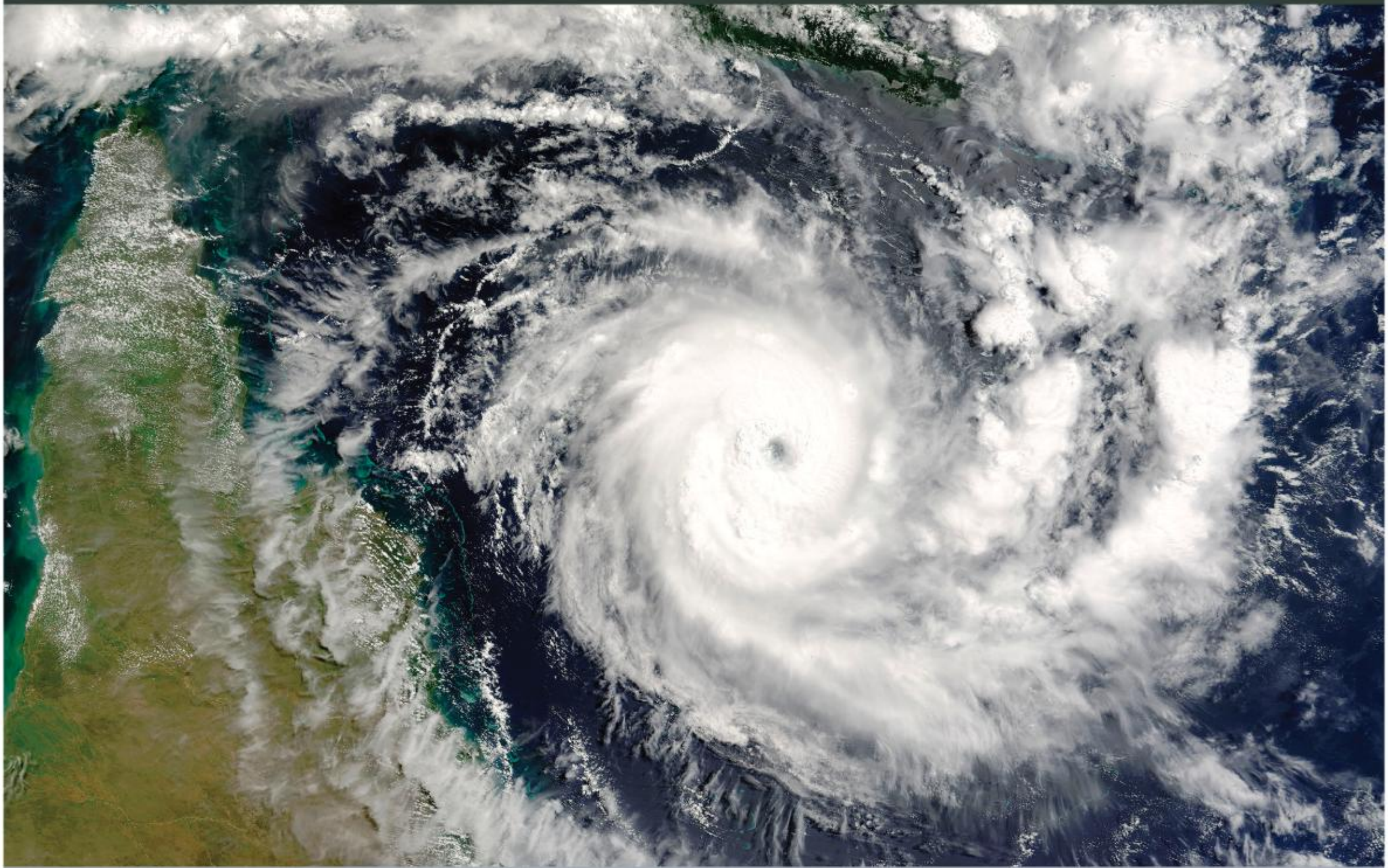
WET TROPICS
NRM CLUSTER

CLIMATE CHANGE IN AUSTRALIA

IMPACTS & ADAPTATION INFORMATION FOR AUSTRALIA'S NRM REGIONS



Adaptation Pathways and Opportunities for the Wet Tropics NRM Cluster region

Volume 1. Introduction, Biodiversity and Ecosystem services

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1. Introduction

Stephen M. Turton, Rosemary Hill and Catherine Moran

Stream 2 of the Commonwealth Government's *Regional NRM Planning for Climate Change Fund* supports the project "Knowledge to manage land and sea: A framework for the future" run by a consortium of scientists from James Cook University (JCU) and CSIRO. This report is the second major product of the consortium project, building on the first report: *Climate Change Issues and Impacts in the Wet Tropics NRM Cluster Region* (Hilbert *et al*. 2014). This second report provides syntheses of current knowledge about potential adaptation pathways and opportunities in response to climate change in the Wet Tropics Cluster (WTC) region (see below) across all relevant NRM sectors. The report is framed by the specific topics and issues defined by the NRM groups in the Wet Tropics Cluster (WTC) region (Appendix A), reflecting the planning processes and priorities of these groups as well as the characteristics of their regional communities. This report has two major aims:

1. To provide a review of potential adaptation pathways and opportunities across all NRM sectors in the WTC region, including a review of potential options for adaptation of species to climate change
2. To provide preliminary information about particular directions for adaptation in the Wet Tropics Cluster, based on collaboration with the four NRM bodies via the Brokering Hub.

For consistency with the first report, this report presents key messages around each topic in bold type at the beginning of each chapter. Key messages for NRM groups are also summarised at the beginning of each chapter. These key messages represent our syntheses of plausible adaptation pathways and opportunities based on expert opinion of authors and also substantiated by published material, including from international sources. Each key message is followed by a brief explanation of the underlying scientific evidence with a small number of key citations to the relevant literature. In most cases there is a fair amount of uncertainty associated with the key messages and they should be understood as best estimates based on the scientific literature and expert opinion. Much uncertainty is due to climate model variability in relation to changes in rainfall amount and timing, critical variables for many NRM sectors in the WTC region. Furthermore, despite increasing climate change-related research in general, there is a limited or lack of explicit research on potential climate change impacts or adaptation opportunities in several areas and some sectors in the WTC region, e.g. infrastructure, ecosystem services and primary industries. Conversely, there is better knowledge of adaptation pathways for biodiversity in some parts of the region, although baseline data are lacking for many areas. Finally, uncertainty persists around the extent to which climate change impacts will be mitigated through reduction in greenhouse gas emissions, creating uncertainty around nature and extent of impacts and associated adaptation actions that will be required. NRM adaptation pathways also depend heavily on the broader set of adaptation options (or lack of) undertaken by the community and society at large.

This report contains ten chapters separated into two volumes. Volume 1 contains the executive summary, an introductory chapter and two chapters dealing with NRM adaptation pathways and opportunities for biodiversity and ecosystem services. Volume 2 contains chapters that discuss NRM adaptation pathways and opportunities for infrastructure, industry, Indigenous communities and broader regional society, as well as planning frameworks and evolving methodologies for developing adaptation pathways in NRM groups. In Chapters 2-5 we provide summary tables of specific adaptation options in relation to climate change risks, as identified within the body of these chapters. Remaining chapters deal more with higher-level principles or frameworks for climate change adaptation, or describe climate adaptation methodologies and tools, rather than identifying specific adaptation actions.

A range terms and phrases associated with climate adaptation are used throughout the documents. Authors have tried to explain these as necessary, but

Table 1.1 provides a summary of key terms used in this report that may assist NRM planners.

Table 1.1 Definition of key terms used in this report.

KEY TERMS USED IN THE REPORT
1. **Adaptation** to climate change is the adjustment, in natural or human systems, in response to actual or expected climatic changes or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.
2. **Autonomous adaptation** is adaptation that does not constitute a conscious response to climate stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems.
3. **Vulnerability** is defined as a function of the character, magnitude, and rate of climate change variation to which a system is exposed, its sensitivity, and its adaptive capacity.
4. **Planned adaptation** is adaptation that is the result of deliberate policy decision, based on awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state. Planned adaptation measures are conscious policy options or response strategies, often multi-sectoral in nature, aimed at altering the adaptive capacity of systems by facilitating specific adaptations.
5. **Adaptive capacity** is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or cope with the consequences. Adaptive capacity of a system is its capacity to change in a way that makes it better equipped to deal with potential impacts.
6. **Exposure** is the degree, duration and/or extent to which a system is likely to be in contact with a perturbation e.g. cyclones, drought, fire. Defined as the external side of vulnerability. It is influenced by a combination of the probability and magnitude of climate change.
7. **Sensitivity** is the extent to which a human or natural system can absorb impacts without suffering long-term harm or other significant state change, i.e. an internal component of vulnerability. It is also defined as the extent to which changes in climate will affect the system in its current form.
8. **Resilience** is the capacity of a system to absorb disturbance, undergo change and still retain essentially the same function, structure, identity, and feedbacks.
9. **Incremental adaptation** is adaptation actions where the central aim is to maintain the essence and integrity of a system or process at a given scale.
10. **Maladaption** is actions or inaction that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future.

Source: Wilson & Turton 2011, IPCC 2014

Geographical scope

Australia’s 56 NRM regions have been grouped into eight clusters through which funding for Element 2 of Stream 2 is delivered. The eight clusters are based on some broad common characteristics such as land use, climate and how these are anticipated to change (Figure 1.1). In total, Element 2 of Stream 2 is comprised of nine projects, one for each of the eight clusters, and a National Project delivering cross-boundary regional level information on issues that are national in scale, such as changes to biodiversity and invasive species resulting from climate change.

This report focuses on four geographically distinct NRM regions grouped in the Wet Tropics Cluster, shown in Figure 1.1.These are the Mackay-Whitsunday, Wet Tropics, Cape York, and the Torres Strait regions, which are managed by Reef Catchments NRM, Terrain NRM, Cape York NRM, and the Torres Strait Regional Authority respectively.

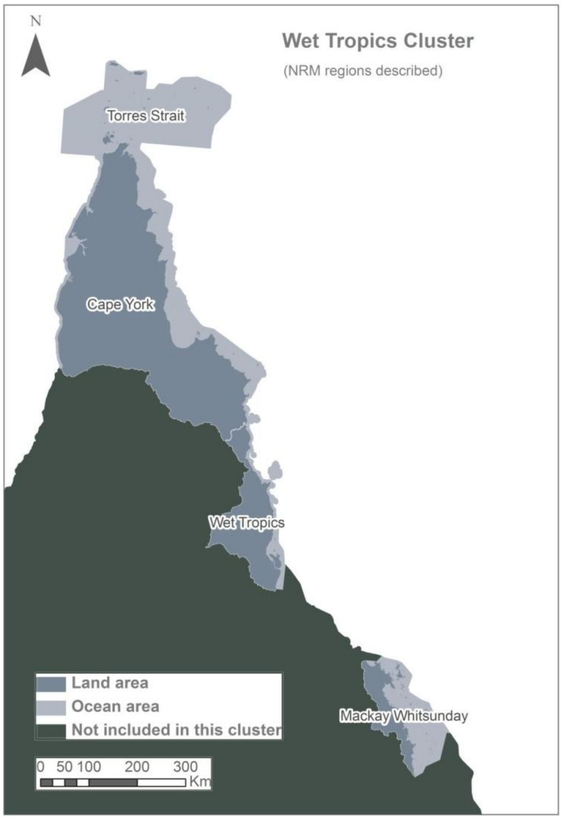

Figure 1.1 The Wet Tropics Cluster region (shaded).

Significance of the Wet Tropics Cluster Region

This cluster contains a broad range of landscapes and seascapes including globally significant savannas, the vast majority of Australia's tropical rainforests, wetlands and low lying tropical islands. It also contains a high proportion of the Great Barrier Reef catchment. The region contains the Wet Tropics World Heritage Area and the Great Barrier Reef World Heritage Area with discussion for a third World Heritage Area nomination for parts of Cape York Peninsula. Arguably, this cluster supports more species overall than any other NRM cluster with many endemic plants and animals. Only the South West of Western Australia is richer in plant species.

The climate change threat to biodiversity has been especially well documented for the Wet Tropics rainforests (Hilbert *et al*. 2001; Kanowski 2001; Williams *et al*. 2003; Hilbert *et al*. 2004; Williams *et al*. 2008; Hilbert *et al*. 2014). While much of the cluster's rainforest is in conservation reserves (especially the Wet Tropics World Heritage Area) some important areas are not, including many fragments and recovering forests on abandoned, previously cleared land. Management of off-reserve lands in response to climate change present both important opportunities and potential threats to biodiversity (Dunlop *et al*. 2012).

Along with very high biodiversity values, there are numerous and substantial economic and cultural values including extensive and intensive agriculture (McKeon *et al*. 2009, Biggs *et al*. 2013), tourism, mining, fisheries (Stoeckl & Stanley 2007) and large areas of Aboriginal lands. Much of the cluster's area is 'highly contested' with multiple and sometimes conflicting demands for the region's natural resources. Climate change is likely to exacerbate the issues and challenges. Climate change impacts and adaptation studies suggest significant changes in all sectors that will require factoring climate change into forward looking NRM planning across the cluster.

Both extensive and intensive primary production are likely to be challenged by climate change requiring adaptations in where, what and how food is produced in the region. The possible adaptation responses of this sector – as all others – will have important effects, positive or negative, on other sectors. There are adaptation opportunities provided by the Australian Government's Direct Action Plan and Emissions Reduction fund (see Chapter 3, this report), that if managed properly, could assist climate adaptation in this sector while also favouring biodiversity conservation.

Traditional owners are important inhabitants and land managers in many areas of the cluster who are likely to be highly affected by climate change in numerous ways (see Chapter 6). The approximate proportion of Indigenous people is 50% in Cape York, more than 90% in the Torres Strait and 12% in the Wet Tropics. Indigenous people living in remote areas within this cluster have a high sensitivity to climate change induced ecosystem change because of the close connection for them between healthy 'country' and their physical and mental well-being and their cultural practices (Green 2006). Other issues affecting their community's welfare are urgent and pressing and these will require strategies and policies to strengthen adaptation capacity of communities for climate-change responses (Petheram *et al*. 2010). Communities located on the low-lying islands of Torres Strait are particularly vulnerable to sea level rise and increasingly intense storm surges caused by more extreme weather (Green *et al*. 2009).

Natural resource management in the regions covered by this cluster has long been contentious due to its highly contested values in multiple sectors. The need for climate change adaptation in most of these sectors accentuates the challenge and requires an integrated approach.

Climate projections the Wet Tropics Cluster Region

The WTC region may expect significant changes in its climate this century and policy makers will need to incorporate the latest climate science knowledge and data into their adaptive management and planning systems. Table 1.2 provides a summary of climate projections for the WTC region over this century.

Table 1.2 Climate projections for the Wet Tropics Cluster region this century

CLIMATE PROJECTIONS FOR THE WTC REGION

- Air and ocean temperatures are expected to increase in response to increasing Greenhouse Gas (GHG) emissions
- We can expect more hot days and fewer cold days in the future
- There is considerable uncertainty about how climate change may affect rainfall across WTC region due to naturally high rainfall variability but with higher GHG emissions there is evidence that the dry season will be longer and drier while the wet season will remain similar
- Extreme rainfall intensity may increase in the future
- The intensity of tropical cyclones is likely to increase in the future while overall cyclone frequency may decrease
- Sea levels should continue to rise but rates of change may vary at the sub-regional level
- Frequency and height of storm surges are expected to increase due a combination of rising sea levels and more intense tropical cyclones
- Fire weather conditions are expected to worsen with increased frequency or intensity of extreme fire days
- Solar radiation is expected to decrease in winter (dry season) and spring (wet season build up), and increase in autumn (monsoon retreat season) under the highest emission scenario; however there is a large spread of model simulations
- Small decreases in relative humidity are favoured over increases during summer and autumn periods, with little change in winter and increases more likely in spring, especially under the highest emission scenario
- Evapotranspiration is projected to increase in all seasons
- Average wind speeds are expected to increase across eastern parts of the WTC region
- Ocean acidity will increase in line with increases in atmospheric CO_2

Source: Turton 2014

Approach and method

A key component of the Stream 2 project was the adoption of a WTC 'Brokering Hub' which formally brings together Stream 2 researchers and NRM regional organisations (Cape York NRM, Reef Catchments, Terrain NRM and Torres Strait Regional Authority) to co-define priorities, objectives, processes, outputs and outcomes for the project, much like a project steering committee (Bohnet *et al*. 2013, Figure 1.2). This arrangement is intended to promote a collaborative approach to the research program and to facilitate communication between Streams 1 and 2. The collaboration moves through a co-research cycle that includes stages that provide for system analysis, processes and tools to support knowledge translation and integration, and updating through social learning (Figure 1.3). This report forms part of the socio-ecological systems analysis phase of the project and will feed in to the knowledge integration phase (Figure 1.3).

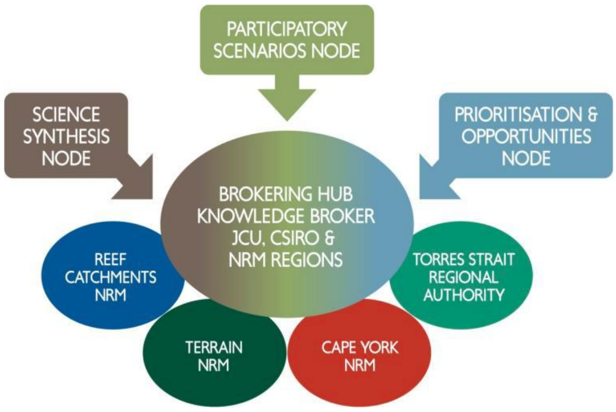

Figure 1.2 Co-research approach that promotes long-term system well-being and collective learning

Source: Bohnet *et al*. 2013

The Stream 2 research component of the Brokering Hub is divided into three 'Science Nodes' (Figure 1.2). The production of this draft report has been co-ordinated by the brokering hub, and researchers from all three Science Nodes have contributed, as well as NRM partners. NRM groups defined existing knowledge and priority information gaps through different processes; initially they convened a meeting to articulate their 'preferred processes and priorities' to inform the development of project bids by research consortia in the region when Stream 2 funding was announced in late 2012. The key issues of concern identified in this document formed the foundation for the science synthesis report (Hilbert *et al*. 2014). During 2013 and 2014, NRM groups in the WTC identified additional detail in relation to their information needs for NRM planning during two workshops, one a joint WTC-National Environmental Research Program (NERP) initiative and the other organised by the Participatory Scenarios Research Node. Finally, NRM groups were invited in November 2013 and March 2014 to clarify or add any further priority information needs. The current list of NRM priority information needs (Appendix A) for the current report reflect the issues NRM project partners expect will be important when engaging with their regional communities to develop adaptation pathways. NRM partners have requested discussion of high-level principles around approaches to adaptation and monitoring outcomes, presentation of case study examples, identification of barriers and enablers, as well as information on a suite of specific issues .The list of NRM interests and concerns covers a wide range of issues in many sectors and experts in all of the fields identified were sought to contribute to the first science synthesis report and to this draft adaptation pathways and opportunities report. While this report is part of the system analysis stage of the co-research cycle, many knowledge integration tasks are underway through these interactions.

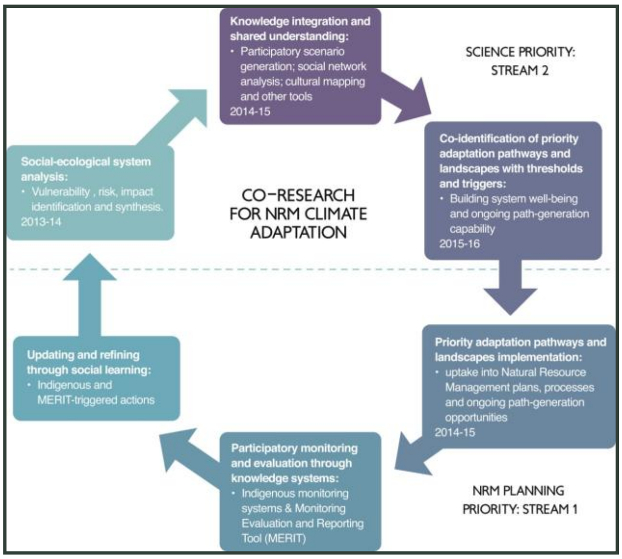

Figure 1.3 The co-research cycle for knowledge integration in NRM Climate Adaptation

Coping range, adaptive capacity and vulnerability

Among the different NRM sectors, natural and modified ecosystems have the lowest capacity to adapt to rapid climate change; even below 2°C temperature change – relative to 1990 - there will be significant negative effects on natural ecosystems (see Figure 1.4), due mainly to their narrow coping ranges. Development of adaptation strategies is a priority especially for natural ecosystems, agricultural systems, coastal communities and water security, all of which have relatively narrow coping ranges as well as adaptive capacity (Figure 1.4). Above 4°C of warming all NRM sectors will be highly vulnerable and well beyond their adaptive capacity to cope.

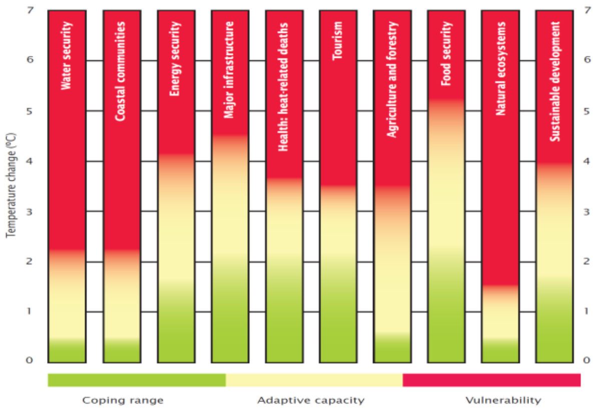

Figure 1.4 Figure shows the aggregated relative vulnerability to climate change for key sectors for Australia and New Zealand region. The vertical axis shows increasing levels of global mean temperature rise from 0 to 7°C, while the colours show how much change the sector can cope with normally (green), how much it can adapt to autonomously (yellow), and when it becomes vulnerable (red)

Source: Stafford Smith and Ash 2011

For successful climate adaptation in NRM, strong linkages are required among researchers, policy makers and practitioners because successful adaptation is the output of appropriate decision-making among all these actors. For example, policy makers can ensure that water and drought policies accord with successful farm adaptation and do not impede it. Researchers can help farmers to select suitable crop varieties, to achieve better water use efficiency measures, and to assist farmers to obtain the skills to achieve such outcomes (Howden *et al*. 2007; Stokes and Howden 2011).

As some uncertainties exist about the magnitude of impacts of climate change, making decisions about appropriate adaptation options is difficult (Stafford Smith *et al*. 2011). For example, decisions about water savings measures in consideration of drought conditions should be taken as soon as possible (Howden *et al*. 2007) but such decisions are difficult when trajectories are uncertain. Early development of technologies, skills and policies are likely to provide more benefits to the community (Stokes and Howden 2011).

A CSIRO survey of industry and government organisations found that Australians hold mixed attitudes to climate adaptation and this was linked with knowledge and beliefs of their particular organisation about climate change (Howden *et al*. 2007). They also found that industry organisations were more likely to undertake adaptation planning when it was perceived that their particular industry was vulnerable to climate change. It is therefore important to work closely with stakeholders to determine their vulnerability to climate change to better assist them to adapt to climate change. To obtain the benefits of climate adaptation stakeholders need confidence that the climate is changing and that inaction is not an option, the motivation to avoid negative impacts and seize opportunities, and wide communication and demonstration of new benefits of climate change adaptation (Stokes and Howden 2011). Therefore the very early part of adaptation is about conveying information to various NRM stakeholders why adaptation is needed and what are the perceivable opportunities of climate change and what are the risks of not doing anything. This task is already being undertaken by the WTC NRM groups; it is intended that this will be supported by outputs of the Stream 2 project (e.g., this and the previous impacts and issues synthesis report, together with associated fact sheets and short film), together with participation of Stream 2 researchers in NRM stakeholder workshops and other participatory processes.

The effectiveness of a community to adapt to climate change is influenced by the adaptive capacity of the respective community. Assessing the adaptive capacity of different stakeholders to climate change is crucial. Through assessment of adaptive capacity it is possible to determine and rectify the factors that may hinder the successful adaptations of a community and also to identify the broader areas where action is required (Stokes and Howden 2011). An assessment of adaptive capacity of different stakeholders of the WTC region will help policy makers and planners to take actions to increase the adaptive capacity of the stakeholders towards implementing successful climate adaptation.

Adaptation pathways and opportunities

Adaptation to climate change will engage all of society, including industry sectors, communities and individuals (Stafford Smith and Ash 2011). Domains that are emerging as key priorities for natural resource management and planning are:

- infrastructure, including roads, ports, coastal structures, water and energy supplies and buildings
- coastal zones, estuaries, wetlands and all areas at risk of sea-level rise, storm surges and floods
- agriculture, the food supply, and other primary production, including forestry and mining
- other climate-dependent industries, e.g. tourism
- the natural environment, including all the biodiversity contained within it
- increased biosecurity risk
- recognising maladaption across key NRM sectors.

Three areas are critical for successful adaptation to climate change (Stafford Smith and Ash 2011):

1. decision-making and choices, i.e. how to go about it
2. the development of specific solutions to climate challenges, i.e. technical and other
3. the analysis of barriers to adoption of systems and technologies that will help us adapt.

Opportunities and threats are both components of adaptation to climate change. In the first science synthesis report (Hilbert *et al*. 2014) we identified key climate change threats to the various NRM sectors in the WTC region. We also need to identity the potential opportunities that may come our way due to climate change but with an understanding that there may be few opportunities in the WTC region (Stafford Smith and Ash 2011). These include:

- 'no-regrets' or low regrets measures, i.e. things we can do which make good sense anyway, e.g. water and biodiversity conservation and carbon sequestration
- 'win-win' activities, where adapting to climate change generates new industries (e.g. renewable energy), income, employment or other desirable community outcomes, e.g. carbon sequestration.

If we are to build 'pathways' to adaptation we need to

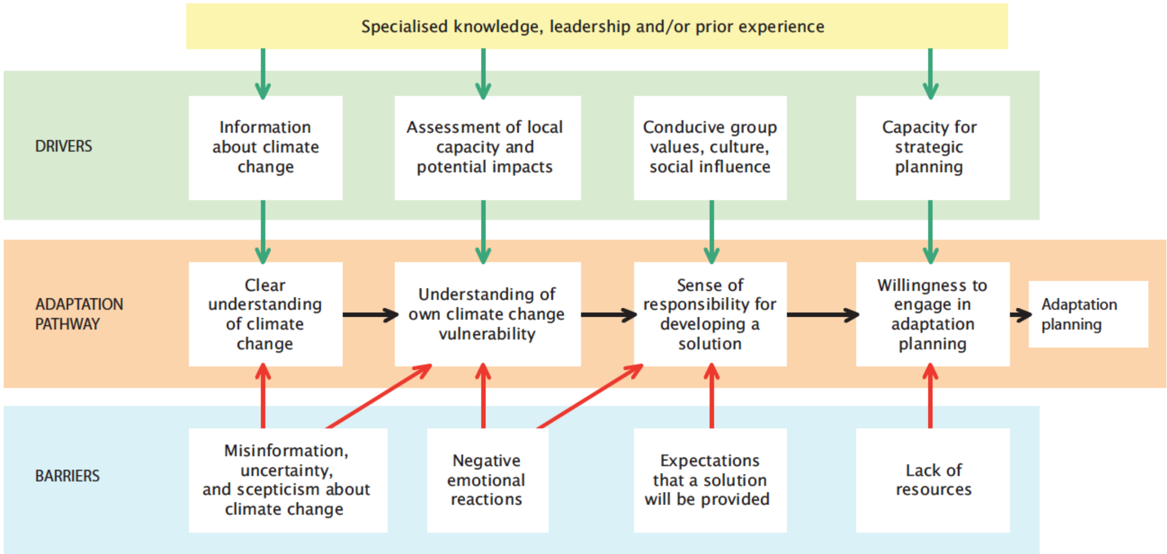

Figure 1.5 A pathway for adaptation engagement with associated drivers and barriers.

Source: Stafford Smith and Ash 2011

position our NRM sectors, regions and communities so that they are flexible and ready to change and this need to happen now (Stafford Smith and Ash 2011). This will require the knowledge and tools to build the necessary biophysical, social and institutional capacity to adapt to climate change. Figure 1.5 demonstrates the stages NRM communities or organisations are likely to transition through along an adaptation pathway, including identifying key drivers and barriers or obstacles to climate change adaptation. Recent studies also emphasise that actors have the capability to come together for path- generation in response to changed conditions in the future—building the conditions and skills for future path-generation is therefore important to adaptation futures (Garud *et al*. 2010).

Figure 1.5 is an example of a 'classic' adaptation pathway where decision-making processes eventually leads to adaptation planning. Figure 1.6 conceptualises the classic adaptation pathway approach, incorporating a series of learning decision cycles over time (Wise *et al*. 2014). In this approach, some chains of decisions lead to maladaptive outcomes over time, but there may be other alternatives that are adaptive. The strongest colour shows a satisfactory pathway that can be plotted into the future.

Wise *et al*. (2014) argue that as the world seems increasingly likely to face a future with more than 2°C warming, it becomes increasingly important to move beyond impacts and vulnerabilities to adaptation action. Moreover, they propose that the classic view on pathways (Figure 1.6) does not always represent the decision contexts where the current status of the

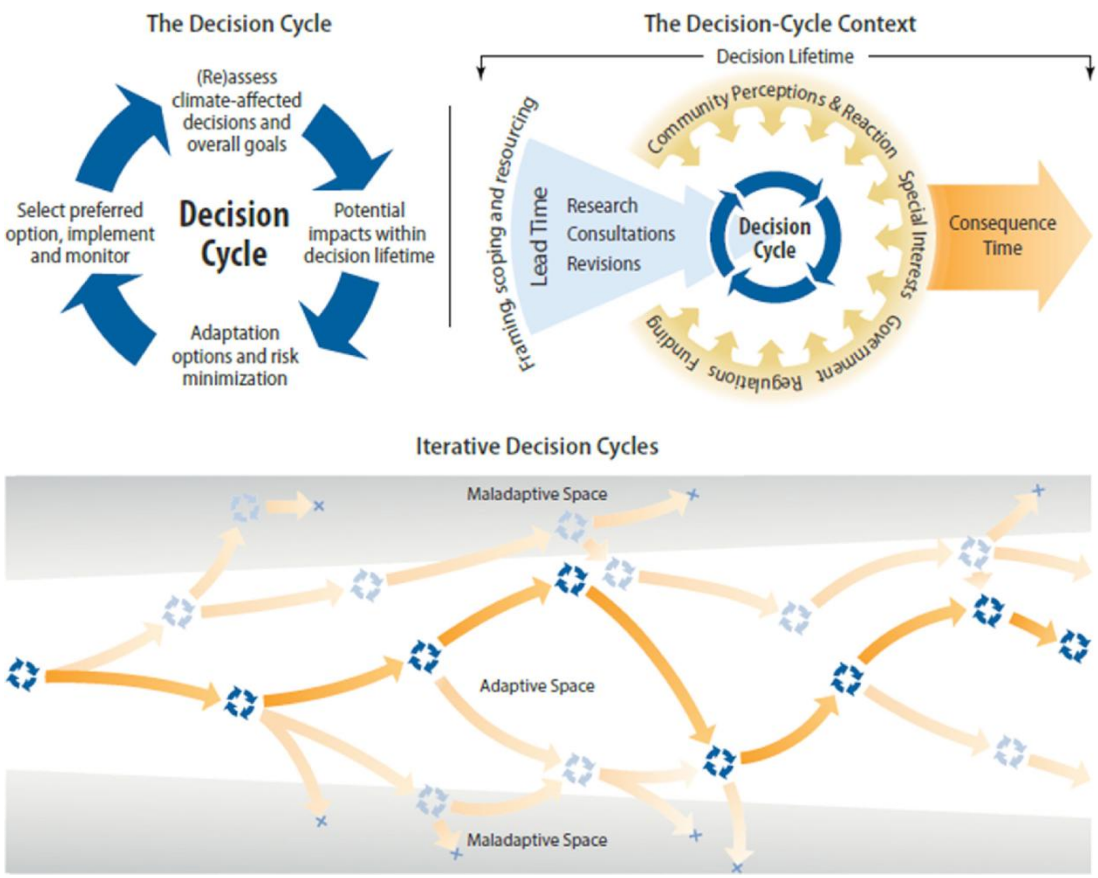

Figure 1.6. The 'classic' conceptualisation of climate adaptation pathways

Source: Wise *et al*. 2014

system and its future trajectory are heavily influenced by the past. Figure 1.7 provides a conceptual framework to trace 'adaptation pathways' through an adaptive landscape where the boundaries between adaptive and maladaptive responses are changing over time, due to biophysical changes, but also due to changes in social and institutional context, including the actions of other decision-makers who may perceive different adaptation pathways (Wise *et al*. 2014). Importantly, if decision-makers are not currently in the adaptive space (e.g. coastal local councils in the WTC region), as at decision point *b*, then all pathways may be maladaptive. For this example, transformation of the institutional arrangements or societal values will be needed, either through dramatic intervention (*pathway 5*) or through strongly directed incremental change (*pathway 6*). Both pathways will require intervention from higher levels of governance, probably driven by responses to natural disasters or catastrophic events (Wise *et al*. 2014).

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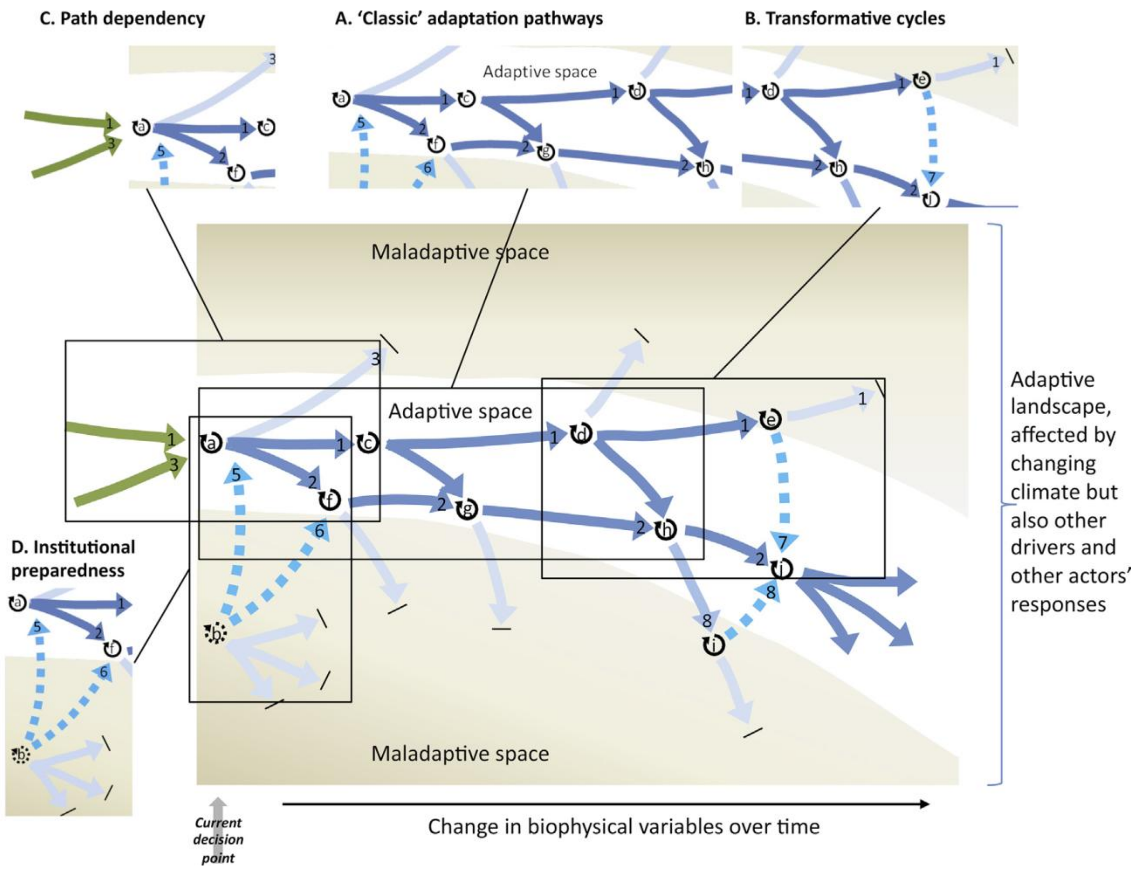

Figure 1.7. An adaptive landscape affected by changing climate, but also other drivers and other actors' responses. Circle arrows represent decision points (see Figure 1.6); dark blue arrows represent pathways that are contemporaneously adaptive; grey arrows lead to maladaptive dead-ends; dashed arrows represent more-or-less transformational pathway segments; and green arrows show antecedent pathways prior to the current decision cycle (a) faced by the decision-maker of concern.

Source: Wise *et al*. 2014

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