Great Barrier Reef Restoration

An analysis of decision-maker perspectives and the decision context

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Great Barrier Reef Restoration: An analysis of decision-maker perspectives and the decision context

by

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Candidate's Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of the author's knowledge, it contains no material previously published or written by another person, except where due reference is made in the text.

Yolanda Waters Date: 25/10/2018

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Abstract

The need to reassess coral reef management and governance in the face of uncertainty is urgent. Without targeted management interventions, the predicted acceleration in climate change will have devastating impacts on coral reefs globally. The Great Barrier Reef is no exception. In addition to continuing climate change mitigation efforts and reducing local pressures, it has been suggested that feasibility of other, potentially riskier tools, such as restoration, need to be explored. However, as with any ecological intervention, for restoration projects on the GBR to be successful, acceptance and trust from all GBR stakeholders is vital.

This research has been conducted with a favourable view towards pursuing restoration on the GBR. Using the values, rules, knowledge (*vrk*) perspective (Gorddard et al., 2016), this study aims to characterise the restoration decision context as the sets of *vrk* which inform decision-maker perceptions. This will: (a) help GBR stakeholders (including the Australian public) to better understand the reasons behind restoration decisions on the GBR, including a better understanding of the risks and benefits, and why certain outcomes are preferred, (b) enable decision makers to determine the extent to which the current decision context supports restoration options, and (c) consider whether the decision context needs to change.

In combination with participant observation at the Great Barrier Reef Restoration Symposium in Cairns 2018, eleven semi-structured interviews were conducted with those involved in protecting and managing the GBR and/or providing expert advice (i.e. those considered to be decision-makers) to draw out their perceived risks and benefits associated with reef restoration approaches, and their underlying *vrk*.

This study finds that whilst the set of knowledge within the decision context is expanding and attitudes towards the need to keep learning are positive, knowledge is constrained by the interactions between sets of related values and rules. Significant links between values (maintaining face and a sense of achievement), rules (politics) and risk (social, political and economic risks) suggest these interactions are creating barriers to change. As these interactions are of a socio-political nature, if they are to change to support restoration, socio-political change is needed. This research suggests that in order to drive this change, decision-makers need to adjust formal rules (regulations, policies, permits etc.) to allow for new knowledge to be generated in small scale trials, thus mitigating some concerns about potential ecological harm (risks), so that more benefits than risks can be revealed. Communicating these benefits will increase social support for restoration. This support will feed back into the decision context to help drive the socio-political change necessary for restoration projects to be implemented on the GBR.

Overall, these findings suggest that with increased social trust and acceptance the outlook for a restoration approach on the GBR is optimistic.

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List of acronyms and abbreviations

AIMS: Australian Institute of Marine Science

COTS: Crown of thorns starfish

CSIRO: Commonwealth Scientific and Industrial Research Organisation

GBR: Great Barrier Reef

GBRF: Great Barrier Reef Foundation

GBRMPA: Great Barrier Reef Marine Park Authority

JCU: James Cook University

NGOS: Non-governmental Organisations

OGBR: Office of the Great Barrier Reef

OUV: Outstanding Universal Value

QLD: Queensland

QUT: Queensland University of Technology

RRAP: Reef Restoration and Adaptation Program

UQ: University of Queensland

WHA: World Heritage Area

WWF: World Wide Fund

Chapter 1: Introduction

1.1 The coral reef crisis

The world is running out of time to save its coral reefs. In the last century, coral reefs have been progressively damaged by a wide range of direct human-induced pressures such as pollution, coastal development, over-fishing and physical destruction. Increasing water temperatures due to climate change are now aggravating these issues (Rinkevich, 2015, Hughes et al., 2017a), and as a result, the future of coral reefs around the world appears dire. The Great Barrier Reef (GBR) is no exception (Hoegh-Guldberg, 1999, De'ath et al., 2012). In the past few decades, the GBR has lost over 50% of its initial coral cover (De'ath et al., 2012), and it is expected that it could lose up to 70-90% before 2050 (IPCC, 2018). Whilst there have been significant efforts to mitigate local pressures (for example see McCook et al., 2010; McClanahan et al., 2006; Mumby and Steneck, 2008), there is concern that current management actions will not be enough as warmer ocean temperatures, and therefore bleaching events, become more frequent and severe (Hoegh-Guldberg, 1999). There is now a need to reassess how to best restore the GBR, especially in response to the inevitable consequences of climate change (Mumby and Steneck, 2008).

The idea of returning coral reefs to prehistoric conditions is largely understood to be unrealistic as novel coral reef ecosystems have already started to emerge (Bellwood et al., 2004, Graham et al., 2014; Hughes et al., 2018). It reasonably follows that to embrace this change, the protection of GBR reef ecosystems requires a novel approach. Recently, there has been a shift in thinking away from the need to simply reduce external pressures towards the need to intervene in a way that increases ecosystem resilience (Hughes et al., 2017a). This shift in thinking recognises that whilst it is still important to address global climate change and continue mitigating local pressures, it is now more important than ever to consider a more active approach (van Oppen et al., 2015). Coral reef restoration has been seriously explored as a way to increase reef resilience to the effects of climate change. Whilst the term restoration covers a wide range of actions, several approaches around the world have shown some success in enhancing stress tolerance and facilitating reef recovery including: macro algal removal, building artificial reef substrates and, most recently, mass larval reseeding (Cruz and Harrison, 2017, Spieler et al., 2001). Whilst it has not yet been evaluated how well these will work on the GBR, as the reality of bleaching events creating potentially irreparable damage becomes apparent, it is possible that exploring the feasibility of these approaches will become vital in securing the reef's future.

1.2 Understanding the need for social research

As it has been realised that climate change adaptation responses are often a socio-political endeavour (Eriksen et al., 2015), a better understanding of how humans respond and adapt to these changes is important (Graham et al., 2014, Pendleton et al., 2016). The literature has therefore called for the greater integration of social science in climate change adaptation research (Heller and Zavaleta, 2009, Hughes et al., 2010, Eden and Tunstall, 2006). Social science reveals valuable human dimensions which can provide insight into how society relates to, and perceives, particular adaptation responses, and thus may reveal opportunities for future management (Aswani et al., 2015). This is particularly relevant for ecological restoration because the nature of restoration challenges traditional ideas of conservation giving it the potential to create problems for decision-makers (Eden and Tunstall, 2006; van Oppen et al., 2015).

1.2.1 The importance of social trust

Gaining social trust or acceptance is a vital component of successful environmental management, especially in cases which require intervention or new technologies (Cvetkovich and Lofstedt, 2013). Due to the size and iconic status of the GBR, management of the GBR marine park is closely watched and scrutinized. It is therefore crucial that all decision makers involved in GBR restoration gain trust from GBR stakeholders before proceeding with any changes. As social trust in using or managing new technology has been shown to be directly related to perceived benefits and risks, and since stakeholders often rely on information provided by decision-makers and experts, gaining trust usually involves the clear communication of risks, benefits, and a deeper understanding of decision-making processes (Siegrist and Cvetkovich, 2000).

In order for restoration to play a role in protecting the world's largest coral reef system, it makes sense that the next step from here is to explore the decision context behind restoration. This research uses the values, rules and knowledge (*vrk*) perspective as put forward by Gorddard et al., (2016) to characterise the decision context as the sets of *vrk* which create feasible options in the reef restoration space. In doing so, this research expects to be able to help stakeholders gain a deeper understanding of decision-maker perspectives (i.e. risks and benefits), provide insight into why certain decisions are made (i.e. understand the sets of *vrk* behind restoration decisions on the GBR, and associated risks and benefits), and hopefully encourage better engagement in the decision-making process.

1.3 Research purpose, aims and objectives

This research has been conducted with a favourable view towards restoration in mind. The purpose of this research project is to contribute a new social dimension to the GBR restoration discussion by exploring the decision context. In doing so, this research hopes to illuminate an important step towards the social acceptance and potential delivery of an active intervention approach (Backstrand, 2003). To achieve these, this study will provide an in-depth analysis which will focus on the perceived risks and benefits of a restoration approach by those who are involved in GBR protection and management, and/or provide expert advice. It will consider: (1) how do these perceptions reflect the decision context in terms of values, rules and knowledge (*vrk*)? (2) How well does the current decision context support a restoration approach? (3) Does the current decision context need to change to consider feasible restoration options in the future? In answering these questions and using the *vrk* perspective, this study aims to provide insight into the decision context and identify potential barriers and opportunities within the decision-making space. In addition, it is hopeful that initiating this dialogue about the risks and benefits of restoration from a decision-maker perspective will help guide the restoration process and hopefully gain the enthusiasm, trust and willingness required from stakeholders, including the Australian public, to incorporate this approach into future reef management (Omori, 2010, van Oppen et al., 2015).

At present, a collaboration of Australia's leading research organisations (CSIRO, AIMS, JCU, QUT and UQ) has resulted in the development of the Reef Restoration and Adaptation Program (RRAP). The program provides a platform for the preliminary scoping of potential technologies for increasing reef resilience. Since it has been recognised that some of these technologies may create unease for GBR stakeholders, the RRAP broadens out into a stakeholder engagement program conducted by CSIRO. This stakeholder engagement program aims to map out the perspectives and potential roles of different stakeholders in order to incorporate them into reef restoration decision-making processes in the future. The research here will complement CSIROs stakeholder engagement research by conducting an analysis of expert, manager and policy maker perspectives. Whilst the research presented here is an independent study based at the Australian National University, it has been conducted in consultation with the CSIRO RRAP team to avoid duplication. This research is the first of its kind in the context of the GBR.

1.4 Approach and thesis Structure

This research draws on a comprehensive review of relevant documents from the Australian Government, Queensland Government, AIMS, CSIRO and other GBR stakeholders, and peer-reviewed literature. This literature review enables the examination of current and previous management approaches on the GBR to gain a better understanding of the nature of these approaches. Data was also gathered from semi-structured interviews and participant observation. Eleven interviews were conducted with those who have an active role in GBR management and protection, and/or provide expert advice and research in order to explore their values, rules, knowledge and perceptions. Participant observation took place at the GBR Restoration Symposium 2018 in Cairns to gain a deeper understanding of the wider decision-making context.

Chapter two will provide the context necessary to gain a better understanding of ecological restoration, how it has come about, the values behind it and most importantly, current ideas about when to apply it. This includes an analysis of transformative adaptation, intervention ecology and ecological restoration literature in order to highlight the move away from traditional conservation. Chapter three will introduce the GBR case study and will argue that in a changing global climate, current reef management approaches are not enough, and a change in thinking, such as that set out in chapter two, may be necessary. Chapter four sets out the methodology and justifies the qualitative approach taken for this study. Chapters five and six present the risks and benefits, and the sets of values, rules and knowledge that emerged from the data. Chapter seven combines both results chapters in order to answer the research questions. It analyses the decision context in order to consider the barriers and opportunities it provides. The final chapter summarises the findings of this report, discusses its applicability in the field, and its implications for future research.

Chapter 2: New Paradigms in Ecological Conservation

There is now almost global consensus that the climate is changing, and with it, so are many of the world's precious ecosystems. These global changes are pushing ecosystems in a direction they have never been before, causing general ecosystem services to decline over time and new novel ecosystems to emerge (Grimm et al., 2013, Graham et al., 2014). This chapter will focus on how approaches to ecosystem conservation and management have shifted in the last few decades. From the broad category of what is known as 'intervention ecology', this chapter will draw out and analyse the current discussion on restoration and its application in our changing world. Whilst there is some controversy, the general consensus amongst the scientific community is that restoration, both active and passive, may be necessary under certain conditions (Holl and Aide, 2011, Elliott et al., 2007). This chapter argues that coral reef ecosystems fit under these conditions and strongly agrees with the literature that restoration provides strong potential for securing the future of the world's coral reefs.

2.1 Transformative adaptation and intervention ecology

Due to the rapidly increasing and unprecedented rate of change currently occurring on a global scale (Steffen et al., 2004), the need to revaluate approaches to ecosystem conservation has never been more certain (Hobbs et al., 2011). There is now strong support for the idea that we need to move on from traditional conservation methods of trying to restore ecosystems to their previous states and intervene with an "eye for managing future change" (Hobbs et al., 2011). To complement this shift in thinking, Colloff et al. (2017) iterate the importance of assisting decision-makers transition to "global-change" ready in a transformative adaption approach which often requires managing trade-offs between maintaining current ecosystems and adapting to major changes in those systems (Colloff et al., 2016). Learning how to manage these trade-offs can be explored through the idea of intervention ecology. Intervention ecology can be thought of as "the science of meaningful and thoughtful intervention in ecosystems" (Hobbs et al., 2011). The term 'intervention ecology' covers a wide subset of actions which are intended either to maintain a system in its current state, or if the current state is undesirable, move the system towards one that is (Hobbs et al., 2011). These actions are often associated with ecosystem restoration and are now becoming increasingly required to ensure the future of many of the worlds ecosystems (Roberts et al., 2009; Hobbs et al., 2011).

2.2 Ecological restoration: What is it?

Ecological restoration can be difficult to define, and this means it has the potential to create unrealistic expectations of what it can and cannot achieve (Hobbs et al., 2011). The term restoration itself, the act of returning something to its original condition, is already misleading as it has been recognised that returning degraded ecosystems to historic conditions is unlikely given the changed conditions of the future (Choi, 2004, Harris et al., 2006). Even concepts such as rewilding, which involves the re-introduction of previously lost species to an area, may have limited successfulness in some cases given rapidly changing climatic conditions (Falcón and Hansen, 2018). Whilst it is not the purpose of this report to define ecological restoration, an awareness of what may constitute restoration is required to give a holistic approach to understanding. Jackson et al. (1995) define ecological restoration as "the process of repairing damage caused by humans to the diversity and dynamics of indigenous ecosystems". Though this definition is unrealistic as it implies the possibility of returning to an indigenous state, it's underlying message that an ecosystem will not repair itself without human intervention remains relevant. The Society for Ecological Restoration (SER, founded in 1987), defines ecological restoration as "the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (Society for Ecological Restoration International Science & Policy Working Group, 2004). Edwards and Gomez (2007) highlight the word "assisting" in this definition as it begins to highlight a shift in the restoration paradigm towards a 'futuristic' approach (Choi, 2004). Some definitions of ecological restoration include aspects of rehabilitation

and recovery (Clewell and Aronson, 2013), and others argue that ecological restoration requires an expanded view which includes social, cultural, political, aesthetic and moral aspects (Higgs, 2002). These definitions, whilst inconsistently used, contribute to a deeper understanding of the possibilities ecological restoration may provide in a changing world.

2.2.1 When is restoration necessary?

There is considerable debate about whether restoration is always necessary (Elliott et al., 2007, Holl and Aide, 2011) and what the goals of restoration should be (Hobbs, 2007). However, overall evidence supporting ecological restoration is growing (Groot et al., 2013). Restoration efforts are now in action all around the world from the UK (Hodge and Adams, 2016) to China (Zhao et al., 2016), and are being applied to a range of different ecosystems.

Another question regarding ecological restoration is deciding when to use *active* restoration versus *passive* restoration. Active restoration efforts are "positive steps taken to change ecosystem properties in a particular direction" (Hobbs et al., 2011). This involves humans actively intervening to encourage and *assist* natural processes of recovery (Holl and Aide, 2011). Examples of this include planting seeds in degraded forest areas, stabilising stream banks using native vegetation and coral "gardening" (Rinkevich, 2008, Morrison and Lindell, 2010). Passive restoration efforts, however, involve the elimination of the drivers of ecosystem degradation to allow for natural, *unassisted* recovery processes to occur (DellaSala et al., 2003). Examples include removing environmental stressors such as grazing and agriculture in forested landscapes, and the use of no-take zones in open marine ecosystems to protect them from overfishing and physical damage (Morrison and Lindell, 2010, Elliott et al., 2007). Deciding which approach to take requires a decision between two fundamental, and potentially controversial, values: the wish to conserve natural ecosystems and the desire to maintain key ecosystem functions (Anthony et al., 2017). Both approaches also induce different perceptions of risk and damage to the environment (Rohr et al., 2016). In many circumstances it is likely that both active and passive restoration will be applied to prevent further degradation and to restore ecological functions (DellaSala et al., 2003). In a changing world, decision-makers must be prepared to consider all options (Colloff et al., 2016).

2.3 Coral reef restoration

There is general consensus amongst the academic community that more needs to be done to protect the world's coral reefs (Anthony et al., 2017, Bellwood et al., 2004, Mumby and Steneck, 2008, van Oppen et al., 2015, van Oppen et al., 2017, Rinkevich, 2008, Rinkevich, 2015). As an accumulation of local and global pressures continue to increase the instability of current reef ecosystems, the need to reassess coral reef management and governance in the face of uncertainty is urgent (Bellwood et al., 2004, Rinkevich, 2008, Hughes et al., 2010, Graham et al., 2014). It has been argued that "new and potentially riskier" interventions, which recognise and manage for

this uncertainty, must be included in management regimes alongside current management efforts (Anthony et al., 2017). Even those who question the effectiveness of restoration, such as Elliott et al. (2007), recognise there is a possible exception whereby ecosystem engineers, such as corals, are reintroduced to facilitate the recovery of the system. As a result, a range of both passive and active restoration approaches have been proposed, and some trialled, to increase coral reef resilience to increasing water temperatures and ocean acidification (Rinkevich, 2014, Spieler et al., 2001, Coles and Riegl, 2013). Examples include: assisted evolution (van Oppen et al., 2015), physical and biological rehabilitation (Omori, 2010), increasing coral recruitment (Edwards et al., 2015, Cruz and Harrison, 2017), assisted colonisation (Coles and Riegl, 2013), the use of artificial substrates (Spieler et al., 2001) and novel ecosystem engineering (Rinkevich, 2015). These examples demonstrate the wide range of opportunities which restoration may provide to improve reef resilience.

2.3.1 Limitations

Although restoration is now seen as a potentially vital component to future reef management, it is important that it is not overestimated (Edwards and Gomez, 2007). Mumby and Steneck (2008) argue that restoration activities should only occur once the causes of degradation have been treated, and thus are only effective in systems of intermediate health (i.e. after local pressures have been mitigated). In addition, at this stage the feasibility of many restoration projects at a large scale, especially those aiming to increase climate tolerance, is limited (Anthony et al., 2017). The costs of these projects is also a contentious issue. Whilst some argue that coral reefs may be too expensive to restore (Bayraktarov et al., 2016), others disagree and argue that the costs of doing nothing under climate change will be far greater than the cost of any restoration effort (Rinkevich, 2017, Anthony et al., 2017). It is also possible that some active interventions carry the unintentional risk of ecosystem disruption. It is important to recognise these limitations in order to understand the feasibility of restoration as a mass solution to help the world's coral reefs.

It is equally important to note that the call to more actively manage reef resilience via restoration is not a call to stop current management practices. Restoration alone will not solve the coral reef crisis and the literature urges that more than a single approach is needed (Omori, 2010, Rinkevich, 2015, Bellwood et al., 2004). Alongside interventions to support reef resilience, there is still the need to continue and intensify current management efforts (e.g. no-take areas, water quality improvement) to reduce local drivers of change, and reduce global carbon emissions (Bellwood et al., 2004, Hughes et al., 2010, Anthony et al., 2017). This integrated approach is crucial to securing the future of coral reefs worldwide (Anthony et al., 2017).

2.3.2 Lessons learned

There are several cases from around the world where reef restoration has been successful to some extent from which valuable lessons can be learned, for example the Florida Reef Resilience

Program (The Nature Conservancy, 2013). Firstly, the success of restoration projects is often determined by the formulation of clear goals and objectives (Edwards and Gomez, 2007, Zhao et al., 2016) and the appropriateness of the decision to implement them (Holl and Aide, 2011). Not all situations are appropriate for restoration, for example, if restoration is implemented in areas where local pressures have not been adequately addressed, restoration efforts may be waste of time as these pressures will degrade restored areas (Mumby and Steneck, 2008). Literature describing ideal restoration situations is increasing (Holl and Aide, 2011). Recently, van Oppen et al. (2017) even proposed a decision tree for when to integrate active restoration (or 'assisted evolution') into coral reef management. The Reef Resilience Toolkit (The Nature Conservancy, 2018), also provides guidance and tools to help ensure the maximum success of reef restoration projects, including key questions to ask before starting a project. It is important to use this knowledge to understand what restoration can achieve, and help formulate appropriate goals for restoration projects. Secondly, it is important that the methods applied in restoration projects are considered in a management and governance context (Edwards and Gomez, 2007). Such projects need to be considered as an ongoing process and as such are likely to require more proactive, flexible styles of governance and management which are able to deal with uncertainty and risk (Edwards and Gomez, 2007, Hughes et al., 2010, DellaSala et al., 2003). Finally, previous restoration efforts have shown that due to the perceived risks of manipulating ecosystems, public understanding and stakeholder enthusiasm is crucial to help govern and manage changing reef ecosystems more effectively (Johnson et al., 2011). For example, reef restoration efforts in Fiji were shown to be more successful where there was strong local governance and support, and community-based resource management (The Nature Conservancy, 2014).

This chapter identifies the ways of thinking and some key factors required to enable the effective delivery of restoration projects in coral reef ecosystems. This has important implications for the next chapter as it begins to explore how well current GBR management and governance systems create the context necessary for restoration to occur.

Chapter 3: The Great Barrier Reef

The Great Barrier Reef (GBR) is one of nature's most remarkable gifts to Australia and the world. It is the world's largest living structure, comprising of nearly 3000 individual coral reefs and over 900 islands. In 1981 the reef was listed as a world heritage site for its Outstanding Universal Value and now, almost 40 years later, this title is now being threatened due to exposure to a range of human-induced disturbances. Several documents, such as the Climate Change Adaptation Strategies, the Reef 2050 Long-term Sustainability Plan and the Blueprint for Resilience, as well as the recently announced funding from the federal government, all demonstrate that protection of the reef against these disturbances is a high priority. However, due to its iconic status and large number of stakeholders involved, management and governance decision-making processes on the GBR are complex and there are often conflicting views on how it should be managed. This chapter explores this complex decision space and considers to what extent it will support restoration in the future.

3.1 Pressures facing the Great Barrier Reef

The Great Barrier Reef is currently being faced with a multitude of local, regional and global pressures. The most recent assessment of the Reefs' overall health, the Outlook Report 2014 (Great Barrier Reef Marine Park Authority, 2014), concludes that the cumulative impact of these pressures is severely affecting the reefs ability to recover and will continue to do so as the impacts of climate change are increasingly felt throughout the delicate and precious ecosystems. This report concludes that additional effort in managing these pressures is required. The highest risks identified in the report are summarised in the table below:

Table 1- A summary of the four main pressures facing the GBR as identified in the 2014 Outlook Report.

Climate change	The devastating impacts of climate change on the Great Barrier Reef are no longer being contested and many agree that more needs to be done (Hoegh-Guldberg et al., 2007). Since the first mass bleaching event in 1998, six subsequent mass bleaching events have followed, and with an expected sea level rise, increase in temperature, ocean acidification and unpredictable weather, these bleaching events are expected to increase in frequency and severity (Wolff et al., 2018). This is of serious concern as after each bleaching event the reefs natural ability to recover decreases significantly (Hoegh-Guldberg, 1999). The long-term effects of the most recent back-to-back bleaching event (2016-2017) are still being unravelled.
Land-based run-off	The quality of water entering the Great Barrier Reef is affected by a range of land-uses and land management practices within the catchment area. Run-off rich in nutrients, pesticides and sediments often flows into the catchment and deteriorates the water quality. This affects the reefs resilience and ability to recover naturally. Increased nutrient run-off has also been linked to COTS outbreaks which is currently devastating parts of the reef (Brodie et al., 2005). Whilst recent reports have shown that the water quality entering the reef is improving, there is likely to be a significant lag time before improvements can be seen overall (Brodie and Waterhouse, 2012).
Coastal development	Developments in coastal areas have substantially modified coastal habitats which support the reef ecosystem such as wetlands, forested floodplains and rainforests. This creates artificial barriers to flow and has been linked to increased outbreaks of disease and pest species (e.g. COTS) due to an increased concentration of nutrients in the catchment area (Great Barrier Reef Marine Park Authority, 2014).
Direct use	Direct use of the GBR and catchment area mainly include tourism, recreation, port activities and fishing. Most of these uses are concentrated inshore, particularly next to developed areas. However, the majority of concern lies between port activities, as their impacts are usually in areas that are already under pressure from an accumulation of impacts, and the overfishing of certain fish stocks (Great Barrier Reef Marine Park Authority, 2014).

3.2 Management Approach

How to effectively manage the GBR in light of these pressures is a subject of considerable speculation and has stimulated much debate (Brodie and Waterhouse, 2012, Biggs et al., 2009). After the enactment of the Great Barrier Reef Marine Park Act ('the Act') in 1975, the GBR has been effectively managed as a national marine park by the Great Barrier Reef Marine Park Authority (GBRMPA). It is considered to be one of the best managed coral reef systems in the world (Wilkinson, 2008). To date, since it has been recognised that regional policies cannot protect the GBR from global climate change risks, the majority of management approaches have been responses aimed to mitigate local non-climate pressures (De'ath et al., 2012, Rinkevich, 2015, Pendleton et al., 2016). A common approach to tackling these pressures is to create a list of current threats, prioritise them and address them individually through a process called adaptive management (Hughes et al., 2010). Whilst this approach makes GBR management more effective when compared to similar marine park management bodies around the world, Brodie and Waterhouse (2012) report that it may not always be the most effective.

3.2.1 Adaptive Management

An increasingly common term being used in ecological conservation and management is 'adaptive management' (Day, 2008, Dobbs et al., 2011, Schultz et al., 2015). Adaptive management is a process which involves the acknowledgement of uncertainty in decision-making and the modification of decisions through learning (Parma, 1998). This allows for the continual improvement of effective management actions and flexibility in dealing with the unexpected (Parma, 1998, Day, 2008). In the GBR, the shift towards adaptive management was triggered by the realisation that the reef was not as resilient as originally believed and its "pristine" future was no longer certain (Olsson et al., 2008, Hughes et al., 2007).

A key principle which guides adaptive management on the GBR is the regular assessment of the reef's overall health in the GBR Outlook Reports. These reports provide a means for highlighting risks to the reef and allow for an overview of the effectiveness of management responses to be undertaken (Dobbs et al., 2011). These outlook reports have been successful in improving management decision-making in some areas. For example, after increased risks associated with biodiversity loss were reported, GBRMPA rezoned the marine park to include more highly protected areas ("Green zones") covering a broader range of habitat types (Hughes et al., 2007, Day, 2008). However, there are some limitations of adaptive management and it has been recognised that as climate change continues to threaten reef resilience, adaptive management may become increasingly difficult (Anthony et al., 2015). Adaptive management often requires science-driven solutions, long-term monitoring and scientific consensus or "certain" science, in order to identify effective and feasible solutions (Boesch, 1996, Brodie and Waterhouse, 2012). Due to the long-time frames between science and management action, this can be a cumbersome

and time consuming process which may not be appropriate given the time-sensitive issue of climate change (Brodie and Waterhouse, 2012).

3.2.2 Building resilience

For coral reef managers, an adaptive management approach is usually adopted with the goal of increasing reef resilience (Hughes et al., 2010, Graham et al., 2013). The definition of resilience in this approach builds on that of ecological resilience as originally described by Holling (1973), and includes aspects of resistance, the ability to cope with pressures (Nyström et al., 2008), and recovery, the potential of the system to reorganise or recover between disturbances (Gunderson, 2000, Anthony et al., 2015). This approach requires both an understanding of the stressors which impact resilience (Anthony et al., 2015) and how resilience is conferred (Nyström et al., 2008). Resilience-based adaptive management therefore includes two key features: (1) reducing threats and (2) supporting the systems resilience to promote recovery and enhance adaptive capacity (Marshall and Schuttenberg, 2006), both of which will influence survivorship during and after mass bleaching events (Anthony et al., 2015). Resilience-based adaptive management has already shown some success on the GBR, with the potential to further improve reef resilience in the future (Anthony et al., 2015).

3.3 Progress: becoming "future ready"

Over the past few decades, the Australian and Queensland governments have delivered significant results in protecting and managing the GBR. Major successes have included improvements in water quality and the Marine Park rezoning in 2004, in which there is some evidence of these contributing to increased resilience and overall ecosystem health (McCook et al., 2010). In addition, 2009 targets for water quality have resulted in the reduction of sediment runoff which has been critical in COTs control (Brodie and Waterhouse, 2012). There has also been successful management in control of shipping and overfishing (Brodie and Waterhouse, 2012). However, whilst these efforts are important to increasing reef resilience, modelling scenarios for the future of the GBR under climate change show that even with substantial progress in these management actions, without a significant increase in climate change action, coral cover on the GBR will fall significantly (Bohensky et al., 2011). This suggests there is a need for further action.

3.3.1 Responses to Climate Change

Both the academic community and the general public perceive climate change to be the biggest threat to the GBR (Goldberg et al., 2016, Hoegh-Guldberg et al., 2007). The GBR has experienced several mass bleaching events in the last few decades, the most recent resulted in some Reefs' having up to 98% of their corals bleached (Hughes et al., 2017b). However, despite concerns about the bleak future of the GBR increasing significantly as a result of these events, there has been a definite lack of effective climate change management action (Brodie and

Waterhouse, 2012, Fidelman et al., 2013). Fidelman et al. (2013) suggest that this is due to the predominance of adaptation measures mostly comprising of short-term solutions.

In 2007, GBRMPA released its first Climate Change Adaptation Strategy. Since building resilience was unlikely in the proposed five year time frame, and being the first of its kind in Australia, the strategy is to be seen as a means for research and development (Great Barrier Reef Marine Park Authority, 2012a). In this sense, has been reasonably successful (Rissik and Reis, 2013). Prior to the strategy, there was little engagement with key GBR stakeholders in regards to climate change (Rissik and Reis, 2013). It therefore provided a platform for stakeholders to share values and interests, and as such fuelled a collaborative approach to protect the GBR (Great Barrier Reef Marine Park Authority, 2012a). The strategy also supported much needed research and delivered over 250 individual projects across the GBR (Rissik and Reis, 2013). This development of knowledge and improved understanding of the need to share climate change responsibilities amongst stakeholders has been crucial in informing GBRMPAs current climate change strategy, the Climate Change Adaptation Strategy and Action Plan 2012-2017 (NCCARF, 2016). This updated strategy builds on the previous one by identifying direct actions to increase the resilience of the GBR (Great Barrier Reef Marine Park Authority, 2012b, NCCARF, 2016).

3.3.2 The Reef 2050 Long-term Sustainability Plan

The Reef 2050 Long-Term Sustainability Plan (the Plan) sets out the Australian and Queensland governments' ongoing commitment to protecting the GBR. The purpose of the Plan is to "ensure the GBR continues to improve on its outstanding universal value every decade between now and 2050 to be a natural wonder for each successive generation to come". With specific targets until 2020 and broader objectives through to 2050, it is the most comprehensive long-term plan in GBR management history (Great Barrier Reef Marine Park Authority, 2015).

The Plan has received positive and negative feedback from the public, NGO and scientific communities (WWF-Australia and Australian Marine Conservation Society, 2015, Roth et al., 2017). The most notable criticisms have been expressed by multiple GBR stakeholders, experts and decision-makers, and include: (1) failure to explicitly address climate change and provide clear indication of how cumulative pressures will be addressed (WWF Australia and the Australian Marine Conservation Society, 2015, Roth et al., 2017), (2) the goal to maintain and enhance the reefs Outstanding Universal Value (OUV) throughout the entire WHA is unrealistic (Tarte et al., 2017, Roth et al., 2017), and finally (3) the Plan both downplays the urgency of the threats facing the GBR and overstates the effectiveness of previous and current management actions (Tarte et al., 2017, WWF Australia and Australian Marine Conservation Society, 2015).

On a positive note, the Plan provides a good starting point for the discussion on the future of the reef under increasing pressures from climate change in Australia. Its integrative approach has lead the way for increased stewardship and communication between GBR stakeholders and the systems which the Plan has put in place such as expert panels, advisory committees, regular

reviews and monitoring plans are all an important step towards better reef management. It has also been commended in areas such as improved targets to cut farm pollution, strengthening coastal planning and water pollution laws, providing additional funding and the recognition of the role of traditional owners in future reef management (WWF-Australia and the Australian Marine Conservation Society, 2015). The Reef 2050 Plan mid-term review was scheduled for July 2018.

Unfortunately, despite the progress made in these plans, it has been recognised that without global efforts to reduce emissions, there is little that can be done to protect the GBR from a changing climate (NCCARF, 2016). It is already of great concern that in the time these strategies have been released, the GBR has experienced some of the most severe mass bleaching events in history. If our inability to manage climate change continues and these plans are not adequately adapted to navigate inevitable change, the long-term outlook for a healthy GBR is poor (Fidelman et al., 2013). Whilst active restoration is not an explicit objective of the Plan, there is flexibility in the kinds of opportunities it can provide for the use of restoration in the future (Hughes et al., 2007). Initial looks into the mid-term review suggest that there will be room for a discussion on restoration greater than there has been before (Roth et al., 2017).

3.4 Restoration on the Great Barrier Reef

Whilst passive protect and conserve approaches have had some local success, there is growing concern that they will not achieve desired reef management goals, requiring the nation to reassess how to best restore the GBR (Mumby and Steneck, 2008). Although a range of reef restoration techniques have been trialled around the world, it is not yet known what will work best on the GBR. In the past, the view to active restoration on the GBR has been short sighted which suggests that in order for restoration to play a role in future reef management, a change in thinking will be required. For example, the Reef Managers Guide to Coral Bleaching (2006) states that "it is critical to reduce or manage as many local threats that affect coral reefs in your area *before* restoration is implemented". This approach generally summarises the one that has been adopted by GBR managers and policy makers as for the past few decades they have strongly prioritised the management of local pressures. However, this view is changing as the importance of adopting active approaches alongside current management efforts as is now recommended (Bellwood et al., 2004).

In the last year, the push towards developing more innovative approaches to reef restoration in Australia has increased significantly. In April 2018, the Australian Government announced $500 million in funding for the GBR, $100 million of which is said to be for reef restoration and science that supports reef resilience and adaptation (Joint Media Release - Record investment in the Great Barrier Reef to drive jobs, 2018). Whilst this funding allocation has received criticism, it demonstrates the Government's ongoing commitment to achieve the outcomes set out in the Reef 2050 Plan and reflects the intent of the Reef Blueprint (see section 3.4.1 below). Other government innovation programs have also been established such as the Coral Reef Innovation

Facility (Department of Foreign Affairs and Trade) and the Boosting Coral Abundance on the GBR (QLD Government). The most recent, and arguably the most important, contributions to GBR restoration agenda however are the Blueprint for Resilience and the Reef Restoration and Adaptation Program (RRAP).

3.4.1 Blueprint for Resilience

The Blueprint for Resilience (the Blueprint) was released late 2017 as the result of a resilience summit held earlier the same year in which over 60 GBR policy, expert and management stakeholders attended (Great Barrier Reef Marine Park Authority, 2017).The Blueprint opens a serious discussion for increasing and diversifying resilience-based management on the GBR and will have a positive impact on the revised 2050 Plan. The Blueprint is the first GBRMPA document to directly address the potential of active restoration, with a 2020 vision for localised trials to be underway. It also recognises that some whilst restorative tools already exist, a strong commitment from GBR stakeholders is required for successful implementation.

3.4.2 Reef Restoration and Adaptation Program

It has been recognized that sustaining critical reef ecosystem functions may require interventions that go beyond the traditional management toolset. As such, there is a growing need to explore the feasibility of interventions with the capacity to enhance recovery, restore damage and encourage resilience (Great Barrier Reef Marine Park Authority, 2012b). In 2017, the collaboration of GBRMPA, CSIRO, AIMS, JCU, UQ, QUT and GBRF led to the inception of the Reef Restoration and Adaptation Program (RRAP). The program presents a platform for the scoping of potential active restoration technologies on the GBR. Initial work on defining the scope of the Program suggests that it is likely to be a lengthy task requiring an investment of $500 million over ten years (Roth et al., 2017). Whilst there is already support for such interventions (Roth et al., 2017), a comprehensive stakeholder engagement agenda is crucial. In the context of a potentially devastated GBR, it is vital and time critical that this restoration approach and the factors which ensure its success are explored thoroughly.

3.5 Summary

The discussion above shows that as cumulative pressures on the reef increase, management of the GBR is changing. The Reef 2050 Plan and initial looks into its revision, demonstrate clear progress in terms of changing attitudes and preparing for future climate conditions. In addition, the Blueprint, RRAP and recent budget announcement demonstrate that there is an appetite for restoration options to be explored. However, conflicting views surrounding where funding money should be allocated and criticisms about the plans and programs discussed highlight the complexity that engulfs decision-making on the GBR. The RRAP is also still in its infancy and will likely have social barriers to overcome once restoration trials begin.

Chapter 4: Approach and Methodology

Ecosystem conservation and restoration projects often have a range of complex underlying social, political and economic problems (Eden and Tunstall, 2006). The methodological approach for this project is therefore largely qualitative as this approach is useful in gaining a deeper understanding of complex phenomena (Rust et al., 2017). The objective of this project was to visualise the GBR restoration decision-making context, by characterising it in terms of *vrk*, to gain greater understanding of the reasons behind restoration decisions and identify any barriers and opportunities for restoration options. To achieve this, eleven semi-structured interviews were conducted. Participant observation was also used to validate interview data through a reflexive process and gain a deeper understanding of the socio-political context behind restoration. The analytical framework, methodological approach and methods are described in this chapter.

4.1 Conceptual framework

The conceptual framework (Figure 1) illustrates how the methodology fits with the theoretical and practical outcomes of this research project.

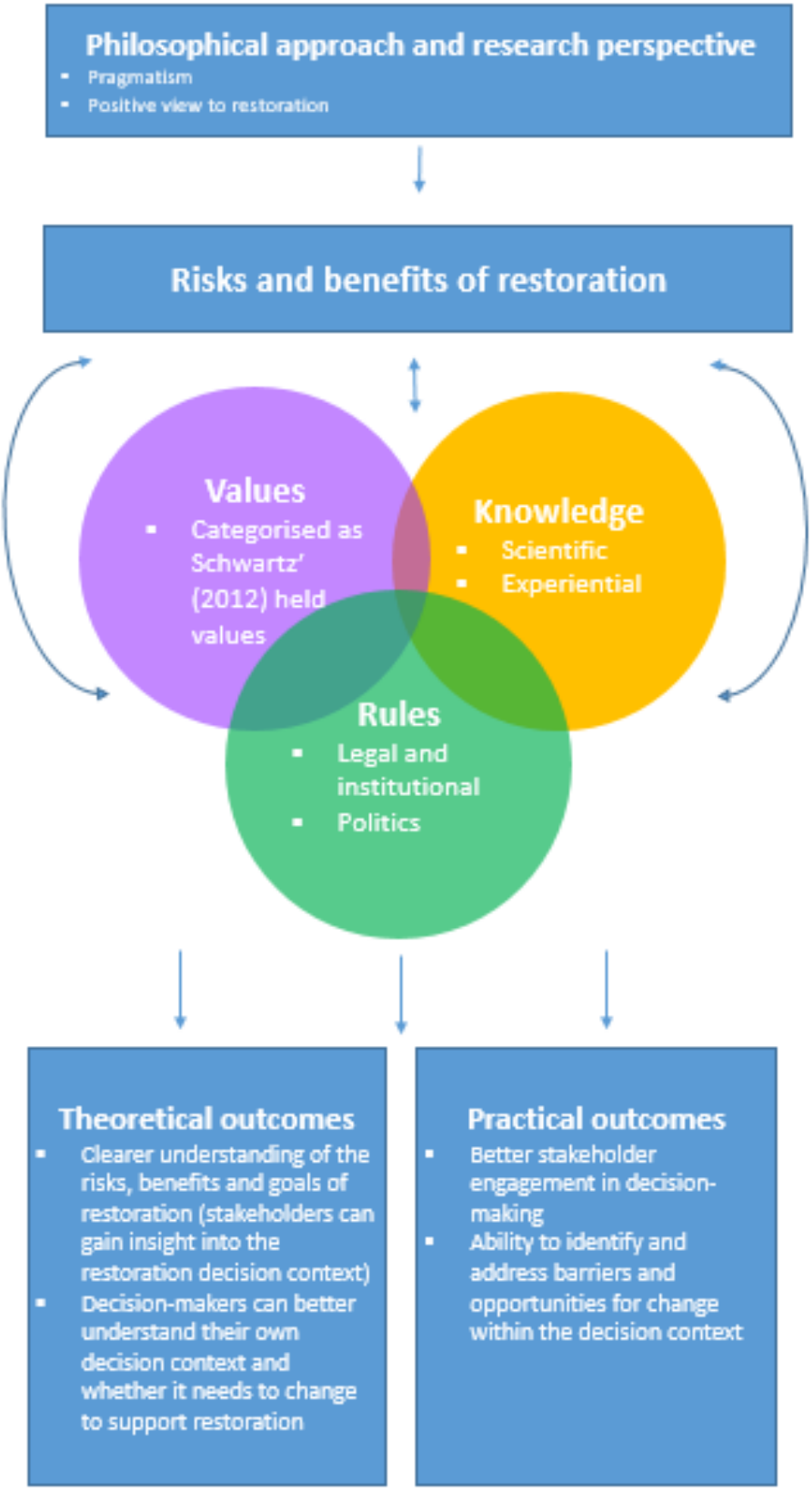

Figure 1 - Conceptual framework

4.1.1 Philosophical approach and research perspective

This research has been approached with a favourable view towards pursuing restoration on the GBR in mind. The methodology has therefore been constructed to help illuminate findings which may contribute to the successful implementation of restoration projects. The philosophical approach of pragmatism, which involves using the methods which appear to be best suited to the research problem, has been employed as it recognises the value of different approaches to conducting inquiry (i.e. acquiring knowledge one way or the other, or, producing one kind of knowledge over the other) and actions that are uniquely important within given circumstances (Morgan, 2014). The methods chosen for this research were therefore chosen to be able to characterise the restoration decision context and reveal barriers to change which need to be addressed.

4.1.2 The *vrk* perspective

Decision-making is central to change (Collof et al., 2018). It therefore reasonably follows that a strong understanding of the decision context is also vital for change to occur. The decision context can be viewed as the sets of values, rules and knowledge (*vrk*) that create options (Gorddard et al., 2016). Conceptualising the decision context as sets of *vrk* helps provide insight into decision-making processes and the reasons behind why particular options are preferred (Gorddard et al., 2016). This study uses the *vrk* framework as it is a practical way reveal how decision-maker perceptions of risks and benefits might be informed, and issues that create barriers to change (Colloff et al., 2018). It also helps decision-makers consider whether a change in the decision context is required and enables them to distinguish between changes that can be made within their decision context and those that may require larger changes in society (Colloff et al., 2018). In understanding the values (categorised across Schwartz' two dimensions of basic human values), rules (formal and informal) and knowledge (scientific and experiential), behind restoration decisions and how they inform perceptions of risks and benefits, stakeholders (including the broader Australian public) can use the *vrk* perspective to gain insight into the decision context and potentially develop more informed opinions about whether they consider restoration on the GBR acceptable.

4.2 Methods

Methods used in this project include semi-structured interviews, participant observation and qualitative data analysis. A detailed literature review was also conducted on relevant literature and documents from the Australian Government, Queensland Government, Great Barrier Reef Marine Park Authority, Great Barrier Reef Foundation and other GBR stakeholders. This triangulation of data methods was used to enhance the quality and credibility of this qualitative study (Krefting, 1992).

4.2.1 Semi-structured interviews

Semi-structured interviews were chosen as they are well suited for exploring issues from the participant's point of view (Barriball and While, 1994). Due to the nature of semi-structured interviews allowing for probing and the clarification of answers, they were appropriate for this study in potentially uncovering topics and themes not previously considered, as well as allowing participants to actively reflect (Barriball and While, 1994). In addition, since the participants selected for this project were all from a variety of professional backgrounds, using a standardised structured interview would have been restrictive. Interview questions were focussed around three key themes in order to answer the research questions for this study: (1) reflection on previous and current management approaches (to elicit values/what they consider important outcomes, interests and goals), (2) the perceived risks and benefits of active ecosystem interventions such as restoration (to elicit knowledge/what they know about restoration, as well as their perceptions of the risks and benefits associated with it), and (3) the integration of restoration approaches into current management and governance systems in the future (to elicit sets of rules involved in restoration). Key questions were open-ended to open a discussion space and to encourage reflection. Each of these themes/key questions were followed by a series of probes to keep the discussion on track and refine future questions through an adaptive process (see Appendix 1).

4.2.1.1 Interview Group

For this project, professional participants who have an active role in GBR management and protection, and/or provide expert advice and research were purposively sampled. Eleven participants were selected to represent four key decision-making groups: NGOs, scientists, managers and policy-makers, and government. Table 2 below shows a summary of each participant's relevant experience and expertise. Participants were contacted initially via email, and were provided with a short description of the project, including general areas of questioning. Seven interviews were conducted in person and four via Skype. Tourism and industry stakeholders have not been included as this group is already being studied as part of the CSIRO RRAP stakeholder engagement program.

Table 2-Summary of participants including their representative decision-making group and relevant experience/expertise. The codes A-K have been used throughout this report as a way to identify participant quotes.

Code	Stakeholder Group	Involvement and experience with the GBR	M/F
A	NGO	Biology research and scientific consulting	F
B	NGO	Marine management and policy	M
C	NGO	Manager and marine biologist	M
D	NGO	Involved in on ground GBR restoration projects	M
E	Science	Biologist	F
F	Science	Restoration researcher	M
G	Science	Reef related research	M
H	Management/Policy	Public policy and governance researcher	F
I	Management/Policy	Manager and reef ecologist	M
J	QLD Government	Office of the GBR	F
K	QLD Government	Office of the GBR	F

4.2.2 Participant observation

Over 200 participants were observed at the 2018 Great Barrier Reef Restoration Symposium (16-19th July) in Cairns. Most observations were recorded via note-taking during presentations, but also during conversations, workshops and general discussion spaces. Notes were taken with the *vrk* framework in mind. Participant observation was selected as a method for this study for two reasons. Firstly, it was selected to gain a better understanding of the GBR restoration context, especially given its complex nature, in order to increase the validity of the study (Kawulich, 2005). Since the symposium actively sought participants from a wide range of disciplines, it was easier to get more diverse views. Secondly, it follows the idea of reflexivity in that it allowed for the interview data to be revisited "with new eyes" and seek for themes that emerged at the symposium.

4.2.3 Qualitative data analysis

Thematic analysis was conducted as it provides a highly flexible approach that is useful in examining different perspectives (Braun and Clarke, 2006) . It was conducted through a process of coding using the computer program NVivo. Coding for interview data occurred in two stages. First was a round of open coding which occurred during data collection as themes arose. These themes were broad categories based around components of the research questions such as risks, benefits and *vrk*. The second round of coding was more selective (i.e. themes were drawn from the context in which the first round of codes were discussed) and was informed by both the interview and participant observation data (see Appendix 2). This allowed for a deeper

understanding of the context in which particular themes were discussed in order to identify any similarities and differences between responses.

4.3 Limitations

It is important to note that this research is context specific and is therefore limited in its applications. Due to the time limitations, the participant sample size for interviews is small (n=11) and therefore may not be representative of all perspectives. There were also a few participants (e.g. Australian Government representatives), who would have contributed to a broader, ideal range of perspectives, who were unavailable. In addition, due to the scope of this project and the roles of the many of the participants selected, participants selected are more likely to be in favour of active restoration which may not be representative of the whole expert perspective. This is why participant observation was included as it involved many people outside of the decision-making space. This project also represents a snapshot in time and may not accurately represent any future trajectories.

Chapter 5: Risks and benefits

This chapter presents the perceived risks and benefits emerging from the data. During interviews, all participants were asked what they saw as being the potential risks and benefits of undertaking restoration projects on the GBR. Responses were coded around mentions of risk/s (or associated words such as problem, mistake, danger, wrong, worried, negative consequences, threat) and benefit/s (or associated words such as new, important, improving, “it could help”, opportunity, positive). After this initial round of coding, emergent themes were selectively coded to reveal the context in which these risks and benefits arose. Overall, there were clear overlaps in the perceived benefits by each group, especially regarding potential social benefits, whilst perceived risks were slightly more varied between decision-making groups.

5.1 Perceived Risks

Three key themes emerged from the data: making a mistake, trade-offs and managing expectations. The risk of "making a mistake" was emphasised as a major concern by every participant regardless of their background or current role. Environmental trade-offs resulting from restoration projects were another frequent concern, especially regarding biodiversity and climate change mitigation efforts. Lastly, the risks involved with mismanagement of expectations were frequently cited. Overall, NGO participants expressed stronger views and spoke more about risk in each of these themes compared to other groups.

5.1.1 Making a mistake

The phrase 'making a mistake' has been broadly construed as it was mentioned in a wide variety of contexts during both interviews and participant observation. NGO participants expressed the most concern for ecological mistakes, whereas other groups spoke more to the risk of making socio-political mistakes.

5.1.1.1 Ecological mistakes

The marine environment is made up of numerous complex environmental and biological processes, many of which are still not fully understood. This is particularly true for coral reef ecosystems. Most participants were concerned with the possibility of restoration having irreversible negative impacts and accidently doing "more damage than good" or "making things worse". Several participants used examples of other ecosystem interventions in Australia, such as the introduction of cane toads, to demonstrate how the risk of unintended negative consequences is reasonably high when intervening in natural ecosystems.

"If they have the capacity to do something that will actually benefit [the reef], the risks are proportionally higher as well." – Participant B

"The issue is that it's not guaranteed, the benefits are not guaranteed." – Participant J

However, the GBR is the size of a small country. Therefore, for restoration projects to have a significant impact on reef health they must be scalable. This was a major concern for many decision-making groups, and in particular NGO groups, as with increased scale, comes an increased risk of unintentional negative consequences. This is demonstrated by the quotes above which suggest that intervening at scale may not be worth the proportionally higher risk. NGO participants at the symposium also spread a cautious message about the potential for ecological harm for example, *"congrats, but don't mess it up! Please be careful" – NGO symposium speaker*.

5.1.1.2 Social, political and economic mistakes

The GBR decision-making space is complex as responsibilities are spread over three jurisdictions. In addition, being a huge economic asset and Australian icon, GBR decision-makers are constantly under pressure from the public. Maintaining a strong and trustworthy relationship between the public and decision-makers is vital. Thus, it is no surprise that many participants were concerned with the possibility of making, social, political and economic mistakes: given the urgency of climate change pressures, the execution of the restoration agenda was of major concern. Specifically, proper engagement, social acceptance, necessary support and funding were flagged. Management, policy and government participants were also particularly worried that it could negatively influence public trust in GBRMPA and the QLD Government.

> *"There is a real risk that we could push ahead with something without having full and necessary acceptance and understanding amongst the population… We have got to get the right balance between a sense of urgency to get on with it and move forward with the job, but doing it in a measured way that we minimise the risk that we are going to make a mistake."" – Participant H*

Since restoration will require a significant amount of money, management and government participants were also concerned about being held accountable for the effective use of resources. Without adequate social acceptance and engagement, there may be public pressure about wasting money on restoration efforts, for example the 2018 budget announcement, which allocated $100 million in funding for restoration efforts, received serious backlash about "throwing money at the problem" (ABC News, 2018). For decisions to go ahead, maintaining a good relationship between the public, managers and the government is crucial. Other relationships that may be affected include those between science and managers, for example if resources such as funding and responsibilities are not communicated and distributed properly. Finally, relationships with traditional owners may be affected if cultural sensitivities are not taken into account. This is a first-of-its-kind collaborative effort, thus there is concern that the partnerships that have been created through the restoration agenda may be ruined - *"I don't want to be the one that screws up some of these relationships." – Participant F.*

5.1.2 Biodiversity and other environmental trade-offs

Given the large amount of time, effort and funding required to support restoration projects on the GBR and the finite amount of resources that exist, trade-offs are inevitable. Firstly, NGOs were primarily concerned with any biodiversity trade-offs that may occur from focusing on particular restoration experiments. For example, a focus on assisted migration may help one section of the reef, but may negatively impact another.

> *"Again it comes back to scale. What happens in one area might not happen in another – it's a big area they are playing with." – Participant B*

Managers and policy-makers also agreed that interventions needed to be mindful of any biodiversity trade-offs. The second trade-off was discussed universally, throughout interviews and the symposium. The concern was that focus on restoration might take focus and efforts away from climate change mitigation, *"There is a major risk that we take our eye off the mitigation ball." – Participant H.* As the leading cause of reef health decline globally, climate change mitigation efforts will significantly contribute towards securing the future of the GBR. While this is not directly the role of reef managers, there is strong concern that the current efforts and funding placed on restoration would have a greater impact if spent on strengthening climate policy.

> *"There are so many other things going on in the reef space that we have to think about those policy needs as well." – Participant K*

Government participants were also concerned about trade-offs in effort and whether restoration would take away focus from other policy needs and plans, such as the Water Quality Plan, which may have a larger impact on reef health.

5.1.3 Managing expectations

The literature has shown that it is easy to misunderstand what restoration projects can and cannot achieve. Most participants showed concern for managing expectations for GBR restoration - what it is, how it will be done, who will do it and what it will deliver. They expressed the need for clear communication so that stakeholders, including both decision-makers and the broader Australian community, know exactly what to expect. Many participants felt that without good communication and engagement there was a large risk that restoration would be perceived incorrectly. There was a fear particularly amongst NGOs and scientists that the idea of restoration would be oversold and would have negative social and environmental effects - *"we need to be careful about the message." – NGO representative at symposium*. For example, the idea behind

some restoration projects is to include community involvement. However, it is important that these groups understand what restoration can and cannot do, and how they can and cannot help.

> *"I was really worried that over excited people [would] just go in and rip out seaweed left, right and centre and they actually do more damage to the reef." – Participant E*

The quote above demonstrates the concern that people might take the opportunity to help the reef too far and may instead cause damage to the environment. In contrast, the quote below demonstrates the concern that if the community believed that restoration would "save" the GBR, then people might be disappointed in its results and lose hope for the reef.

> *"I think there's always the risk if you've got communities and citizen groups involved and they just see things going bad, like they've put all this effort into it, they go out and year after year it bleaches and dies and you have to redo it. It creates a sort of fatigue in society…So yeah the risk of making people just shrug and give up, yeah just like that fine balance between caring and feeling like it's hopeless." – Participant A*

In line with fears about conveying the wrong message and overselling the potential outcomes for restoration, all participant groups expressed concern that people might see restoration as a "fix" for the GBR, causing them to lose focus on mitigating other pressures facing the system.

> *"I am worried that some people will see it as a fix and go 'ah we don't need to do anything else, we'll just replant it'." – Participant E*

All groups emphasized the importance of pursuing all options for the reef and clearly communicating that restoration is not a "silver bullet". Finally, large projects require large numbers of people to deliver them. This is especially true for restoration projects as they require people to deploy and continually manage and monitor these projects over time. NGO and policy participants expressed concern that some decision-making groups might not be managing their expectations properly in terms of how much effort, time and resources would need to be allocated make sure that restoration projects succeed in the long-term, *"I think GBRMPA is going to come across some huge capacity issues." – Participant H*. In addition, as the public may become involved in restoration projects, NGO participants raised the potential risks involved with

unregulated restoration projects. Without adequate monitoring and supervision, there is the potential for those involved to do more damage than good to the reef ecosystem.

5.1.4 The risks of inaction and miscommunication

Other risks mentioned include the risk of inaction and the risk of lost communication between scientists.

"The time to intervene is when the risk of intervening is less than the risk of not intervening…So the do nothing option in this case is not risk free." – Participant G

The risk of inaction was strongly emphasised by all scientists interviewed and was spoken about heavily at the symposium. Many consider that considering current climate change predictions, the risk of doing nothing is far greater than the potential risks of restoration as demonstrated by the quote above. Scientists were also concerned about the possibility of miscommunication or no communication between two groups of scientists – those that believe in pursuing restoration options as a necessary step in climate change adaptation, and those that believe efforts focussed on restoration would be better placed towards directly mitigating climate change.

"I am disappointed that some scientists have gone for polarised views." – Participant F

"I'm worried that at some stage these two camps don't talk to each other - that would be the worst outcome." – Participant E

For restoration and overall reef management to be successful, over the next few decades, decision-making needs to be a collaborative and adaptive process, and communication needs to be clear.

5.2 Perceived Benefits

All groups saw major social benefits in terms of involving people in restoration. Other benefits which emerged from the data include the generation of new science and innovation, buying the reef time until the climate stabilises, creating hope, and increasing partnerships and stewardship. Overall, science participants spoke the most strongly about the benefits and potential opportunities in each of these themes compared to other groups.

5.2.1 Involving people

Social benefits were the most consistent theme that emerged from the data. NGO participants saw potential for restoration to encourage transformational change by expanding awareness of the challenges facing the reef. Scientists, manager and policy participants saw strong benefits arising from involving local community and indigenous groups. One of the largest benefits expressed however was that restoration may create hope for the future of the GBR. The Australian public has been exposed to a large range of media suggesting that the GBR is dead and "too far gone". Involving people in restoration, educating them and letting them feel that they can help therefore creates a message of hope. Box 1 shows a quote from each decision-making group to demonstrate how all groups saw involving people as a major benefit.

1. *"Pretty big measurable benefits in terms of not only knowledge but behavioural change. You know, people wanting to, as a result of this program, wanting to reduce their carbon footprint or changing their behaviour." – Participant C*
2. *If you can do it and get people involved, I mean even if that's on a small scale, even at a point where it's not actually going to help the GBR but it will get enough people in there and caring and feeling like they want to look after it, and maybe that will change how they vote and maybe that will mean that we will actually finally do something about climate change." – Participant A*
3. *"People wanting to know that there's a tool that can help the reef and they can potentially get involved and make a difference."- Participant F*
4. *"So potentially there's benefits of people having that stewardship, feeling more involved and going this is part of my life, I want to do something." – Participant E*
5. *"Yeah I think getting citizens more involved, more aware and more involved. I think it would raise awareness of the challenges the reef faces." – Participant H*
6. *"Having people involved in restoration as well, so the whole concept of citizen science and having people out and monitoring what's going on and getting them involved in some of those projects would be good…I have no comment on whether this is a good or bad approach, but it is a good way of building the knowledge around and getting people involved in protecting a good tourism asset." – Participant J*

Box 1 - Perceived social benefits. Participants from each group perceived restoration projects as having significant social benefits, as demonstrated by the quotes.

5.2.2 Generating science and innovation

Both NGO and scientist interview participants spoke positively about the amount of "new" science that would come out of restoration projects. Both saw the same potential benefits, including the flow-on benefits from reef restoration science and technology.

Innovation programs in themselves generate innovation, they generate spill-over and I suppose there will be spill-over benefits to what we do here." – Participant G

It was expressed that this generation of science would help expand the concept of restoration and potentially create technologies that could be used to restore other reef habitats. Government participants also discussed the benefits associated with embracing innovation.

5.2.3 Buying time

It is now almost widely accepted amongst the GBR community that reef conditions will change dramatically over the next 30 to 50 years.

"I think that a program like the RRAP will be instrumental in making sure that we maintain the reef though this period of locked climate change until it stabilises again and it gives it a chance of surviving into the future." – Participant A

Whilst decision-making groups are aware and fully recognise that restoration alone will not help the reef, many believe that it will buy the reef more time by assisting the reef through new temperature levels. Some saw it as providing an "insurance policy" in making sure that there will always be some form of reef.

5.3 Summary

The perceived risks and benefits discussed in this chapter are summarised in Appendix 3. Perceived benefits, particularly those to do with involving people, were quite consistent between groups. In contrast, whilst many social, political and economic risks were commonly perceived, NGO participants stood out as having the most perceived risks. This was especially with regards to those risks associated with environmental impact and inadequate planning. Scientists also emphasised the risk of inaction versus the risk of intervening. These results will inform the discussion in Chapter 7 which examines how perceived risks and benefits reflect values, knowledge and rules.

Chapter 6: Values, rules and knowledge

As a national and international icon, and an important asset for many stakeholders, it is no surprise that there are many different views about how decisions on the GBR should be made. Due to the nature of ecological intervention, restoration on the GBR is especially controversial. This chapter presents the sets of values, rules and knowledge (*vrk)* expressed by decision makers in the restoration space in order to gain a deeper understanding of the decision context for restoration. Visualising the decision context is important as it will allow other stakeholders to understand why particular choices have been made and certain options regarding restoration are preferred. It can also enable decision makers to identify barriers and consider whether changes need to be made to the decision context to overcome constraints on decision-making over possible options, and opportunities to better align actions with broader goals and visions for the reef. The values, rules and knowledge perspective discussed in this chapter will inform the analysis and discussion in chapter seven.

6.1 Values

Held values are the motivations that are important to us in determining our goals, shaping our worldviews and prompting our actions (Schwartz et al., 2012). For decision-makers, having a shared held values system is important as it enables them to express why a particular outcome is important. Refining his original theory of ten basic human values (held values), Schwartz now proposes 19 basic human values which can be categorised into four higher-order groups across two dimensions: openness to change versus conservative values, and self-enhancement versus self-transcendence values (Schwartz et al., 2012). As chapter two suggests, restoration on the GBR will require a particular set of values that align with the changing paradigms in ecological conservation. These are likely to include Schwartz' 'openness to change' values, such as simulation and self-direction, and 'self-transcendent' values such as universalism and benevolence to people and nature.

In order to better understand the held-values system of restoration decision-makers, this study defines values more broadly to include interests, goals and motivations (i.e. how held values might be expressed or operationalised as interests, motivations and potentially actions). Values were therefore coded by looking for words such as "need", "goal", "aim", "purpose", "important", "it's all about", "outcome" and "focus". The motivations, interests and goals expressed by each decision-making group are shown in Appendix 4. These codes were then framed in relation to Schwartz' two main dimensions in order to determine whether the interests and motivations expressed by participants reflect values supportive of restoration. This is summarised in table 3.

As seen in table 3, many of the motivations, goals and interests expressed reflect values associated with openness to chance and self-transcendence. These values might be considered intuitively, to be aligned with supporting restoration. There are a few however, which reflect conservative and self-enhancement values which may either create barriers to restoration or, alternatively, moderate or prompt more careful consideration of certain restoration objectives and options.

Table 3(a) – Values expressed by GBR restoration decision makers. *Expressed motivations, interests or goals from interview data were coded and categorised using Schwartz 19 basic human values (values column). The final column shows which of Schwartz 4 key categories (openness to change, self-transcendence, self-enhancement and conservation) the expressed values fall under.*

Expressed interest, goal or motivation	Description	Example (quote)	Basic human values	Key value categories
Mitigating climate change	All participants discussed being torn or "on the fence" between two different views, mitigating climate change and pursuing restoration. This reflects values of universalism as both mitigation and adaptation, which includes restoration, are required to protect the natural environment.	*"I feel really ethically challenged." – Participant H*	Universalism	Self-transcendence
Strategy and process	All participants discussed the importance of having a unified vision for restoration. This involved having a clear strategy, objectives and an adaptive process. This relates to several values including achievement (to be judged as successful), dependability (trusted by other stakeholders), universalism and conformity – rules (compliant with expectations).	*"Because without a plan, a strategy and a vision of what we want to do in the restoration space, it would be very easy to spend a lot of time and resources without actually knowing whether we were having an impact, or the desired impact." – Participant H*	Achievement Conformity – rules Benevolence – dependability Universalism	Conservation Self-enhancement Self-transcendence
Collaboration, communication and co-ordination	All participants in this research project expressed the importance of collaboration, communication and co-ordination between all GBR stakeholders in going forward for restoration. Communication and collaboration were also heavily emphasised throughout the symposium during presentations and speeches. This relates to universalism (equity), benevolence (caring for the welfare of others), conformity (avoiding upsetting others) and stimulation (working together to try new things).	*"A manager needs to think 'I can see me applying that method', there needs to be popular acceptance of 'yeah I would be comfortable with that being applied on the reef', the scientists going 'here is what I can tell you about risks and benefits', and then the more applied scientists going 'here is my outline of how we could scale that up'. So those things need to always come together." – Participant E* *"It just shows you what you anyone can do. You don't have to be a marine biologist or anything like that to make a difference." – Participant D*	Universalism Benevolence – caring Conformity – interpersonal Stimulation	Conservation Self-transcendence Openness to change
Being prepared for the future	All participants recognised the need to be prepared for managing the GBR under different and more stressful conditions. Many stressed the importance of having as many options or management tools as possible ready to be used if needed, including restoration. Participants also discussed the need to start developing these options now or start building reef resilience "before it is too late". This relates to values of stimulation (trying newer, potentially riskier options), and self-direction (having the capacity to obtain goals).	*"It's just a case of looking at every possible option for supporting, I guess the return of the reef ecosystem to a better condition." – Participant J* *"I still think that it's something we need to start thinking about and researching to make sure that we don't get there and go ah s***, we should have started thinking about this 30 years ago because now it's too late and we've got nothing, no diversity, nothing to work with anymore." – Participant A*	Stimulation Self-direction	Openness to change
Generating science and innovation	Science participants discussed being motivated to generate more science in order to create more options for managing the reef under changed future conditions - discovering "what we don't know" and developing solutions quickly enough to keep up with an adaptive management process. Similar to 'being prepared for the future', this relates to values of self-direction and stimulation.	*"We started talking around the need to increase the rate of knowledge if we were to be in a position to develop management solutions to some of the challenges that we could see emerging." – Participant G*	Self-direction Stimulation	Openness to change

Table 3(b) – Values expressed by GBR restoration decision makers. *Expressed motivations, interests or goals from interview data were coded and categorised using Schwartz 19 basic human values (values column). The final column shows which of Schwartz 4 key categories (openness to change, self-transcendence, self-enhancement and conservation) the expressed values fall under.*

Expressed interest, goal or motivation	Description	Example (quotes)	Basic human values	Key value categories
Protection	NGO participants voiced concerns about protecting biodiversity, "maintaining naturalness" and limiting environmental trade-offs whilst trying to increase resilience .Whilst each of these participants also agreed that restoration options should be explored and may offer significant benefits, the emphasis on protection by NGO participants stood out from other decision-making groups. This strongly reflects Schwartz' value of universalism - protection of nature.	*"I tend to think that resilience needs to be around, or trying to maintain resilience means trying to maintain the naturalness and letting nature do a bit more of the heavy lifting." – Participant B* *"If you're a very firm conservationist, and many of us are, then you don't want any activity in the marine park, you want it 100% protected."– Participant C*	Universalism - nature	Self-transcendence
Effective resilience-based management	Protecting an area as big and complex as the GBR requires an effective management system. NGO and science participants spoke about the importance of having strong reef management led by trusted people who recognise threats to the reef and guided by an effective resilience-based management regime. They discussed the importance of maintaining effective management over the entire GBR world heritage area. This relates to universalism and dependability (managers being reliable and trustworthy).	*"So it's a bit like having a bank account, you want it to continue to grow rather than decline and the current asset is declining. So if you have got a problem you really need those managers to understand what those issues are and to treat them." – Participant C*	Benevolence - dependability Universalism - nature	Self-transcendence
Taking control and directing change	Science, government and management participants all accepted that change in the GBR ecosystem is inevitable and is already occurring in several ways, mostly due to human impacts. Therefore we should be taking control and trying to direct this change in a way that is favourable and ensures that there will still be some sort of reef in the future. This strongly reflects Schwartz' value of power (avoiding anxiety-arousing threats). It also relates to components of self-direction (action – choosing own goals and purposes).	*"We are entering a completely human dominated world now and we have to decide what we want that world to look like."- Participant F* *"You know, humans have been impacting on natural ecosystems already, it's not that we don't impact on the GBR, so we are already actually playing god to the system to some degree, we have been impacting it, this is just trying to impact it in a positive direction and try and reverse some things that we've done." – Participant G*	Power Self-direction - action	Self-enhancement Openness to change
Outcomes and applied science	Science, policy, management and government participants voiced clear concerns about restoration becoming "a science project". They strongly argued, that given certain time limitations, reef restoration science should be outcomes rather than outputs focussed. They emphasised the importance of making sure that science was targeted to ensure effective use of reef restoration resources by providing necessary evidence to decision-makers quickly. This relates to values of achievement (deemed successful by society), and face (gaining social respect and recognition for effective use of resources).	*"It's about science for the sake of society. That science should not happen, should not, simply should not, unless you have approval from society and the problem is we tend to ask for that approval too late in the game." – Participant H*	Achievement Face Universalism	Self-enhancement Self-transcendence

Table 3(c) – Values expressed by GBR restoration decision makers. *Expressed motivations, interests or goals from interview data were coded and categorised using Schwartz 19 basic human values (values column). The final column shows which of Schwartz 4 key categories (openness to change, self-transcendence, self-enhancement and conservation) the expressed values fall under.*

Expressed interest, goal or motivation	Description	Example (quotes)	Basic human values	Key value categories
Transformational change	NGO participants all recognised the importance of transformational change and the potential benefits it would provide for the GBR. Transformational change includes both changing behaviours and changing attitudes towards global issues such as climate change. This strongly reflects all components of universalism (especially society and nature).	*"So I'm after transformational change and the thing that I would largely focus on is people and social research, and find out how you can change people from being basically a passenger or apathetic about the reef to an active participant in restoration." – Participant C*	Universalism	Self-transcendence
Image and reputation, accountability, prioritisation and maintaining OUV	Management and government participants discussed maintaining Australia's, and GBRMPAs, reputation as world leaders in reef management. This includes maintaining the reefs OUV so that it remains a world heritage site. They also emphasised the need to be careful with management options they choose to prioritise as they are held accountable by the Australian public and need to avoid criticism. This relates strongly to values of face (protecting attacks on public image and gaining social respect), security (societal), and conformity (avoiding upsetting others and being compliant with societal expectations). It also may relate to the value of achievement (success by societal standards).	*"I think it's an opportunity for Australia to really be cutting edge on reef management and reef restoration practices." – Participant H* *"I guess the risk if we don't do anything we will get criticised that we didn't try. And then if we do something and it doesn't work, the risk would be that you know, Governments will be held account for having negative impacts on the reef." – Participant K*	Face Security – societal Conformity Achievement	Conservation Self-enhancement
Maintaining cultural connectivity	Several participants emphasised the need to be careful when making any changes to the GBR as it may affect cultural connectivity. This strongly reflects the value of tradition (maintaining cultural and religious traditions). It also relates to aspects of universalism (commitment to equality and protection for all people) and benevolence (devotion to the welfare of others).	*"There are cultural things that we need to be very careful about. How people feel about the place, how important it is to them and if you're playing around with it and things go afoot there you know, I guess if it offends the cultural sensitivities and they lose connection or they feel like somethings been changed such that they no longer feel connected to it" – Participant J*	Tradition Universalism – concern Benevolence	Conservation Self-transcendence
Moral obligation	Science and NGO participants described feeling morally bound to consider all reef restoration options in light of climate change. More than one participant also spoke of the need to do this for their children and future generations. This has strong links to universalism (protection for the future) and self-direction (taking action to reverse what we have already done).	*"All of us would rather be working on something else, we would rather not be in this circumstance." – Participant G* *"Having a six-year old come out of the water crying because the corals are dead reminds me why we are doing this restoration thing." – Participant D*	Universalism Self-direction - action	Openness to change Self-transcendence
Impact at scale	Science and NGO participants spoke of the importance of making an impact at scale. Science participants discussed the issue of scale with excitement and as a "new challenge", whilst NGO participants questioned whether we should be focussing more on projects that do have an impact at scale. This relates to the values achievement (success by societal standards).	*"There is capacity to do something at a meaningful scale." – Participant B. (*The following quote was in the context of discussing using restoration techniques on inshore reefs and catchment management.)	Achievement	Self-enhancement

6.1.1 Openness to change versus conservative values

This dimension of held values represents the conflict between values that highlight independence of thought and action, and enthusiasm for change (self-direction, stimulation), and values that highlight preservation, and resistance to change (security, conformity, tradition). Several of the interests and goals expressed by participants reflect values of stimulation and self-direction. In expressing an interest in being prepared for the future, and generating ongoing science and innovation, participants demonstrate the desire to try new, potentially risker interventions in order to obtain restoration goals. The need to take control of the climate situation and the feeling of moral obligation to reduce human impact also demonstrate a level of self-direction as they emphasise the desire to determine one's own actions and impact on the environment. Collaboration, communication and co-ordination can also be categorised as openness to change values as they involve working together to develop new ideas and solutions to drive restoration action as a group.

> *Look I think that the future for the reef has to be really hopeful but we will need those hundreds if not thousands of leaders. We will need a really determined effort in multiple locations. It can't just be led by the scientists, the whole community, state and country has to get behind it." – Participant C*

However, the need for strong collaboration can also be seen as a reflection of conformity and used as a tool to avoid upsetting other stakeholders. This is a conservative value which may be restrictive in the future. Other conservative values expressed include tradition (maintaining cultural connectivity), secure social status (maintaining image in order to have stability and respect in wider society), and compliance with rules and expectations (being compliant with expectations of how to act and make decisions in terms of strategy and process).

6.1.2 Self-transcendence versus self-enhancement

This dimension of held values represents the conflict between values that highlight concern for others (universalism, benevolence) and values that highlight one's own interests and success (power, achievement). Many of the motivations, interests and goals expressed by participants reflect underlying values of universalism (protection of nature and society), particularly those to do with mitigating climate change and protection of the GBR. Even expression of the importance of strategy, process, and effective management, reflects values of universalism as the underlying motivation is protection. Discussions of transformational change also strongly reflect values of universalism as they emphasise the need for society to work together to protect natural resources

for future generations. In Schwartz refined theory, benevolence values are categorised in two ways: dependability (trusted by others) and caring (caring for the welfare of others) (Schwartz et al., 2012). Interests in strong collaboration and maintaining cultural connectivity demonstrate the desire to work together with regard to the welfare of others, whereas the need for strategy, process and effective management reflect values of dependability as they are motivated by the need for trust from other stakeholders.

In contrast, participants, particularly those involved with government, management and policy, expressed self-enhancement values such as achievement, face and power. Power values were expressed as restoration leaders wanting to be seen as taking control and directing change in a positive way. Achievement (successfulness determined by social standards) and face (maintaining public image and reputation) values were expressed as concern for GBRMPA and Australia's reputation for managing the GBR. Without positive outcomes and impacts at scale (measurements of success), it is possible that others may see restoration as a waste of resources.

> *"...what we are doing right now is going through systematically and identifying what is working really well and things that don't work and why they don't work and when we come around to expanding or trying again or working out what we do next, we use that data to inform those decisions and I think that's a really important way of going forward" – Participant K*

The majority of participants reiterated the importance of having continued testing, monitoring and risk assessments, developing performance indicators, and always having a contingency plan, to ensure that any negative impacts were quickly resolved and face was maintained.

6.2 Rules

Rules allow decision makers to determine what is considered legitimate and make certain choices within the decision context. They can be formal or informal (Colloff et al., 2018). Participants were asked their thoughts about the current regulatory and policy landscape and whether they thought it was supportive of restoration. Answers to these questions were categorised into themes which were then selectively coded for. Participants who attended a regulations workshop held by GBRMPA at the symposium were also observed to gain deeper understanding of the attitudes towards formal rules within the decision context. Three sets of rules were consistently discussed by all participants as key influences in shaping the decision space: intervention policies, regulations and permits, the promotion system in academia and politics. All decision-making groups expressed concern that the politics and bureaucracy involved with public resource management could potentially become a major barrier to restoration.

6.2.1 Changing attitudes towards intervention policies, regulations and permits

In order to manage the risks associated with intervening in a marine ecosystem, there are often a range of processes and approvals required before any intervention can occur. In order to get something approved on the GBR (not just restoration projects, but anything "artificial", from marine buoys to pontoons etc.), GBRMPA has a set of guidelines and regulations which need to be followed. During the symposium, scientists voiced concerns particularly about the difficulty of gaining permits to trial their technologies. Whilst interview participants recognised that in their current state, GBRMPA regulations and policies may not be the most "restoration friendly", they did not see any major issues as attitudes towards the current regulatory landscape are changing as demonstrated by the quotes below.

"One thing that is very clear is that the marine park authority recognises that something needs to be done and that they need to change their permitting and guidelines and policies to allow people to do something, that sort of monitoring the GBR isn't going to be good enough, and they need to do something more." – Participant A

"Tomorrow? No. But down the track? Absolutely." – GBRMPA representative at symposium

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The regulations workshop at the symposium encouraged scientists and managers to work together to avoid having permits denied or taking too long. This demonstrates a shift in thinking towards becoming more supportive of restoration projects. The following quote supports this and suggests that this way of thinking will need to continue as the climate continues to change.

"I think [GBRMPA] are more and more so becoming flexible in allowing more stuff to happen on the reef… if we can't get some benefits happening for the reef then I think more pressure will have to go on GBRMPA in terms of being more flexible in terms of restoration processes used." – Participant K

Other mentions of rules were to do with genetics legislation and the GBRMPA Act regarding protecting biodiversity. Some participants were unsure as to whether they thought restoration conflicted with the Act's biodiversity goals. Genetics legislation is new territory and is currently being looked into as part of the RRAP.

6.2.2 Politics and bureaucracy

Australia's political climate is difficult to navigate at best. For example, the 2018 budget announcement to give $500 million to a private foundation (GBRF) for reef related efforts has created some unease and there has been a lot of media coverage on whether this was a good allocation of resources (Chen and Gartry, 2018). The following set of quotes in Box 2 demonstrate that ultimately, many of the decisions made on the GBR are limited by politics and bureaucracy.

1. *"When you work for government there are rules and policy that go with it." – Participant F*
2. *"It often depends on who the leader is at the moment and what the politicians say is reasonable or not." – Participant C*
3. *"It's hard to have an independent authority because they are still provided money by the government to do their job. So it is a very tricky line that these authorities have to tread." – Participant B*
4. *"I think changes in government and things like that could be a risk, as we could have a government that is less risk adverse to innovative approaches." - Participant K*
5. *"I think the difficult thing with GBRMPA is that it's a very large government organisation. It's very hard strung by the bureaucracy that that is." – Participant A*

Box 2 – Quotes which demonstrate the effect of politics and bureaucracy on GBR decision making

The GBR marine park is managed by joint partnership between GBRMPA, QLD government and the Australian government and as such are held accountable by the Australian public, especially when large amounts of money are involved. Participants discussed the effect of avoiding public criticisms on deciding how to spend funding money. They also emphasised that management bodies need to make it clear that they are not wasting resources and need to prioritise and integrate any new decisions into existing projects.

"You know people in Australia are really suffering in a lot of places, so that decision to give all that money to the reef…I think that was pretty brave." – Participant F

> *"I mean [GBRMPA] are a tax payer government, massive organisation. They are accountable for every little thing they do." – Participant A*

The current political position on climate change has been stagnant and until the political climate changes, there is concern that efforts put into restoration will be wasted. All participants reported the difficulties involved with trying to move ahead with restoration when efforts are clearly needed to mitigate climate change. Quotes like the ones below demonstrate this difficulty.

> *"Well climate change is the huge one and this is really challenging for us as Australians because the policy framework at federal level has probably not embraced climate change." – Participant C*

> *"Obviously the elephant in the room is climate change. SO you know that one school of thought is why do any of this when we could be tackling the real issue head on, so until we have agreement between state and Australia government about some of those approaches, that makes it difficult." – Participant K*

The above quotes suggest that if Australia can embrace climate change and take mitigation more seriously, it is more likely that restoration decisions will be supported and successful.

6.2.2.1 Public opinions, perceptions and attitudes

The Australian public indirectly, via public opinion, play a major role in determining what decisions are made at a national level. They therefore have the potential to create both barriers and opportunities for restoration on the GBR.

> *"I don't see the regulatory regime as the barrier, the regulatory regime is just there to enforce what society has decided is acceptable or not." – Participant G*

At the end of the symposium, all participants were asked to vote, by show of standing up, which areas of restoration they believe future research should be focused on. When asked about further ecological, technological and financial research, less than 50% of the room stood up for each, compared to when asked about social research where almost 90% of the room was standing.

This demonstrates that there is a general consensus about the need to further understand the social dimensions of restoration and the way that society perceives it. Interview participants also expressed that these social issues may extend to include society's perceptions and attitudes towards climate change as expressed by the quote below.

> *"There is still that human nature aspect of thinking 'maybe it's all not true, maybe it will all magically come good again', because it is so close to the bone that you need, society needs to change and it's such a big problem that people just shut off." – Participant E*

The best outcome for the GBR depends on serious global climate change action.

> *"At a small scale, even at a point where [restoration] is not actually going to help the GBR, it will get enough people in there and caring and feeling like they want to look after it and maybe that will change how they vote and maybe that will mean that we actually will finally do something about climate change and then you've got an outcome in it." - Participant A*

By changing public opinion towards climate change, some participants, such as the one above, were hopeful this would influence voting preferences, and therefore would eventually lead to people in charge who might be more likely to take a stance against carbon pollution.

6.2.3 Adaptive management and science

The adaptive management approach by which the GBR is managed and governed relies on strong scientific evidence and advice. Science participants, who are involved in providing this evidence and advice, expressed concern that the promotion system in academia and the scientific method were slowing down the adaptive cycle. Firstly, the current promotion system in academia is based on "first in best dressed" in regards to publishing and sharing findings. Prior to publishing, results are often kept hidden. As expressed by the following quote, for adaptive management on restoration to be successful, scientific findings need to be shared quickly.

> *"I would change the promotion system in academia so that people got more encouraged to collaborate and work together and release their data and talk to each other I think that if research became more outcomes focussed rather than metrics focussed we would progress a lot quicker than we currently do." – Participant A*

Secondly, the scientific method does not allow for much uncertainty and often employs the precautionary principle as demonstrated by the quote below.

> *"Managers can deal with much higher uncertainty than researchers. So before a researcher makes a prediction based on a model, they go through lots of iterations and we try to have as little uncertainty as possible, whereas managers go well I need to do something now and its always like 'what do you mean 50/50 is good enough?" – Participant E*

However, waiting for scientific certainty may not be appropriate given the current condition of the reef, especially given the certainty of ocean warming predictions. One symposium participant expressed that when it comes to endangered ecosystems "we need to turn the precautionary principle on its head…We need to save this planet together!" It is possible that the rules of the scientific method and academic promotion may need to change in order to support a faster adaptive process.

6.3 Knowledge

Knowledge systems are the ways we make sense of the world. They may be factual and logical, based on scientific method, experience of how the world works, or they may involve belief systems such as myths, creation stories or legends. In the *vrk* perspective, different forms of knowledge used in decision-making refers have explanatory value about the decision context, the decision-making process and the issues being addressed (Colloff et al., 2018). Forms of knowledge in this study were coded for by looking at the way participants explained and described different concepts and systems. Mostly experiential and scientific forms of knowledge where identified and appeared to be shared between and within decision-making groups. Both interview and participant observation data suggest that both forms of knowledge are equally desirable in the restoration context. As spoken at the symposium - *"We have all the ingredients in this room to make something great."* – suggesting that there is adequate knowledge within the current decision context. The only area of knowledge that potentially needs to be explored further is social science. This was expressed in both interviews and at the symposium.

6.3.1 Experiential knowledge

Since participants in this study were selected due to their professional roles and experience, all groups had a significant level of management (marine, reef and research management), restoration (in other ecosystems and habitats), policy development and project management experience. There were no significant differences in the types of experience between each decision-making group.

> *"We are working really closely with the international community to make sure that we are learning from everything that has been done so far and looking really closely because it's a global challenge." – Participant F*

> *"I guess it's all about thinking outside of the box and thinking about other parts of society where things could be transferred into the reef space. So it might be something to do with health, or other parts of society that have actually got some good gains from doing some innovative approach that we could learn from." – Participant K*

Other experiential knowledge referred to included lessons learned from other restoration projects and innovative fields. As reef restoration is relatively new in Australia, participants drew on lessons learned from the global reef restoration community, as well as lessons learned from other aspects of society as demonstrated by the two quotes above.

6.3.2 Scientific knowledge

As expected, experimental knowledge is heavily science focussed (biology, chemistry, ecology, engineering, modelling, statistics etc.). It includes findings from experiments and trials, as well as predictions and estimates from models. There are many scientists who have been running coral experiments and working on predictive climate models for years (for example see projects under National Sea Simulator, https://www.aims.gov.au/seasim). Science participants both in interviews and at the symposium were excited about the amount of new scientific knowledge being generated in the reef space and its implications for future reef management. Many non-science participants said that, whilst they were not directly involved in experimental stages, they relied on getting this scientific knowledge and evidence from the scientists to help guide their decision-making processes. Whilst all participants agreed that restoration should not solely be a science mission, they recognised the importance of having a solid scientific basis.

6.4 Summary

This chapter presents the values, rules and knowledge which shape the restoration decision context. It shows that whilst underlying values of openness to change and self-transcendence were expressed, a diverse range of values across both dimensions (i.e. there are also conservation and self-enhancement values) are involved. Knowledge in the reef restoration space includes mostly scientific and experiential knowledge. This knowledge is shared between all decision-makers. Three key sets of rules were identified: policies, regulations and permits, politics, and the academic system. The sets of *vrk* identified here will inform the discussion in the next chapter which will determine how they inform perceived risks and benefits, and consider the barriers and opportunities they present.

Chapter 7: Putting it together

A key aim for this research project was to determine how values, rules and knowledge inform perceptions of risks and benefits of reef restoration amongst decision-makers. This chapter draws links between sets of *vrk* and the risks and benefits discussed in chapter five and explores the implications of these links in enhancing agency for change within the decision context. The most significant finding was the link between values (maintaining face and a sense of achievement), rules (politics) and risk (social, political and economic risks) suggesting that the interactions between values and rules are creating barriers to change. Therefore, this chapter concludes that in order to support feasible restoration options in the future, a change in social and political rules is required. The findings from this study also suggest that decision-makers can help influence these rules in a positive direction through the better communication of associated benefits (driven by knowledge and values).

7.1 Shared knowledge: opportunities to reveal risks and benefits

Knowledge appeared to be shared between decision-making groups. This may be partly because participants, especially interview participants, in this study were selected due to their professional roles and experience. Both scientific knowledge, held mostly by science and some NGO participants, and experiential knowledge, held by all participants, appear to have informed all perceived risks and benefits to a large extent. For example, many of the ecological risks discussed in chapter five can be based on sound scientific understanding and experience in ecological interventions, whereas social risks are more likely to be based on experiential and historical (i.e. comparing social reactions of similar past events) knowledge (Department of Environment and Energy, 2018, Freudenburg, 1988). Government, policy, manager and NGO participants who expressed strong concern for social risks also had substantial experience working with the public and other stakeholders. All participants recognised the need to keep learning and emphasised uncovering "what we don't know". This need for continued learning is in line with the rise of restoration literature, which as discussed, has grown exponentially and is still growing. Both interview and observation participants also recognised the need for stronger social science. This can also explain the perceived social risks and benefits mentioned. Since there was no noticeable difference in knowledge between decision-making groups due to the sharing and mixing of knowledge, and the recognition of the need to keep learning and better integrate social science, it is unlikely any dramatic changes to knowledge are required in this decision context. As long as values and rules permit, the set of knowledge will continue to evolve naturally as new knowledge is generated, experiments trialled and experience gained. This ongoing generation of knowledge provides opportunities for more risks and benefits associated with restoration to be revealed.

7.2 Rules and risks: potential barriers to change

A strong link between rules and perceived risk in this study makes it possible to suggest that the set of rules constraining the decision context are creating barriers to change (Wildavsky and Dake, 1990, Colloff et al., 2018). Take two sets of rules mentioned by interview participants for example: policies, regulations and permits, and the scientific method. Firstly, many participants perceived risks to do with making a mistake and ruining relationships between stakeholders. These risks can be linked to the development of policies, regulations and permits in that if they become more flexible and thus it becomes easier for restoration trials to be approved, it is more likely that GBRMPA and the government will receive criticism from the public, especially if something goes wrong. On the other hand, if permits are too difficult to obtain, they may ruin relationships with scientists, slow down the restoration process all together and run the risk of inaction. Secondly, the career promotion system in academia and the uncertainty tolerance between managers and scientists, discussed in chapter 6, can be linked to ecological, social and

political mistakes. Communicating uncertainty can leave room for doubt, criticism and can increases fears of making a mistake (Fischhoff and Davis, 2014). In contrast, waiting for scientific certainty and academic promotion and sharing (i.e. publishing) may take too much time which could increase the chances of making social and political mistakes as it could appear as "doing nothing" or "wasting resources".

Whist it is important to make sure that these risks are considered and balanced appropriately to avoid challenges in the future, these rules are not the most concerning as the attitudes towards them are slowly changing. The most concerning set of rules identified in this study were political (i.e. informal). Many of the risks discussed in sections 5.1.1.2 and 5.1.3 (social mistakes and managing expectations) have underlying political barriers. Since restoration will only work in the context of strong action on climate change which will require political change and effort from society, the wider socio-political decision context and the barriers it creates needs to be considered, as will be discussed in section 7.5.

7.3 Conflicting values

Understanding how values inform decision-maker perceptions is important as people are more likely to trust and understand the reasons behind decisions made by those who hold similar values to themselves (Siegrist et al., 2000). This study finds that significant links can be drawn between values, and perceived risks and benefits (summarised in Table 4). A few things are noticeable. Firstly, the values associated with perceived risk appear to have mostly underlying self-enhancement and conservation values. In contrast, the values shown to be associated with benefits appear to have mostly underlying self-transcendence and openness to change values. Corner et al. (2014) found that human values can affect perceptions of risk and lead to distinct views on how to deal with them, making it is possible to suggest that based on the different values discussed above, the decision-making groups in this study may have inherently different ways of approaching the problem. For example, the link between values and risk suggests that those who hold values of self-enhancement and conservation (such as conformity, manifested as restraint of actions likely to cause harm or violate social expectations or norms) are more likely to perceive risks in restoration and thus less likely to consider all restoration options. On the other hand, the link between values and benefits suggests that those that express openness to change and self-transcendence values are likely to be more open to new options and potentially more risk tolerant as they see more benefits. Although all participants discussed progressing towards the same end goal, it may reach a point where these different pathways create barriers to change in the decision context and, thus, better alignment of these values may be necessary.

Table 4 - Links between values and perceived risks and benefits. The arrow on the left hand side depicts Schwartz two dimensions of basic human values. The values closest to the top of the table are those which have both underlying openness to change and self-transcendence values. Those closest to the bottom have both conservative and self-enhancement values.

Values	Risks	Benefits
Collaboration	Social, economic and political mistakes Managing expectations	Involving people
Being prepared	The risk of inaction	Generating science and innovation Buying time
Generating knowledge		Generating science and innovation
Innovation		Generating science and innovation
Transformational change		Involving people
Maintaining cultural connectivity		Involving people
Moral obligation		Buying time
Outcomes		Generating science and innovation
Maintaining OUV		Buying time
Mitigating pressures	Biodiversity and other trade-offs	
Protection	Ecological mistakes Biodiversity and other trade-offs	
Impact at scale	Ecological mistakes	
Strategy and process	Social, economic and political mistakes Managing expectations	
Effective WHA management	Biodiversity and other trade-offs	
Social acceptance	Social, economic and political mistakes	
Prioritisation	Biodiversity and other trade-offs	
Image and reputation/accountability	Social, economic and political mistakes	

7.4 Changing the decision context

The decision context is already changing through shifts in interactions between values, rules and knowledge. Decision-makers in the reef restoration space have recognised the need for the generation of new knowledge and the integration of different kinds of knowledge. As such, the rate of knowledge is expanding rapidly. As this rate of knowledge generation and integration increases, so potentially does the range of options it allows in the decision context as more risks and benefits associated with restoration will be revealed. However, in order for the decision context to allow for feasible restoration options in the future and reveal more benefits, values and rules will have to accommodate this shift in knowledge.

7.4.1 Knowledge-rules interactions

This expanding knowledge, as well as the integration of different kinds of knowledge, is already forcing decision-makers to consider a shift in rules, more specifically a shift in risk tolerance and flexibility. As discussed in sections 6.2.1 and 6.2.3, attitudes towards risk and uncertainty are changing both at a regulatory and management level, and a scientific level. This shift is to allow the consideration of more feasible options made possible by new knowledge and lessons learned within the decision context. Whilst there is still work to be done in terms of shifting these rules, it is widely recognised that they do need to change and small steps, such as GBRMPA changing their permitting guidelines (Great Barrier Reef Marine Park Authority, 2018), have been made in this direction. Chapter three shows that there is potential for current management and governance systems to continue to support these types of changes. This shift in rules is crucial for new knowledge to be able to demonstrate potential benefits associated with restoration.

7.4.2 Values-knowledge interactions

Although a diverse range of values and interests were expressed, it was clear that some aligned with those discussed in chapter two. Those values which emphasized the need to be prepared, have options and direct inevitable change show that values have already been changing in light of new knowledge on the effects of climate change. It is possible that values will continue to shift in this direction as the need for intervention becomes clearer and more benefits are revealed (knowledge). It is important that these values (i.e. those that reflect openness to change and self-transcendence) are emphasised by decision-makers as these are more likely to encourage others to associate restoration with benefits rather than the risks. This demonstrates that the decision context is slowly becoming “future-ready” and decision makers are becoming “future makers” as put by Bohensky et al., 2011.

7.4.3 Values-rules interactions

Values-rules interactions in the restoration decision-context are strongly linked to risks and are therefore the most likely to create barriers to change. Self-enhancement values such as face

and achievement in this context are heavily associated with politics and bureaucracy. Concerns about the government, GBRMPA and others involved in restoration receiving criticism for pursuing restoration options are all engrained in the complex socio-political context that is GBR management. Since values of face and achievement are based on this context and rules are created because of these values (i.e. rules are created to maintain reputation), which further contributes to the complex socio-political context, these interactions will be difficult to change. However, to support restoration, this change is needed as currently these interactions are creating a greater perception of risk within the decision context. Since values and rules constraints are much harder to address than knowledge constraints (Prober et al., 2017), they should be the focus of change for this decision-context.

7.5 Overcoming socio-political barriers

The *vrk* perspective emphasises that opportunities for change can be constrained by the existing decision context. Despite the changing values, rules and knowledge discussed above, changes in the decision context are limited without the consideration of the broader set of rules which constrain decision processes. This project reveals that there are rules which need to change outside of the immediate decision context in order to fully support restoration options in the future. Many of the major risks perceived by all decision-making groups had a social and political basis, and thus can be said to have been informed by the rules set out in section 6.2.2 on politics and public opinion. To overcome the socio-political barriers that these risks potentially pose, social change is needed. Whilst social change will require large action from society, this research suggests that there are some changes that decision-makers can make to the decision context to help drive this change in a favourable way.

7.5.1 How the decision context can help drive socio-political change

In decision-making processes that resist change, change can be driven by collective action taken by those outside of decision-making groups (Colloff et al., 2018). Whilst social change sits in a much broader decision context than the one discussed here, decision-makers in the reef restoration space can help navigate change in a way that will broaden the set of rules currently limiting their decision context. Ultimately, a political landscape which strongly supports climate change mitigation and a social understanding of the need to explore active interventions will expand the set of rules which support restoration decisions. The conceptual model presented in Figure 2 demonstrates how changes made within the decision context can help influence factors outside of the decision context in order to potentially broaden the set of options available at the *vrk* intersection.

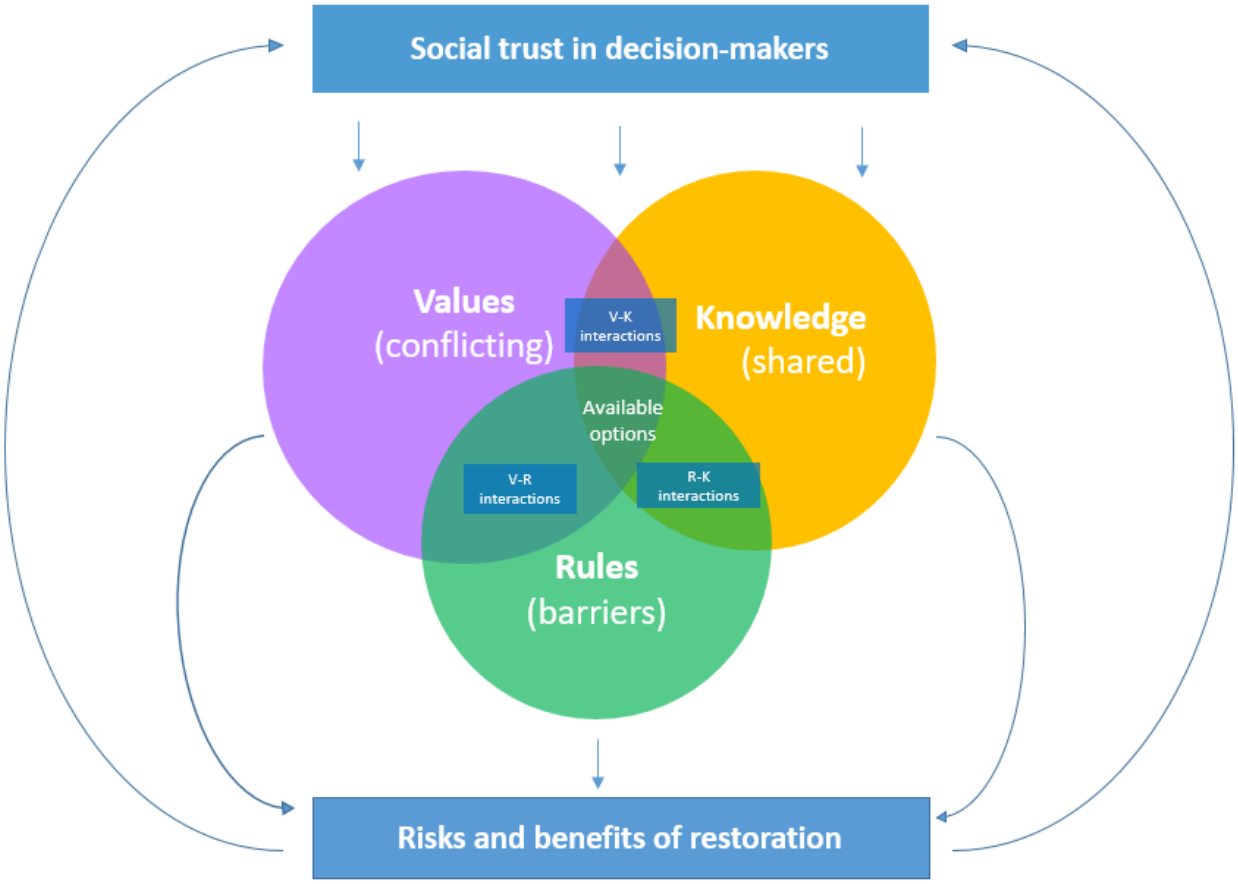

Figure 2 – Conceptual model demonstrating the potential for changes within the decision context to influence social values, norms and perceptions outside of the decision context in order overcome potential barriers. Interactions between values, knowledge and rules inform the decision context and subsequently, the options available at the intersection between *vrk*. Increasing social trust through the communication of risks and benefits, and thus aligning social values and perceptions with restoration, will influence the set of socio-political rules constraining the decision context.

The discussions earlier in this chapter identify that the most significant barriers to change in the restoration decision context are created by the interactions between values and rules (section 7.4.3). This suggests that in order for the decision context to support restoration, two major changes are required: (1) a shift in informal rules (social norms and perceptions created through politics), and (2) the conflicting values set out in section 7.3 need to be resolved. As both sets of rules and values are deeply rooted in politics and public opinion, a possible way to influence them in a positive direction is to increase social acceptance, trust and understanding towards restoration.

As social and political structures that create barriers to change are reproduced by social feedbacks, employing an adaptive approach to gaining social trust is imperative (Colloff et al., 2018). As people often form their opinions on new technologies based on the communicated risks and benefits (Siegrist and Cvetkovich, 2000), decision makers in the reef restoration space need to better communicate and demonstrate more tangible benefits associated with restoration projects on the GBR. Since attitudes towards learning and generating new knowledge (i.e. revealing more

risks and benefits) are already supportive of restoration, what needs to change in the decision context is the set of formal rules (i.e. regulations, policies and permits) which allow small scale restoration trials, which mitigate concerns about irreversible ecological harm, to proceed. If these trials can begin to demonstrate more benefits than risks, it will become easier for society to understand the reasons behind restoration decisions and why certain outcomes are preferred. This will have an impact on socio-political barriers as increased social understanding and trust will feed back into the decision context (i.e. more social acceptance would help shift political rules which constrain decision-making and help resolve values associated with face and achievement). This adaptive process of communicating benefits in order to increase social trust and overcome socio-political barriers in the decision context may provide the necessary acceptance for restoration projects on the GBR to move forward.

7.6 Summary

This chapter analyses the restoration decision context in order to gain a better understanding of decision-making processes, and identify the barriers and opportunities it provides. There are three key takeaway messages from this discussion: (1) the most significant barriers to change are created through the interactions between values and rules, (2) as these barriers are of a socio-political nature, to overcome them, increased social acceptance, trust and understanding is needed, and (3) this can be achieved by allowing the continued generation of knowledge to demonstrate more benefits.

Chapter 8: Conclusion

The Great Barrier Reef is in for a dismal future if additional action is not taken to increase its resilience against the effects of climate change. As such, restoration has been put forward as an additional tool to help increase the reef's resilience to changing conditions. However, due to the controversial nature of ecological intervention, restoration will only work if there is sufficient support from all GBR stakeholders, including the Australian public. To gain the necessary support and acceptance required for restoration projects on the GBR to be successful, GBR stakeholders need to be able to trust decision-makers, and understand the reasons and implications behind restoration decisions.

The aim of this research was to visualise the restoration decision context and characterise it in terms of *vrk* for two key reasons: (a) to help increase social trust and acceptance, and (b) to consider whether the current decision context needs to change to support restoration. Characterising the decision context as sets of *vrk* is important as it enables stakeholders to understand the underlying *vrk* behind the benefits, risks and goals of restoration on the GBR. It also enables them to see whether the decision context supports restoration decisions. If the decision context supports restoration decisions and stakeholders can understand the decision-making process, it is more likely that they will engage in decision-making and be more open to restoration options.

Altogether, this analysis demonstrates that whilst the restoration decision context is already changing, more needs to be done to better support a restoration approach in the future. Ultimately, a decision context which supports restoration should be able to clearly communicate the benefits associated with certain restoration decisions and the reasoning behind them to all GBR stakeholders. Currently however this is not the case since within the decision context there is a greater perception of risk (social, political and economic) due to the barriers created by related sets of values (face and achievement) and rules (politics).

This research suggests that, if rules can change to allow new knowledge to be generated and tested in small scale trials, it is more likely that increased benefits rather than risks associated with restoration will be seen, especially as small scale trials may help mitigate concerns about "making things worse" or causing irreversible damage to the environment. It is more likely that the public and other GBR stakeholders will become supportive of restoration decisions once more benefits than risks can be demonstrated. The conceptual model (figure 2) suggests that this social trust and support will feed back into the decision context and potentially influence the sets of socio-political values and rules currently constraining decision processes.

Since this research only provides a snapshot in time, future research could involve an exploration of decision-making on different scales (e.g. national) and a more comprehensive data set (n>11). Future research could also further explore the practical outcomes of this project by

combining it with current research being conducted by the CSIRO on the social perceptions of restoration and expanding on the model presented in figure 2 to gain a better understanding of how GBR stakeholders could use and engage with the decision context.

Whilst there is still work to be done in regards to gaining social trust and acceptance, and changing the decision context to fully support restoration approaches on the GBR, the findings from this research project show that there is potential for Australia to set an example for reef restoration globally. If Australia can successfully demonstrate the benefits of restoration projects by increasing the resilience of the largest coral reef system in the world, combined with continued efforts on climate change, then there may be hope for the long term future of the world's coral reef ecosystems.

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Appendix 1

Semi-structured interview protocol – Key areas of questioning and general prompts used

[Research Question 1: How do perceptions of risks and benefits reflect values, knowledge and rules?]

1. Just briefly, tell me a bit about your role and how you are involved with the Great Barrier Reef (management, research, RRAP etc.)?
2. How do you define restoration?

   [Prompts: What might the aims of restoration be? What are some examples you might/have come across so far? What kinds of approaches does it include? Can you tell me about any interactions you have had with restoration projects? Are some approaches more promising than others? Why?]
3. When do you think restoration first started to receive attention in Australia?

   [Prompts: When do you think people started to see it as a viable solution? Do you see it as a necessary solution? Examples?]
4. What are some benefits of restoration?

   [Prompts: Ecological? Social? Economic? What are some opportunities it may provide now? In the future?]
5. What are some of the risks you associate with restoration?

   [Prompts: What are some limitations? How might these be addressed? Are there things that we still need to know?]
6. How has restoration been approached in Australia?

   [Prompts: What are some of the feelings towards it? Is there any consensus on whether it should or should not be used? Why do you think this is?]
7. What are your thoughts about the progress in Australia so far?

   [Prompts: Have there been any barriers/challenges? How were these addressed? Do you think there is something we could be doing/could have done better?]

[Research Question 2: Does the current decision context support restoration approaches?]

8. What do you think is important in reef management?

   [Prompts: What should be the focus? Would you make any changes to current management and governance systems? What are your thoughts on adaptive management? Do you think it is an effective management approach? Risk tolerance?]
9. Do you think anything has been done so far that is a step in the right direction?

   [Prompts: 2050 Plan limitations? Recent budget announcement? In what areas will this funding be used? Why has funding taken so long?]

10. Where do you think leadership on restoration should come from? Why?

    [Prompts: What do you think about the balance of the role of public and private sector? Would you like to see this change? If so, how?]

11. Have you seen effective active restoration models elsewhere? How could/could they be applied in Australia? Why/why not?
12. To your knowledge, has research in this area been used to inform any decisions? Can you give an example?
13. What are some barriers to implementation?

    [Prompts: Any counterproductive policies? Conflicting strategies? Research?]

[Research Question 3: Does the decision context need to change to support restoration? What strategies or approaches may make restoration a more viable option for climate adaptation in the future?]

Say that the RRAP comes through with a successful small scale active restoration trial (e.g. larval reseeding experiments on Heron Island) and the plan for a large scale trail looks promising.

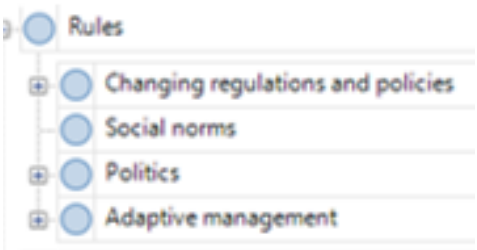
14. What is your vision in the next 5, 10, 50 years?

    [Prompts: What are some factors that contribute to this vision? What do you think are the most important things to consider when implementing a new approach?]

15. If you could change the focus of research in this area what would you say? What would you like to see the next generation do differently?
16. What are the next steps from here?

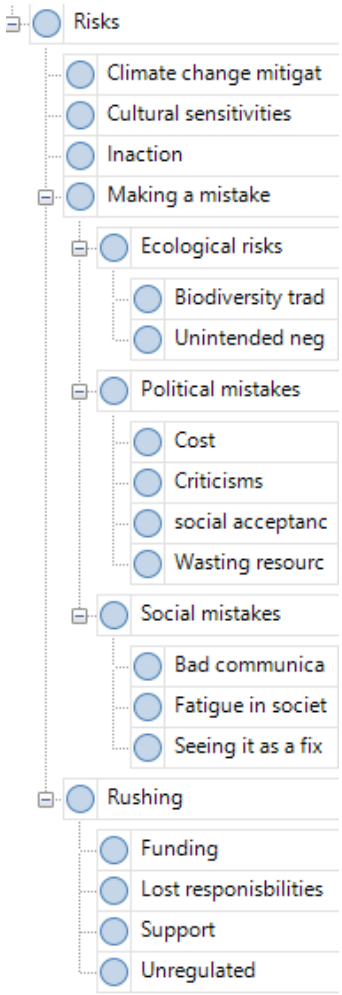
Appendix 2

Codes used for analysis generated using the computer program NVivo



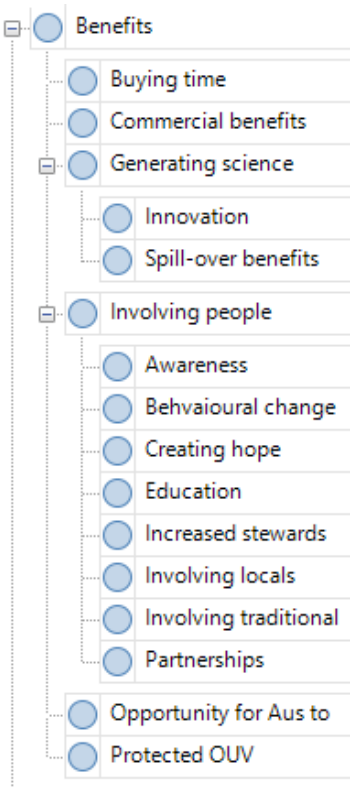
Appendix 2 (cont.)

Codes used for analysis generated using the computer program NVivo



Appendix 2 (cont.)

Codes used for analysis generated using the computer program NVivo



Appendix 3

Summary of the perceived risks and benefits mentioned by each decision-making group

	Perceived Risks	Perceived Benefits
NGOs	▪ Unintended negative consequences ("more damage than good") ▪ Taking away from climate change mitigation ▪ Biodiversity trade-offs ▪ Rushing without proper funding and support ▪ Creating fatigue in society ▪ Becoming unregulated ▪ Becomes a science project ▪ Lost responsibilities ▪ GBRMPA not playing correct role	▪ Involving people (education and behavioural change) ▪ Generating science ▪ Hope (changing the narrative) ▪ Buying-time ▪ Partnerships
Scientists	▪ Making a mistake/ecological risks ("surprises in the marine environment") ▪ Taking away from climate change mitigation ▪ Bad communication and engagement (scientists with polarised views, ruining relationships, conflict of resources and responsibilities) ▪ Risk of inaction	▪ Involving people (locals, traditional owners) ▪ Buying time ▪ Hope ▪ Generating science (innovation and spill over benefits) ▪ Increased stewardship ▪ Commercial/economic benefits
Managers/ Policy-makers	▪ Making a mistake social and ecological mistakes by not balancing positive and negative outcomes correctly ▪ Taking away from climate change mitigation ▪ Wasting resources ▪ Rushing without proper engagement and social acceptance ▪ Not understanding own limitations ▪ Biodiversity trade-offs ▪ Seeing it as a "fix"'	▪ Involving people (awareness and education) ▪ Strong partnerships ▪ Protected values (ecosystem goods and services) ▪ Opportunity for Australia to be a leader in reef management
Government	▪ Making a mistake/making things worse ▪ Government could be criticised ▪ Cultural sensitivities ▪ Issues with scale ▪ Cost	▪ Involving people ▪ Starting the conversation/feeling like we are doing something ▪ Innovation ▪ Tourism/commercial

Appendix 4

Interests, motivations and goals mentioned by each decision-making group. *Key overlaps are shown in the middle (blue) box and in the grey boxes on the outside.*