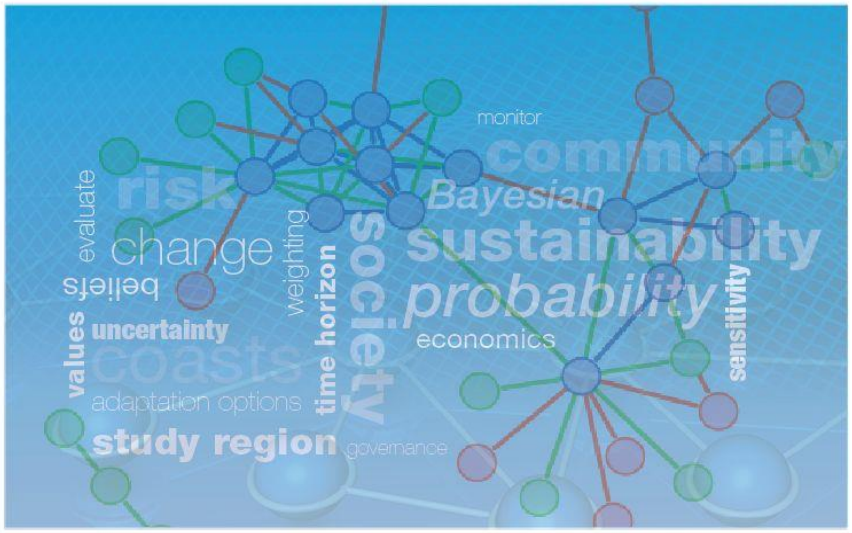
Prioritising Coastal Adaptation Development Options for Local Government



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Literature Review of Adaptation to Climate Change in the Coastal Zone

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Coastal Adaptation Decision Pathways Project **(CAP)**

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1. Introduction

1.1. Scope of the review

This report provides a critical review of current and emerging issues for climate change adaptation in coastal areas with a focus on the implications for prioritising and evaluating adaptation options in Australian local government areas. More specifically, the intention of the report is to provide a summary of the key concepts and adaptation strategies relevant to climate change adaptation in coastal areas to inform the workshops being conducted to develop multi-criteria analysis and monitoring and evaluation tools to enhance decision-making in the coastal zone among the project participants. The project is led by the Sydney Coastal Councils Group Inc. (SCCG) in collaboration with researchers from the University of the Sunshine Coast (USC) and Oak Ridge National Laboratory (ORNL). The project is funded by the Australian Department of Climate Change and Energy Efficiency with additional support from the Sunshine Coast Council.

The review draws on national and international literature and specific examples from the local governments participating in this study (the 15 member councils of the Sydney Coastal Councils Group, Sunshine Coast Council, and Bega Valley Shire Council). The review focuses on the following issues:

- Climate projections and how they are incorporated in policy and management for coastal areas;
- Plausible adaptation strategies including applicability and limitations; and
- Approaches to adaptation monitoring and evaluation including criteria relevant to assessing the performance of adaptation strategies.

Exploring these issues will allow the identification of the range of adaptation options that may be considered for coastal settlements in the case study areas and the relevant decision-making processes that may be employed to select, monitor and evaluate various adaptation initiatives at multiple stages throughout the adoption/implementation cycle.

1.2. Adaptation to climate change impacts in the coastal zone

1.2.1 Overview of climate change impacts in the coastal zone

Adaptation to climate change is critical in coastal zones that are vulnerable to climate change impacts associated with increasing temperature, accelerated sea level rise, and increasing intensity of extreme weather events such as cyclones, storm surges, intense rainfall and strong winds. Increased vulnerability of human and natural systems to these extreme weather events and other climate change associated risks is driving the international and Australia wide push for reform and improved coastal resource management (Thorn and Harvey 2000 ; Gurran 2008; Christensen et al. 2007; Wang et al. 2010).

The combined and interacting influence of climate variability and change is likely to adversely affect coastal communities through:

- repeated short and long term interruption to the functioning of infrastructure; and
- negative impacts upon the delivery of services (e.g. health, education, emergency services) and mechanisms for social cohesion (Department of Climate Change and Energy Efficiency 2009; Roiko et al. 2011).

Of particular relevance to the case studies in this project, 1,200 commercial buildings, almost 5,000 km of roads and 320 km of railways are at risk of inundation from a 1.1m sea level rise in New South Wales alone (Department of Climate Change and Energy Efficiency 2011). Inundation-associated damage to this infrastructure is estimated to cost up to $40.7 billion, with the replacement value of residential buildings alone constituting up to 34% of this cost. Lake Macquarie, Wyong, Gosford, Wollongong, Shoalhaven and Rockdale local government areas constitute 50% of the residential buildings at risk of inundation (Department of Climate Change and Energy Efficiency 2009, 2011).

1.2.2 Adaptation to climate change impacts

Investment in climate change research has focused on biophysical climate processes including the magnitude and frequency of extreme conditions and ways to mitigate the impacts on natural and human systems (Smit et al. 1999; Daffara 2009). However, adaptation to climate change is increasingly receiving attention as the threats of climate change to socio-ecological systems become more apparent (e.g. Adger, Arnell, and Tompkins 2005; Adger et al. 2007; Adger et al. 2009; Preston et al. 2009; Villanueva 2011).

In the coastal context, many communities have a history of adapting to natural disasters including those induced by weather variability and climate change through a range of measures including insurance, migration, infrastructure design, engineering works and disaster risk management (Leadbitter 1996; Bussey et al. 2010; Harvey and Caton 2010). However, projected changes in global climate processes are predicted to expose human and natural systems to impacts that may be outside the range of historical experiences due to differences in magnitude and frequency of occurrence (Adger et al. 2007). The vulnerability of coastal communities is further exacerbated by the growing concentration of populations and commercial activity in coastal areas. Approximately 80% of the Australian population lives in coastal areas and this proportion is projected to increase (Attorney-General's Department 2010; Bambrick et al. 2011). As such, the impact of climate change in coastal areas is an issue that is predicted to affect most Australians.

The First Assessment Report of the IPCC outlines that the adaptation options for coastal communities can be described as 'protect', 'accommodate' or 'retreat' (IPCC CZMS 1990). Protect options have been used widely in Australian coastal management and can include hard or soft measures to maintain coastlines such as sea walls, groynes and dune rehabilitation. Accommodate measures are diverse and represent a range of strategies designed to maintain the use and amenity of coastal areas such as building codes and insurance (IPCC CZMS 1990). Retreat options involve the migration of settlements away from coastal areas to lessen exposure and vulnerability to the impacts of coastal erosion and other impacts such as storm surge. All options pose a degree of disturbance to coastal socio-ecological systems and adaptation options need to be considered

cognisant of local contexts and the long term sustainability implications (Klein et al., 2001; Nicholls et al. 2007).

In particular, an early critique of climate change adaptation by Smit et al. (1999) and Smit et al (2000) provides a useful framework for evaluating adaptation strategies and encourages interrogation based on the following questions:

- *Adaptation to what?* Assessment of risks, threats and vulnerabilities related to anticipated impacts (e.g. sea level rise, storm surge, heat stress, pest species)
- *Who or what adapts?* Consideration of the responsibility and capacity for various adaptation options (e.g. protect, accommodate or retreat) within a broad sustainability agenda
- *How does adaptation occur?* Assessment of various implementation strategies associated with adaptation options including monitoring and evaluation strategies.

Figure 1 provides an illustration of the iterative steps of adaptation (pre-implementation evaluation, awareness and education, planning and design, implementation, and monitoring and evaluation) described by Klein et al., (1999). As the impacts of climate change and associated responses will continue to evolve, the questions of Smit and colleagues will remain important points of reference throughout adaptation processes and can be used to frame and evaluate responses.

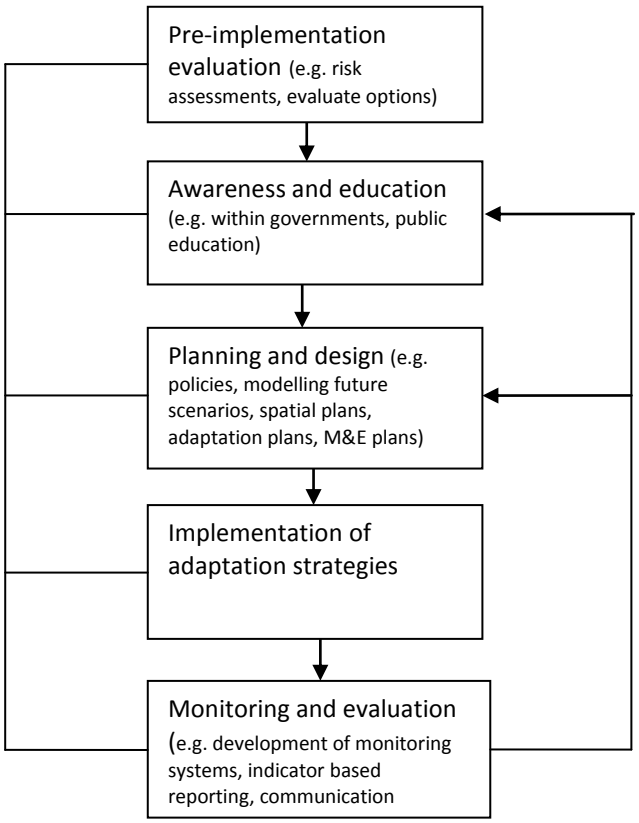

Figure 1 Adaptation processes (modified from Klein, Nicholls, and Mimura 1999)

For example, the pre-implementation stage defines climate related stimuli and specifies the systems and subsystems of interest (e.g. human settlement and infrastructure). This stage represents an

information development stage involving risk assessments, and the identification of adaptation options, needs and priorities (Klein et al. 2001; Rosenzweig et al. 2007).

The awareness and education stage seeks to ensure that community members and decision makers are informed of climate change risks and possible response actions. The implementation of this stage can be facilitated by education campaigns and participatory processes towards a two-way flow of information.

The planning and design stage builds on the previous stages to chart response strategies including the development of policies, action plans, management goals, and monitoring and evaluation strategies in support of adaptation (Klein et al. 1999). Several studies (e.g. Cundill and Fabricius 2009; Mcfadden 2010) highlight the importance of periodic or continuous evaluation following implementation against intended outcomes to ensure relevance, effectiveness, and efficiency; as well as, providing an opportunity for adaptive learning and adjustment.

Implementing adaptation faces a number of challenges and barriers even where adaptive capacity levels are reportedly high (Adger 2003; Adger et al. 2009). Factors that may affect implementation include individual or local adaptive capacity, inabilities and inefficiencies in the application of existing resources, and limited institutional support and integration (especially between and across governments) (Christensen et al. 2007). Determinants of adaptive capacity reported in the literature have focussed on generic societal factors such as education, income, household structure, age, social networks, traditions, values and perceptions (e.g. Adger 2003, Roiko et al. 2011) and technological factors associated with the ability to lessen the impacts of specific impacts such as air conditioning for heat related impacts (Adger et al. 2007). Yet, there is increasing recognition that adaptive capacity varies across and within social groups (e.g. age, gender, income, ethnicity), indicating that the development and implementation of adaptation strategies requires careful consideration of context-specific factors (Adger 2003, 2005; Gurran 2008; Roiko et al. 2011).

1.2.3 Principles for adaptation practice

A range of guiding principles for best practice adaptation to climate change have begun to emerge in the literature. Many of these stem from broader sustainability considerations and some have been tailored to regional and/or coastal contexts. For example, the quadruple bottom line dimensions of sustainable development provide a general guiding framework for the development and implementation of adaptation as climate change threatens:

- goods and services (economic dimension);
- the resilience of ecosystems (environmental dimension);
- livelihoods, lifestyles and equitable access to amenities and service (social dimension); and
- governance (the fourth dimension), the societal institutions and processes through which to facilitate a coordinated and integrated response to changing contexts.

More specific requirements for adaptation are beginning to emerge internationally and these have influenced the development of guiding principles for some Australian contexts. For example, the UK DEFRA Climate Change Plan (2010) specifies that adaptation actions must be:

- sustainable;
- avoid maladaptation and embrace coordinated adaptation;

- flexible to encompass uncertainty;
- evidence based;
- prioritised; and
- equitable and efficient.

Similarly, Prutsch et al. (2010) developed the following ten guiding principles for adaptation to climate change impacts in the European context based upon a literature review and surveys involving 252 experts in adaptation practice:

- Initiate adaptation, ensure commitment and leadership;
- Build awareness and knowledge;
- Identify and corporate with relevant stakeholders;
- Work with uncertainties;
- Explore potential climate change impacts and vulnerabilities and identify priority concerns;
- Explore a wide spectrum of adaptation options;
- Prioritise adaptation options;
- Modify existing policies, structures and processes;
- Avoid maladaptation; and
- Monitor and evaluate systematically.

Within Australia, the Great Barrier Reef Marine Park Authority (GBRMPA) and the National Climate Change Adaptation Research Facility (NCCARF) (2011) have drawn on the work of Prutsch et al (2010) and a workshop with leading practitioners in the climate change adaptation sector to develop 16 adaptation principles for the Australian marine context. These principles centre on the definition of adaptation, planning, flexibility in implementing adaptation strategies, effectiveness, participation and social equity (GBRMPA and NCCARF 2011) and are consistent with the findings of a review of the activities of eight SCCG member councils by Morrison and Withycombe (2007) that indicated the importance of coordination, capacity building, partnerships, advocacy and education in minimising barriers to achieving sustainable coastal zone development.

Whilst not always explicitly referred to, the long term effectiveness of such guiding principles in achieving sustainable adaptation is strongly linked to the ability of management agencies and communities to learn through the implementation of various adaptation options. Indeed, Middle (2002) highlighted the need for ongoing learning as vital element for effective coastal management generally in Australia. As the well-established adaptive management literature suggests (e.g. Lee 1999), and guiding principles for climate change adaptation are beginning to suggest (e.g. Prutsch et al. 2010), this may be achieved through the early and ongoing development and implementation of monitoring and evaluation frameworks to institutionalise learning throughout adaptation.

2. Climate projections and policy framework

In Australia, temperature increases of between 0.7 – 0.9^{0}C have been projected by 2030 using Global Climate Models (CSIRO and BoM 2007). These increases have the potential to increase the vulnerability of many communities by increasing their exposure to a range of impacts associated with climate change. For example, in New South Wales, the number of days where the temperature is predicted to exceed 35^{0}C is projected to increase from a current 3.5 days per year to 12 days by 2070 with no climate change mitigation. Similarly, a lengthened fire season is likely to occur as early as 2020 with the number of extreme fire danger days projected to increase from the current 9 days per year to 15 days per year by 2050 (Department of Climate Change 2009).

Reviewing a range of studies focused on different climate change impacts such as extreme heat (e.g. Bambrick et al. 2011) and sea level rise (e.g. Department of Climate Change and Energy Efficiency 2011) highlights that while all sectors of social and ecological systems will be affected to some degree by various impacts, there are particularly vulnerable societal sectors (e.g. the aged and those with chronic diseases) and particularly vulnerable ecological systems (e.g. coastal ecosystems).

Until recently, the integration of climate projections into coastal policy has been limited within the Australian local government context. Lemos and Rood (2010) suggest that this is largely as a result of the inherent uncertainty in climate science. In Australia, coastal adaptation to climate change in the coastal zone has traditionally been embedded within broad coastal management legislation. For example, Queensland's *Coastal Protection and Management Act 1995* and the related *State Coastal Management Plan*. Relevant policy in New South Wales includes *The Coastal Protection Act 1979* and the *NSW Coastal Policy 1997*. Such laws and policies have provided guidelines for coastal management which can also be extended to the management of climate change impacts. While climate change is acknowledged in these documents as exacerbating coastal zone risks, there is no explicit mention of the relevance of the projected climatic changes to coastal management. Smith et al. (2008a) argued that the lack of accounting for future climate in such legislation and policy limits the usefulness of the accompanying plans and guiding manuals.

Nevertheless, there has been growing recognition of future climate projections and the associated risks to social and natural systems in recent planning and policy development at all levels of government within Australia. Projections have been used as planning benchmarks to help identify future hazards, develop hazard guidelines and plan responses to the associated risks (Table 2). For example, the *New South Wales Coastal Planning Guidelines* suggest that sea level rise is one of the most significant concerns (NSW Government 2010) and the *NSW Sea Level Rise Policy Statement* (2009) adopts a sea level rise of 0.4m by 2050 and 0.9m by 2100 for determining potential future coastal risks and planning adaptation objectives and outcomes (NSW Government 2009). The Sunshine Coast Council has adopted a sea level rise of 0.2m by 2030, 0.7m by 2070, and 1.1m by 2100 for planning purposes (Sunshine Coast Regional Council 2009).

Table 2 Application of climate changes projections in coastal legislation and planning (NSW and QLD examples)

Example law, policy or plan	Climate change projections	Application
NSW Sea Level Rise Policy Statement (2009)	Sea level rise of 0.4m by 2050 Sea level rise of 0.9m by 2100	a) Risk identification • increased or permanent tidal inundation of land by seawater • recession of beach and dune systems and to a lesser extent cliffs and bluffs • changes in the way that tides behave within estuaries • saltwater extending further upstream in estuaries b) Response strategies
NSW Coastal Planning Guideline (2010)	Sea level rise of 0.4m by 2050 Sea level rise of 0.9m by 2100	Planning benchmarks
State Planning Policy for Coastal Protection within the Queensland Coastal Plan (2011) - under the Coastal Protection and Management Act 1995 (Queensland)	Sea level rise of 0.8m by 2100 An increase in the maximum cyclone intensity by 10 per cent by 2100	a) Risk identification • coastal erosion • storm tide inundation • permanent inundation • human exposure to coastal hazards • infrastructure exposure to coastal hazards b) Defining coastal hazard areas c) Response strategies
Queensland Coastal Planning Guidelines (2011)	Sea level rise of 0.8m by 2100 Changes in wind speed and increased intensity of storms	a) Risk identification b) Defining coastal hazard areas

While the integration of climate change projections in policies, plans, strategies and guidelines is increasingly becoming part of governmental response to climate change, the implementation of associated adaptation actions remains limited in extent when compared to mitigation actions. Dovers and Hezri (2010) suggest that there is a need for more attention on public institutions' capacity to develop practical adaptation responses to the challenges of climate change.

In addition, the adaptation literature related to coastal communities focusses on responses to sea level rise projections in comparison to other climate change projections such as temperature, relative humidity, and annual rainfall that could also have significant impacts on the health and viability of coastal communities. Thus, there are opportunities for increased integration of future climate change impacts and associated adaptation strategies in other related areas of concern to local government such as flood management and infrastructure maintenance and development.

3. Local government adaptation to climate change in the coastal zone

3.1. Adaptation in practice in Local Government

Local government supports adaptation through service provision including governance, planning and asset management (River 2006; Leiter 2011). The importance of local government in adaptation initiatives is enhanced through the close proximity to local communities and associated organizations that provide avenues for community engagement and organizational collaboration in supporting climate adaptation.

Local governments have been involved in coastal adaptation as part of routine coastal management strategies as guided by formal coastal management provisions such as the New South Wales Coastal Design Guidelines (2003) and the Flood Risk Management Guide (2010). Nevertheless, projected changes in global climate processes are likely to expose socio-ecological systems to impacts in magnitude and/or frequency outside the range of historical experiences. Therefore, there is need to review existing measures in light of future climate change projections as well as other socio-ecological dynamics. Of significance to this project, the Local Government and Shires Associations of New South Wales (2010) have identified the following additional drivers for adaptation:

- liability concerns for not taking action;
- fiscal savings from resource use efficiency and avoidance of additional costs arising from climate change impacts; and
- the need to prioritise climate change as part of a broader sustainability agenda.

Recent adaptation activities within local governments have been driven by Commonwealth Government funding under the *Local Adaptation Pathways Program* (LAPP)—the Sunshine Coast Council and three SCCG councils, from a total of 97 councils across Australia, received support from this program. More advanced adaptation activities resulting from this program can be seen within Byron Shire Council, which has developed a climate change adaptation plan including:

- a prioritized implementation schedule specifying risks;
- a risk analysis extending to periods 2030 and 2070; and
- adaptation actions and time frames for implementation (Byron Shire Council 2009).

A review of the current adaptation strategies of the SCCG member councils, Sunshine Coast Council, and Bega Valley Shire Council (Table 3) demonstrates that current initiatives focus on five main activities that provide a basis for future adaptation including:

i) raising council staff awareness;
ii) climate change risk assessment;
iii) development of adaptation plans;
iv) updating of different types of coastal risk plans to integrate the latest climate change projections and associated risks; and
v) monitoring and evaluation of existing coastal defense measures in light of climate change.

The focus of these efforts is consistent with the findings of a review of 57 adaptation plans in Australia, the United Kingdom and the United States by Preston et al. (2011) that noted that while formal planning for climate change adaptation is evident across a range of geo-political scales, such

plans were limited by the narrow scope to climate change factors. They argued that there was need for more consideration of non-climate factors including adaptive capacity and the broader governance context in which adaptation occurs. In addition, the review revealed a preference for 'low-risk capacity-building over the delivery of specific actions' (Preston et al. 2011, p. 407) suggesting a reluctance to commit to more progressive or targeted actions.

Consequently, proactive and integrated planning is increasingly being recommended as an effective mechanism for promoting sustainable coastal development (Klein et al. 2001). Nevertheless, a number of constraints limiting the ability of local governments to advance adaptation are well documented in a number of publications (e.g. River 2006, Smith et al. 2008ab, Local Government and Shires Associations of New South Wales 2010). River (2006) identified resource constraints, lack of leadership and competing priorities, lack of information and institutional constraints within and across governments as limiting local government ability to yield beneficial adaptation outcomes. For example, Smith et al., 2008a note that such integration is partly hindered by legislation, such as development and building codes, that restrict the ability of local government to undertake certain adaptation actions.

More collaboration within and between local governments and, more broadly, with other tiers of government (e.g. State and Commonwealth) and the private sector are common recommendations to address some of these challenges. Specific mechanisms to enhance collaboration include partnership funding schemes, collaborative research, and joint implementation of adaptation actions (Gurran 2008, Government and Shires Associations of New South Wales 2010).

Nevertheless, some local government areas (e.g. Rockdale Council) have identified a number of measures in their adaptation action plan (e.g. groynes, sea walls, coastal dunes, education programs, development controls and beach watch hotline) that have already been implemented (Rockdale City Council 2009) (Appendix 1).

Table 3 Sample climate change adaptation activities within SCCG, Bega and Sunshine Coast Councils

Council	Formalized adaptation activities	Scientific and technical support
Bega Valley	Echelon risk assessment and adaptation plan report Coastal hazards studies	Echelon private consultants
Hornsby	SARCCASM climate adaptation strategy	SCCG
Leichardt	SARCCASM climate adaptation strategy Echelon risk assessment and adaptation plan report Updated estuary plan incorporating DECCW sea level benchmarks (0.4m by 2050 and 0.9m by 2100)	SCCG Echelon private consultants
Pittwater	SARCCASM climate adaptation strategy Flood risk studies incorporating DECCW sea level benchmarks and +30% increase in rainfall intensity)	SCCG DECCW
Rockdale	SARCCASM climate adaptation strategy Adaptation action plan Environmental education	SCCG
Sutherland	SARCCASM climate adaptation strategy Sea level rise risk assessment (incorporating DECCW sea level benchmarks)	SCCG GHD private consultants
Sunshine Coast Council	SCC Climate Change and Peak Oil Strategy 2010-2020 (incorporating state, regional and local climate change sea level rise, temperature, rainfall and extreme weather event projections for 2030, 2070, and 2100)	SCC

3.2. Coastal adaptation strategies

As noted in the preceding sections, significant impacts from climate change are already being experienced. Therefore, it is imperative that adaptation initiatives transition from risk assessment and planning towards implementation in the short to medium term. A wide range of adaptation

options that span the protect-accommodate-retreat continuum are well documented in a number of studies. Table 4 indentifies some of the more common strategies associated with coastal adaptation.

Table 4 Sample adaptation measures (summarised from Klein, Nicholls, and Mimura 1999; Klein et al. 2001; Smit et al. 1999; Smit et al. 2000; Hallegatte 2009).

Adaptation strategy	***Example adaptation measures***
Protect	Seawalls Groynes Beach nourishment Wetland and/or dune restoration and creation
Accomodate	Early warning systems Education and awareness raising of safety measures Establishing or updating building codes Retrofit of buildings Artificial drainage Disease screening Insurance Air conditioning
Retreat	Evacuation systems Relocation strategies Economic diversification

Typologies have been used to prioritise such adaptation options. For example, the United Kingdom Climate Impacts Program Adaptation Wizard (UKCIP 2008, in Hill and Barrett 2010, p.11) identified three main categories namely:

- win-win options
- no-regret options, and
- low-regret options.

Win-win options yield climate change adaptation benefits and other social, economic and environmental (including mitigation) benefits. No-regret adaptation strategies yield effective and efficient outcomes irrespective of climate change occurring or not occurring. Low regret adaptation options are low cost with high benefits under projected future climate. However, certainty on the associated risk is low. Hallegatte (2009) devised a similar typology that also included strategies driven by the flexibility of application, financial costs, temporal issues and the ability to integrate with other climate change management measures.

Within the Australian context, Gurran (2008) categorized coastal adaptation options according to the ability to:

- enhance the ability of natural systems to adapt to hazards;
- prevent new developments within areas at risk;
- use engineering measures to protect infrastructure and settlements; and
- relocate existing structures within areas at risk.

To ensure the effectiveness of the adaptation options summarised in Table 4, several studies have revealed the importance of supporting processes including:

- risk assessments to enhance the understanding of existing and future climate hazards, and the associated vulnerabilities of natural and human systems (e.g. Klein et al. 2001)
- climate change action planning including emergency planning (e.g. Department for Environment and Rural Affairs 2010, Byron Shire Council 2011)
- collaboration and coordination within and between sectors (e.g. community, private, government, and non-governmental organizations) in adaptation planning and implementation (e.g. Morrison and Withycombe 2007, Gurran 2008, Cundill and Fabricius 2009)
- development of institutional arrangements that build adaptive capacity across communities including within the private and public sectors (Middle 2002, Dovers and Hezri 2010, Measham et al. 2011)
- mainstreaming climate change adaptation within the broader range of local government coastal management activities (e.g. Measham et al. 2011)
- establishing mechanisms to monitor and evaluate adaptation processes and outcomes (e.g. (Villanueva et al. 2011)

These supporting or foundational processes indicate that there is a significant amount of preparatory work that could be conducted to ensure the initial and continued efficacy of adaptation strategies beyond the standard practical, technical and financial issues associated with most new initiatives. However, perhaps the most important hurdle to overcome relates to public perception of the nature and reality of climate change phenomena and the need for adaptation as societal perceptions are not only dynamic, but influential.

4. Approaches to adaptation monitoring and evaluation

A number of studies have discussed the need for coastal management monitoring and evaluation, including the monitoring and evaluating the effectiveness of adaptation measures and policies (e.g. Klein, Nicholls, and Mimura 1999; Preston et al. 2009; Walker, Leverington, and Peterson 2009). Monitoring and evaluation of adaptation is important for providing insights and information that not only facilitate the necessary adjustments to strategies to enhance adaptive capacity and reduce vulnerability, but also contribute to broader learning and adaptive management processes (Klein et al. 2001, Villanueva 2011). Therefore, monitoring and evaluation go beyond determining success and failure but also support the understanding of problems, public awareness of impacts of problems, and the development of possible solutions (Stephenson et al. 2009).

Adger et al. (2005) argued that adaptation should be appraised for its effectiveness, equity and legitimacy to ensure sustainability. Drawing on the work of Adger, Villanueva (2011) lists five principles of successful adaptation:

i) Effectiveness, the ability to achieve intended objectives and to be flexible for adjustments under different climate circumstances

ii) Efficiency, in relation to cost effectiveness

iii) Equity, particularly between different community groups

iv) Legitimacy, to ensure acceptance by different stakeholders

v) Sustainability, the ability of adaptation interventions to be sustained beyond the duration of particular projects

Nevertheless, existing adaptation evaluations have been dominated by the need to ensure the cost efficiency of adaptation measures, the effectiveness of policies and input-output evaluations (Table 6). Such evaluations are limited by the narrow scope of focus and assumptions of adaptive capacity whereby it is often assumed to be static (Preston and Stafford-Smith 2009). Indeed, equity and legitimacy are rarely evaluated.

4.1. Monitoring and evaluation frameworks

The need for consistent monitoring and evaluation frameworks to facilitate the management of the coastal zone is widely advocated in the related literature (e.g. Olsen 2003; Frankel-Reed and Brooks 2008). Monitoring and evaluation frameworks highlight what needs to be monitored and evaluated, why, how, when, and by whom. As current efforts to evaluate adaptive efforts are limited, this section will also draw on other fields to help inform adaptation monitoring and evaluation (e.g. protected area management).

A number of evaluations of costs and benefits, and the performance of adaptation strategies follow the Logical Framework Approach (LFA) (e.g. Olsen 2003; UNFCCC 2004; Stojanovic, Ballinger, and Lalwani 2004; Frankel-Reed and Brooks 2008). LFA is a widely applied approach in the design, monitoring and evaluation of development projects and natural resources management initiatives (e.g. AusAID 2005; Australia Government 2009). It is also applied in smaller scale, local evaluations such as protected areas (e.g. Hockings et al. 2006). Monitoring and evaluation frameworks are generally based on the premise that if a certain set of activities are undertaken they will yield outputs (under a set of assumptions) that facilitate the achievement of specific goals. Indicators are used to objectively verify activities and outputs.

Olsen (2003) proposed an outcomes-based monitoring and evaluation framework, highlighting that outcomes of an initiative can be ordered to reflect the interrelationships of different levels of outcomes ranging from societal actions and related behavior change to sustainability (Figure 3). The framework emphasizes changes in state, which should translate into improvements in socio-ecological systems. It also recognizes the different spatial scales over which initiatives are implemented and coordinated, and the temporal scales in which a range of outcomes may be achieved.

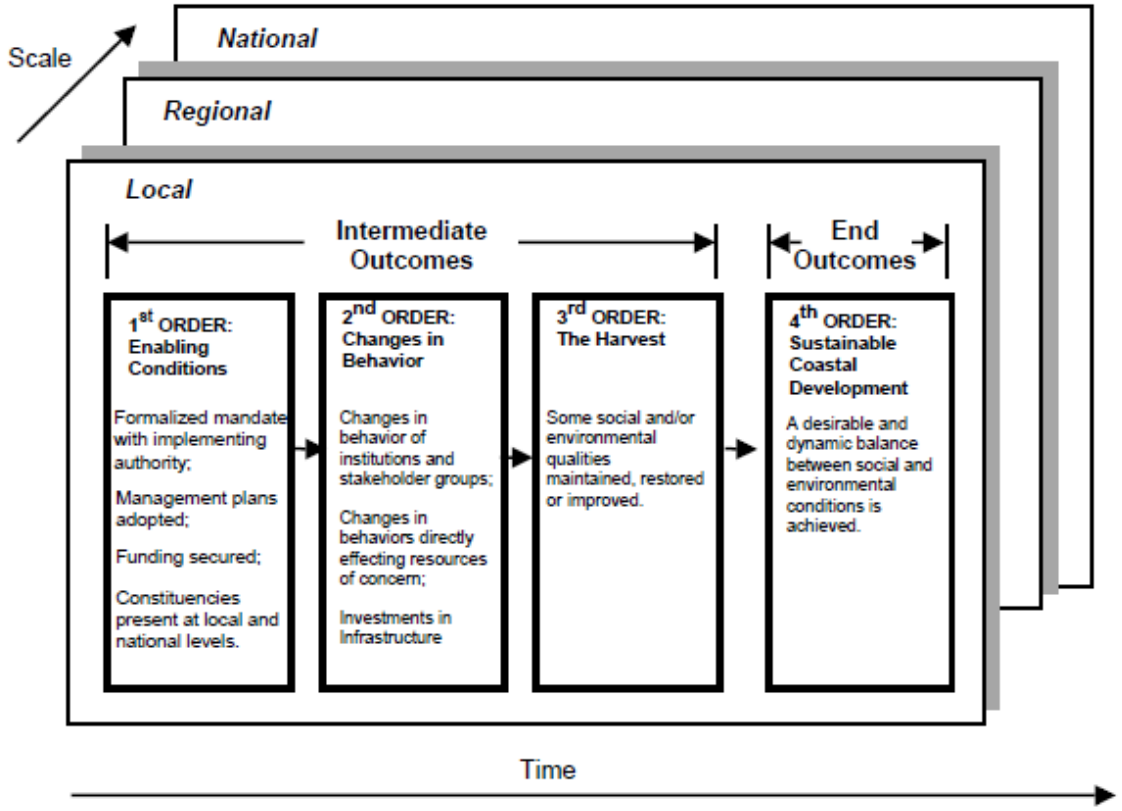

Figure 3 The four orders of coastal governance outcomes. Source: Olsen and Hale 1998 in Olsen 2003, p. 349

Similar to LFA, the Monitoring, Evaluation, Reporting and Improvement Framework (MERI) tracks the progress and impacts, and reporting of natural resources management strategies by evaluating the cause and effect relationship between activities, outputs, and outcomes (Australian Government 2009). Comparable to Olsen (2003), the framework distinguishes intermediate (e.g. enhanced NRM engagement, awareness, organizational policy change) and long-term outcomes (enhanced capacity to manage natural resources). The MERI process is broken into four related components namely:

(i) monitoring (regular collection of data and analysis to assist ongoing decision-making and evaluation);

(ii) evaluation of the effectiveness, efficiency and legacy of the program;

(iii) reporting and communication of evaluation findings; and

(iv) improvement-based evaluation of findings and recommendations for decision-making to ensure long-term goals are achieved.

The MERI framework emphasizes participation within the program improvement and adaptive management cycle (Figure 4).

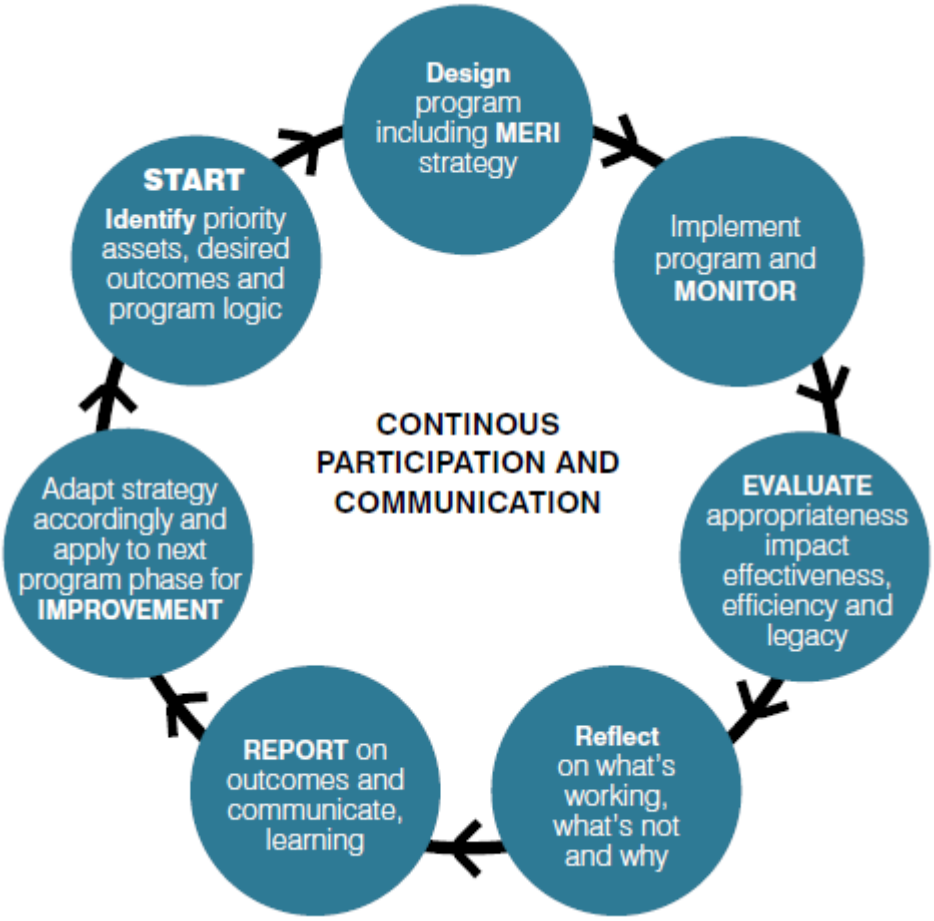

Figure 4 Program improvement and adaptive management (Australian Government 2009)

Hockings et al. (2006) argue that monitoring and evaluation needs to occur at every stage of project implementation in the context of protected area management (Figure 5). The primary objective is to monitor the extent to which management approaches and practices are achieving values, goals and objectives (e.g. Hockings et al. 2006, Walker et al. 2009). This involves the evaluation of the whole management cycle including context, planning and processes involved, inputs, processes involved in the management approaches and practices (e.g. top down, participatory approaches), outputs and outcomes (Hockings et al. 2006). This is based on the understanding that while outputs and outcomes assessments are important to identify the products of management and achievements, assessing the whole management cycle is vital for ensuring 'greater explanatory power' and the ability to 'tease out aspects of context, planning and processes' (Walker 2009, p11).

Figure 5 Framework for assessing management effectiveness (Walker et al. 2009 after Hockings et al. 2006).

Bellamy et al. (2005) proposed a systems-based framework in the context of natural resource management and highlighted the importance of a range of factors including complexity, scale and engaging with a multiplicity of perspectives (e.g. environmental, economic, social and institutional and technological) to provide a more robust understanding of management.

The monitoring and evaluation frameworks reviewed in this section demonstrate that monitoring and evaluation needs be considered as an integral aspect of adaptation rather than an additional phase. Therefore, an effective monitoring and evaluation strategy will reflect the principles of adaption and consider both the processes and outcomes of adaptation across a range of dimensions and perspectives. As there are various ways to define adaptation strategies (see Section 3), it is also important to clearly define what counts as successful adaptation (i.e. how will/should adaptation be judged?) prior to the commencement of adaptation strategies.

4.2. Monitoring and evaluation indicators

Indicators for the pressures and drivers for adaptation, costs and benefits of management for adaptation (e.g. UNFCC 2004), and outcomes of different management approaches (e.g. UNDP 2007) are critical for ensuring the continued effectiveness of adaptation strategies.

A number of generic indicator selection criteria have been developed. For example, Stephenson et al. (2009) identified six criteria including the need for relevance, reliability and validity, simplicity and comprehensibility, measurability, accessibility (in terms of data), and cost effectiveness. These align closely to the widely adopted SMART (Simple, Measurable, Accessible, Relevant, Timely) criteria. Other researchers have also proposed the framing of indicators within the Pressure-State-Response (PSR) and the associated Pressure-State-Impact-Response (PSIR) frameworks (e.g. Hart 2006; Stephenson et al. 2009; Wu and Xiao Wang 2011) where indicators are developed against targets or benchmarks to measure and track the status of each of the PSR/PSIR framework components. In cases where measures for the performance of an activity are not appropriate the use of surrogate indicators is recommended (Australia Government 2009). Surrogate indicators may also be chosen for communication or education purposes especially if there are particular indicators of relevance or interest to various communities.

4.3. Climate change adaptation monitoring and evaluation

In addition to the general requirements of monitoring and evaluating coastal management strategies outlined earlier, a comprehensive monitoring and evaluation framework tied specifically to climate change adaptation has been developed by the United Nations Development Program (UNDP) (Frankel-Reed and Brooks 2008). This framework is based on the LFA approach to evaluate the effectiveness and efficiency of adaptation measures across the UNDP portfolio of projects at local, national and international levels. It identifies the following thematic areas: agriculture and food; natural resources; public health; water; disaster risk management; and coastal zones, and develops output/outcome indicators. While this framework remains a draft, it provides valuable insights into post-adaptation implementation monitoring and evaluation. The UNDP framework also identifies four areas of achievement that can be monitored and evaluated (UNDP 2007):

i) Coverage, achievements regarding the involvement of stakeholders (e.g. individuals, households, business, communities) in an intervention and the physical extent to which an intervention is implemented. Example indicators include number of stakeholders implementing vulnerability reduction measures or length of coastline covered by interventions coupled with population of adjacent coastal areas;
ii) Impact, outcomes of interventions;
iii) Sustainability, continuity of interventions in time scales beyond project implementation. Example indicators include the perceived awareness of climate change within organizations compared to baseline levels; and
iv) Replicability, potential usefulness of results and lessons in comparable contexts. Example indicators include the number of policies or guidelines incorporating project approaches and lessons learned.

4.4. Applicability and limitations of adaptation monitoring and evaluation

Consistent with the current extent of implementation of specific adaptation initiatives, the monitoring and evaluation of various adaptation activities is also limited. Several authors have described the challenges associated with the emergent nature of adaptation, diversity of adaptation types, lack of conceptual clarity (regarding processes or outcomes), difficulties in attributing outcomes to adaptation responses, and difficulties in evaluating climate response actions with regard to the uncertainty of future climatic regimes (Adger et al. 2007, Preston et al. 2008, Preston and Stafford-Smith 2009). Similarly, the UNDP monitoring and evaluation framework identifies three fundamental challenges that need to be overcome in monitoring and evaluation efforts (UNDP 2007):

i) Attribution, the complexity surrounding the interaction of climate change with other stresses and drivers (including associated management interventions) creates attribution challenges for monitoring and evaluation;
ii) Relevance, adaptation can have immediate and long-term benefits. Monitoring and evaluation of adaptations that deliver long-term benefits needs to include indicators for vulnerability reduction, improved adaptive capacity, and the drivers of vulnerability; and
iii) Calibration, climate hazards evolve over time and may change in frequency or severity requiring adaptation interventions that can account for the dynamics of climate change.

In addition to these challenges, it is important to note that adaptive capacity and vulnerability also change over time and are influenced by socio-cultural, economic, technological and environmental factors (Adger 2005, Roiko et al. 2011). Therefore, adaptation evaluation takes place against moving 'targets' involving ever-changing and interacting socio-ecological factors that affect determinants of vulnerability and adaptive capacity (Villanueva 2011).

While some level of pre-adaptation implementation evaluation, mainly to identify climate risks, is evident within the LGAs of relevance to this project (see examples in Table 3), systematic and dynamic climate change adaptation monitoring systems do not exist. As local governments are already engaged in various reporting and/or monitoring and evaluation requirements, initiatives for the specific monitoring and evaluation of adaptation initiatives have the potential to increase existing staff workloads if not sufficiently integrated or resourced.

5. Conclusions

While the need for climate change adaptation is widely recognized, implementation of adaptation actions remains limited. There is a need for more integration of adaptation planning activities into other local government activities to ensure a holistic management of climate change and therefore limiting the chances of maladaptation. However, multiple related program areas within local governments exist such as coastal management activities that create opportunities to mainstream adaptation and to incorporate climate change scenarios to enhance decision-making.

Monitoring and evaluation for effective and efficient adaptation to climate change clearly goes beyond the dominant pre-adaptation cost (monetary) and benefits (outputs/results) evaluations,

and needs to include criteria relating to the processes involved in adaptation. Success of adaptation needs not only to be measured against short and immediate outcomes but also against long term goals. Therefore, processes (e.g. planning, implementation, and management approaches) involved in adaptation require continuous/ongoing review and adjustments to facilitate learning for adaptation. Within local government's scope for adaptation in coastal areas, it is also important to note that adaptation outcomes are interrelated to other coastal issues. To this extent, cause and effect relationships need to be established beyond narrow adaptation planning (e.g. sea level rise response). This supports holistic responses to climate change impacts, thereby limiting the chances of maladaptation.

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Appendix 1: Example of existing coastal management initiatives in Rockdale Council

Risk	Associated impacts	Existing controls	Additional controls required
Category: Infrastructure & Property			
Increased mean temperatures and/or extreme heat days	Increased discomfort of users due to insufficient design or temperature control	Basix for new development	Introduce passive design and basix requirements for all buildings in LGA where possible, possibly fit AC onto all council buildings (Residents will be burdened with the majority of the cost for this action)
	Increased cost of maintenance and running cost (air conditioning, insurance etc)	Energy efficiency education to reduce costs	Introduce energy efficient devices and passive design to Council property assets
Higher Sea Levels	Temporary inundation	Rockdale Flood Plan- Available for restoration, wind blown sand, groynes, some existing sea walls and Coastal Dune system provides Some protection to unknown standard	Review State Emergency Services's Rockdale flood plan (2009) and request amendments by SES if necessary to account for sea level rise
	Tidal end of drainage pipelines become submerged and ineffective – loss of capacity	Tidal flaps	Analysis to identify problem areas, Install flap valves on all outlets, Consider levees & pump out systems in affected areas
Increased Storms/Wind	Cost of removal and replacement of trees blown over in storms.	Existing maintenance budget	Increased maintenance program. Seek grants
Category: Natural Resource Management			
Higher Sea Levels	Sea level rise leads to decreased health of fresh waterways e.g. wetlands	Storm water levy & plan, wetlands management strategy	Form partnerships with State Govt agencies for funding and to access their knowledge. Integrated Waterway Health Strategy implementation
Increased Rainfall Intensity	Flash flooding leading to river/creek bank erosion/ and sedimentation – effect on waterway health	Stormwater plan, maintenance program, emergency plan	Develop a bank stabilisation plan to identify and prioritise stabilisation areas and introduce preventative stabilisation, linking to Biodiversity Strategy and Estuaries Management Strategy
Decreased Mean Rainfall & Increased Evaporation	Increase evaporation and decreased rainfall for regional water supply leads to an increased need for the community to store water	Community Education through workshops, schools network, stormwater DCP	Revision of planning controls especially for commercial development and Increase the number of water efficiency projects

Risk	Associated impacts	Existing controls	Additional controls required
Category: Recreation, open space and community services			
Higher Sea Levels	Loss of sand area at beach. Impacts on coastal tourism and recreation. Cost of beach replenishments to replace lost sand	Beach nourishment/ Management Beach stabilisation- south end, DECC- seek grants, groynes, financial reserve	Continue beach nourishment program. Study into need for expanded program in future (i.e. to determine if groynes need to be raised and or increased).
Increased Storms/Wind	Winds cause reduction in beach comfort due to wind blown sand – reduced beach patronage		Provide sheltered areas on the beach
Increased Mean Temperatures and/or Extreme Heat Days	Increased demand/need to mitigate increase in temperature in community centres/facilities (environmental sustainability options/ passive energy design)	Current Development Controls. Limited retrofit.	New buildings to incorporate passive energy design principles include H20 reuse/ capture/ on site detention Integrate passive design into future social housing developments. Identification of most vulnerable residents.
Increased Storms/Wind	Increased cost of operation and maintenance of public amenities and recreational sites due to storm damage	Maintenance programs	
Increased Rainfall Intensity	Increased beach closures due to sewage/ storm water/ marine algae pollution after storms	Beach watch hotline	Consider more specific signage at swimming point (publicise results on site). Increase water testing (liaise with State Gov). Sydney Water to rectify sewage overflow events.
Increased Storms/Wind	Increased risk of injury during extreme storm events	Education programs, disaster plan, codes of conduct association	Increased education awareness campaigns.
Decreased Mean Rainfall	Increased pressure on drinking water supplies	Basix, education on rain water tanks, retrofit, water efficiency, WSUD	Introduce permanent tougher water conservation strategies. Consider retrofitting of buildings

Adapted from Rockdale City Council (2009)

Appendix 2: Examples of coastal development indicators in the UNDP adaptation framework

Project objective: Coastal development secured in the face of increasing coastal hazard as a result of measures to reduce vulnerability of coastal systems and enhance adaptive capacity of coastal populations.

Outcomes	Indicators	Type
1. Policies and plans revised on the basis of the scenario planning to accommodating increasing coastal risk associated with the sea-level rise, accelerated erosion, and more destructive storms	1.1 Number of policy makers and planners trained in scenario planning (alternatively number of government departments represented among those trained).	Coverage
	1.2 Number of policies and plans relating to coastal development under review, in order to ensure climate change issues are addressed.	Coverage
	1.3 Number of new policies introduced or existing policies and plans are updated as a result of scenario planning exercises.	Impact
2. Investment decision made on basis of risk assessment based on climate change scenario planning	2.1 Number of private sector bodies (organisation and individual business) engaged by project and provided with training in climate risk management and scenario planning.	Coverage
	2.2 Value of planned new development in high-risk areas compared with projected baseline value.	Impact
	2.3 Number of private planning application of development in high-risk areas.	
3. Resilience of coastal geomorphological and ecological system enhanced	3.1 Length of coastline covered by project interventions, coupled with population of adjacent coastal areas.	Coverage
	3.2 Number of different resilience enhancing measures employed by project, combined with number of ecological and geomorphological system addressed.	Coverage

	3.3 Number of sites/locations where resilience building measures are piloted.	**Coverage**
	3.4 Area and length of coast where project leads to changes associated with enhanced resilience (e.g. rehabilitation of dune systems, (re-) establishment of mangroves, corals, resumption of sediment transport to eroding beaches etc.	**Impact**

Project objective: Coastal development secured in the face of increasing coastal hazard as a result of measures to reduce vulnerability of coastal systems and enhance adaptive capacity of coastal populations.

Outcomes	Indicators	Type
4. Capacity to plan for and respond to changes in climate-related coastal risks improved through awareness building and enhanced access to information on potential climate change impacts, coupled with guidance on and improved access to available adaptation measures	**4.1 Population covered by awareness building programmes to increase understanding of risks associated with climate change among general public and key stakeholder groups.**	**Coverage**
	4.2 Understanding of climate change related coastal risks among general public and key stakeholder groups (QBS).	**Coverage**
	4.3 Percentage of population with access to key resources for adaptation compared with projected baseline measures (EWS, storm shelters, post-disaster financial assistance).	**Impact**
	4.4 Perceived change in likely ability to respond effectively to future changes in coastal risks.	**Impact**
5. Construction of storm shelters and improvements in the resilience of settlements, to reduce vulnerability to tropical	**5.1 Number of stakeholders involved in piloting of vulnerability reduction measures at the local level.**	**Coverage**
	5.2 Percentage of population benefiting from access to shelters and other improvements in physical infrastructure such as installation of storm shutters etc.	**Impact**

storms and associated storm surges	**5.3 Perceived change in individual vulnerability by members of coastal communities (QBS).**	**Impact**
All Outcomes: 1 – 5	**6.1 Perceived ability to sustain interventions implemented by the project beyond the end of the project's lifetime, based on knowledge acquired and availability of essential resources.**	**Sustainability**
	6.2 Number of 'lessons learned' about coastal risk management in the context of climate change as a result of the project (QBS)	**Replicability**
	6.3 Number of 'lessons learned' disseminated through the Adaptation Learning Mechanism (ALM) project.	**Replicability**
	7.1 Losses resulting from coastal disasters (e.g. mortality, injury, financial, properties or infrastructure lost or damaged, coastline eroded) compared with recent historical experience or projected baseline.	**Supplemental (impact)**