also explored. The current legal and administrative framework for its implementation in Queensland is also reported, together with information related to maintenance requirements, timeframe for review, risk of failure and costs. Finally, a multi-criteria overview is presented to assess each option against climate uncertainty, social, environmental and economic criteria.

The list of coastal hazard adaptation options was identified through a thorough analysis of the existing information at the international and national level in parallel with an extensive consultation process with academic and industry experts, and Queensland Government and LGA representatives.

The adaptation options are divided into:

1. Regenerative options, including beaches, dunes, riparian vegetation and wetlands restoration.
2. Coastal engineering options including a range of structures for erosion and flood control.
3. Human settlement design options covering building and infrastructure retrofitting and design, and the raising of land levels.
4. Planning options, including development setbacks, buy-backs schemes, land swap and land-use change.

However, the boundaries between the option categories can be ambiguous. For example: Is the construction of a dune more “natural” than the construction of a dyke, when both of them are covered in vegetation? The four category classification system is proposed to assist the end user to easily identify those strategies relevant to the subject LGA area for the development of the future CHAS documents.

Accordingly, each adaptation option was assessed using the following framework:

- A table describing the option’s role in the context of a chosen approach, whether it is defend, accommodate or retreat (DAR);
- A technical description, illustrating how the option works and the context in which it can be implemented;
- The option’s role in coastal hazard adaptation, including discussion on how this option can improve the resilience of coastal settlements and infrastructure under coastal erosion and storm tide inundation scenarios;
- A table assessing the synergies and conflicts with other adaptation options, to understand how different adaptation options can be combined to reach the desired outcomes;
- Details on how the adaptation option might work within the legal and administrative framework for Queensland’s LGAs.
- Information on maintenance needs, timeframes for review and costs, where applicable;
- A multi-criteria overview, in terms of climate uncertainty, social and environmental impacts, and costs; and
- Case study boxes describing how the option is currently working in place in specific contexts at the international, national or State level.

5. Summary

CHAS studies are inherently complex undertakings that will provide critically important information needed for strategy development, planning and implementation by coastal LGAs for generations to come. The Townsville Pilot Study project highlighted that the complexity of such investigations requires a very significant level of effort and data in order to assemble the most basic yet essential set of information capable of addressing the study requirements. The findings of the CHAS study represent the first step in providing coastal protection or adaptation plans for vulnerable coastal communities. This work will underpin a significant investment in the future viability of coastal communities and as such is deserving of a high priority in Government funding allocations. LGAs responsible for vulnerable coastal communities should recognise that they have a responsibility to ensure that the long term viability of ‘at risk’ localities can be based reliably on the outcomes of their CHAS study and its likely future revisions.

6. Acknowledgements

The role of Griffith University Centre for Coastal Management (Dr Marcello Sano) in assisting GHD with aspects of the CHAS Pilot Study is gratefully acknowledged.

7. References

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